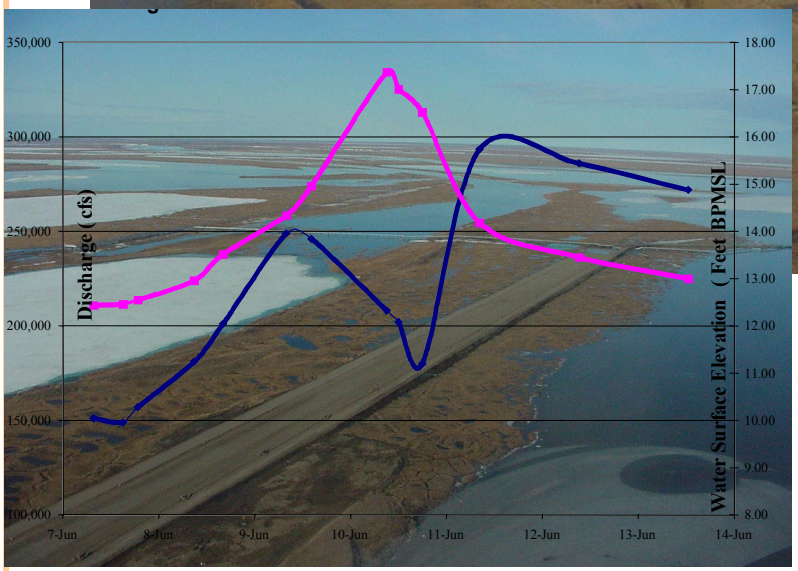
Alpine Facilities 2001 Spring Breakup and Hydrologic Assessment



Submitted to:

PHILLIPS Alaska, Inc.
A Subsidiary of PHILLIPS PETROLEUM COMPANY

By

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1.0 Introduction

This report summarizes the hydrologic observations and measurements made during the 2001 spring breakup of the Colville River Delta in and around the Alpine Development (Alpine). This hydrologic breakup assessment was done, in part, to satisfy permit stipulations associated with the construction and operation of the Alpine facilities. Following are summaries of the applicable permit stipulations and identification of the report section that address each criterion.

US Army Corps of Engineers, Department of the Army Permit 2-960874, Colville River 18 (USACE 2-960874)

Page 2-A Item 6. *Aerial and ground photography shall be taken within 24 hours of peak flood discharge during spring breakup and any high water event that results in water passing through the infield facilities (subject to weather conditions and safety requirements).* (Section 2.1) *Monitoring shall continue weekly after the high water event until water is no longer ponded upstream of the road. The monitoring shall be done for the first five years after completion of construction and for high water events greater than the 10-year predicted flood water surface elevation event. A monitoring plan shall be submitted to the District Engineer prior to completion of gravel placement for the infield facilities. The annual report shall contain: data and analysis related to the peak flow during the event;* (Section 2.2)*...the relationship of the observed peak flow with the predictive model*; (Section 3.0)*...water velocity along road and pad side slope corners;* (Section 2.1)… *velocity and discharge rates through culvert and bridge openings*; (Section 2.3)… *drawings showing the locations and extent of any erosion, scour, or gravel deposition greater than 20 cubic yards per 100 linear feet, a cross section of each erosion area superimposed on the as-built cross section of the area of concern, and an estimate of material eroded from each affected area*. (Section 4.0)

Page 2-B, Item 7. *Remedial action plans (to include additional or modification of drainage structures) shall be developed, submitted for approval, and implemented when water surface elevation is equal to or greater than 0.5-foot higher than the*

downstream side water surface elevation one week after the peak discharge has occurred. (Section 2.3) *Remedial action measures (recovery, placement of additional erosion protection material, tundra restoration resulting from scour holes, revegetation, etc) shall also be developed when erosion of more than 20 cubic yards of gravel material occurs in any 100 linear feet of infield gravel fill placement. Any road washout area that occurs when water surface elevations are below the predicted 50-year flood event shall be further armored to withstand the predicted 100-year flood event water surface elevation.* (Section 4.0)

State of Alaska, Office of Management and Budget, Final Consistency Determination, State I.D. No. AK9703-03OG (AK9703-03OG)

Page 7, Item 6. *A photographic records shall be established of the flow around and through the gravel fill on the Colville River Delta during the first occurrence of a spring breakup that results in a flow between Q2 and Q10, and the first occurrence of a spring breakup that results in a flow greater than Q10. A report of the photographic records is due to DEC before December 31 of the year the documented flow event occurs.* (Section 2.1)

Page 9, Item 24. *Each culvert and the culvert battery shall be monitored following installation. A report summarizing observations made (e.g., scour, erosion, water surface elevation differences and identifying remedial work (if needed) proposed shall be submitted to the DFG annually by July 1 following spring breakup. Note: If the monitoring indicates little or no change, the reporting requirements may be changed by permit amendment.* (Section 2.3)

State of Alaska, Department of Fish & Game, Fish Habitat Permit FG99-III-0051 (FG99-III-0051)

Page 2, Item 3. *ARCO Alaska Inc., shall monitor the water surface elevation of Lake L93-12 (U6.1) Water surface elevations shall be taken immediately after ice breakup and at least once a week for three weeks following breakup.* (Section 5.0)…*Water surface elevations also shall be taken once each month until freeze-up.*

State of Alaska, Department of Fish & Game, Fish Habitat Permit FG97-III-0190-Amendment #1 (FG97-III-0190-Amendment #1)

Page 2, Item 1. *ARCO Alaska Inc., shall monitor the water surface elevation of Lake L93-13 (T6.1) Water surface elevations shall be taken immediately after ice breakup and at least once a week for three weeks following breakup.* (Section 5.0)…*Water surface elevations also shall be taken once each month until freeze-up.*

In addition, water surface elevations and mechanisms for spring recharge were monitored in Lake L93-42.

2.0 Breakup Summary

2.1 Water Surface Elevations and Observations

All elevations presented in this report are in feet and are based on the British Petroleum Mean Sea Level (BPMSL) datum unless otherwise noted.

Observation of the permanent staff gages in the Alpine vicinity began on 7 June 2001 after flowing water was first observed at the head of the Colville Delta. Water surface elevation measurements began when rising water levels were noted at the gages on 9 June 2001. Measurements continued through 16 June 2001 at which point breakup flows had receded from the gages. Staff gage locations are shown on Figure 2-1 and 2-2, and water surface elevation and observations for permanent staff gages are presented in Tables 2-1 through 2-7.

The peak water surface elevation occurred in the Alpine area sometime during the afternoon or evening of 11 June 2001. A peak water surface elevation of 8.03 feet was recorded at Permanent Staff Gage #6. Peak water surface elevations recorded at the remaining permanent staff gages ranged from 6.95 to 7.95 feet . The location of Permanent Staff Gage #8 was used as a snow disposal site. Permanent Staff Gage #8 was surrounded and influenced by snow for the duration of the monitoring program and readings are not considered to be representative of the observed breakup conditions.

Measurements indicate that during the Spring 2001 breakup, the maximum difference between water surface elevations on either side of the road was 1.20 feet. The difference occurred between Gages 3 and 4 on the afternoon of 9 June 2001 and can be attributed to the damming effect from the ice pads constructed immediately upstream of the bridge openings. This caused an increase in water surface elevation and the backing up of water into the swale area and Lake M9524. As the flow over the ice pads increased and the rate of ice pad erosion increased, differences in water surface elevations between the south and north sides of the road decreased.

Breakup flooding conditions at Alpine on the morning of 11 June (within 24 hours before the peak water surface elevation), on the morning of 12 June (within 24 hours after the peak

water surface elevation), and on 14 June can be seen in Photographs 2-1(a-f), 2-2(a-c), and 2-3(a-e), respectively. This photographic record satisfies the requirements of USACE 2-960874, Page 2-A, Item 6 and AK9703-030G, Page 7, Item 6. Water velocities through bridge openings and culverts are presented in Section 2.3. At areas away from these openings, water velocities along the road and pad side slopes were not perceptible.

To monitor water surface elevations at the head of the Colville River Delta and in the Nigliq Channel, temporary staff gages were established at selected locations (Figure 2-1). Measurements began on 6 June the day after water was first observed near Monument 01. Measurements continued until 13 June at which time all temporary gages were removed from the field. Water surface elevation and observation records for temporary staff gages are presented in Tables 2-8 through 2-14.

The peak water surface elevation at Monument 01 occurred on the morning of 10 June at an elevation of 17.37 feet. In the Nigliq Channel near Monument 12 and Temporary Benchmark 20N (TBM 20N), the peak water surface elevations occurred sometime during the afternoon of 10 June at elevations of 11.94 and 10.16 feet, respectively. The peak water surface elevation near Monument 22 (near Nanuq Lake) likely occurred the evening of 10 June at an elevation of approximately 8.8 feet. Definitive high water marks were not available at Monument 22 (near the mouth of the channel) and the peak water surface elevation presented has been estimated. At Monument 28, the temporary staff gages were destroyed by ice on the evening of 11 June and high water marks were not available due to the lack of channel banks in this area. The highest recorded water surface elevation at Monument 28 is 3.83 feet and was taken on the morning of 11 June, probably with 12 hours of the peak water surface elevation.

2.2 Peak Discharge in the Colville River Delta

Normal depth computations were used to estimate the spring discharge in the Colville River. All discharge estimates are for the East Channel at Monument 01 (also known as river mile E27.09 or “the head of the delta”) located upstream of Nuiqsut, just downstream of the confluence with the Itkillik River. Water surface elevation and slope data were obtained from

the measurements made at Monument 01 and temporary benchmarks 01U (TBM 01U) and 01D (TBM 01D). Cross section geometry was based on a 1996-surveyed cross section at Monument 01 (Shannon & Wilson, 1996), and hydraulic roughness values were estimated based on a 1993-discharge measurement (Alaska Biological Research and Shannon & Wilson, 1994).

The peak water surface elevation at Monument 01 occurred on the morning of 10 June and the discharge at the time of the peak water surface elevation is estimated to have been 208,000 cubic feet per second (cfs). The low water channel ice on both the East and Nigliq Channels was mostly intact (however floating) at the time of the peak water surface elevation. In addition, the Sakoonang Channel, as well as other channels in the lower portions of the delta, was blocked with snow.

The peak discharge at the head of the Colville River Delta is estimated to have been 300,000 cfs and to have occurred on 11 June. It is estimated that this discharge will be equaled or exceeded, on average, approximately once every 4 years (Michael Baker Jr., Inc. et. al., 1998). At the time of the peak discharge, the channel at Monument 01 was clear of low water channel ice. During the evening of 10 and 11 June, much of the low water channel ice in the East Channel and the upper Nigliq Channel had cleared out as well as the snow that was blocking flow in the Sakoonang and other channels in the lower delta. The clearing of the channel ice likely caused an increase in discharge, and a decrease in water surface elevation at Monument 01. A hydrograph of water surface elevation and discharge vs. time is presented on Figure 2-3.

2.3 Alpine Facility Bridge and Culvert Observations

2.3.1 Bridges

Discharge was measured at both bridges on the CD-2 access road on 11 June 2001 to satisfy the USACE 2-960874 and AK9703-030G permits. As previously discussed, the peak water surface elevation occurred at the head of the delta on 10 June and occurred in the Alpine area sometime on the afternoon or evening of 11 June. Discharge at the 62-foot swale bridge was measured to be approximately 600 cubic feet per second (cfs) with an average adjusted

velocity of 1.8 feet per second (fps). Discharge at the 452-foot swale bridge was measured at approximately 3,700 cfs with an average adjusted velocity of 2.4 fps. The average adjusted velocity represents the average velocity normal to the bridge section. The maximum recorded water velocity at the bridge sections (not adjusted for flow direction) was 4.1 fps at the 62-foot swale bridge and 3.2 fps at the 452-foot swale bridge.

Discharge measurements was completed using standard United States Geological Survey midsection techniques. A Price AA velocity meter and sounding reel on a bridge board was used and a 30-pound Columbus-type lead sounding weight was used to stabilize the meter. A Scientific Instruments Model 9000 current meter digitizer was used to time velocity measurements. Methods used at the 452-foot swale bridge were modified after it was found that long grass on the channel bottom hampered measurements made at the eight-tenths depth on the 62-foot Swale Bridge. A method coefficient was used to correct those velocity measurements that were affected by the grass. Discharge measurement notes are provided in Appendix A.

The peak discharge estimated through the 62-foot swale bridge is 620 cfs and the peak discharge estimated through the 452-foot swale bridge is 3,900 cfs, and is estimated to have occurred on the evening of 11 June. Peak discharges were estimated using peak water surface elevations and normal depth computations. At the time the discharge measurements were made (11 June), the ice pads in the vicinity of the bridges had cleared and did not affect the discharge through the bridges. Based on the water surface elevations and the timing of the discharge measurements, the conditions observed at the time of the measured discharge can be considered to be reasonably representative of flow conditions at the bridges at the time of the peak discharge.

2.3.2 Culverts

On the evening of 11 June, velocity measurements were taken at each culvert to satisfy the USACE 2-960874 and AK9703-030G permits. Water velocity and water depth were determined using a Price AA velocity meter and wading rod. Of the 26 culverts surveyed, 13 contained measurable flow; the remaining culverts were filled with snow. Snow blocked water from flowing through Culverts C11-C17 and water levels receded before the snow was

eroded enough for flow to begin. Depths of flow through the culverts ranged from 1.00 to 2.7 feet and velocities ranged from 0.83 to 5.13 fps. Culvert locations and numbering are shown on Figure 2-4 and culvert water depths and velocities are provided in Table 2-15.

Culverts were visually inspected on the afternoon of 16 June 2001, five days after the peak water surface elevation. All flow through the culverts had ceased by the time of the inspection and flowing water was not observed on either side of the road; however, discontinuous, shallow standing water was observed on both sides of the road. No evidence of scour was observed at any of the culverts, including Culverts C10 and C11 where scour was documented as a possibility during the 2000 spring breakup (Michael Baker, Jr., 2000). Further discussion on scour and erosion is presented in Section 4, Gravel Pad and Road Erosion.

Water surface elevation differences on the upstream and downstream side of the road were not more than 0.5 feet seven days after the peak water surface elevation, thus meeting the requirements of USACE 2-960874, Page 2-A, Item 7 and AK9703-030G, Page 9, Item 24. No remedial planning measures to alter the drainage structure design are required at this time.

Table 2-1 Permanent Staff Gage #1, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Water Depth (feet)	Observations
6/7/01	17:45	—	—	Localized ponding only.
6/11/01	8:46	6.66	4.76	Reading prior to discharge measurement at bridges
6/11/01	16:27	6.81	4.91	Reading after discharge measurement at bridges
High Water Mark		6.95	5.05	
6/12/01	7:01	6.7	4.8	
6/14/01	13:56	4.39	2.49	Reading taken by Alpine Environmental personnel
6/16/01	13:39	2.79	0.89	

Notes

1. Coordinates for Staff Gage #1 are N5975948.0, E386920.3, Alaska State Plane, Zone 4, NAD 27.
2. Elevations are based on an elevation of 2.16 feet (BPMSL) located at the top of the 1-inch angle iron welded on the 5-inch drill stem staff gage support. Elevations were established by Kuukpik/LCMF Incorporated.
3. Water depths are based on ground elevations that were surveyed by Kuukpik/LCMF Incorporated.

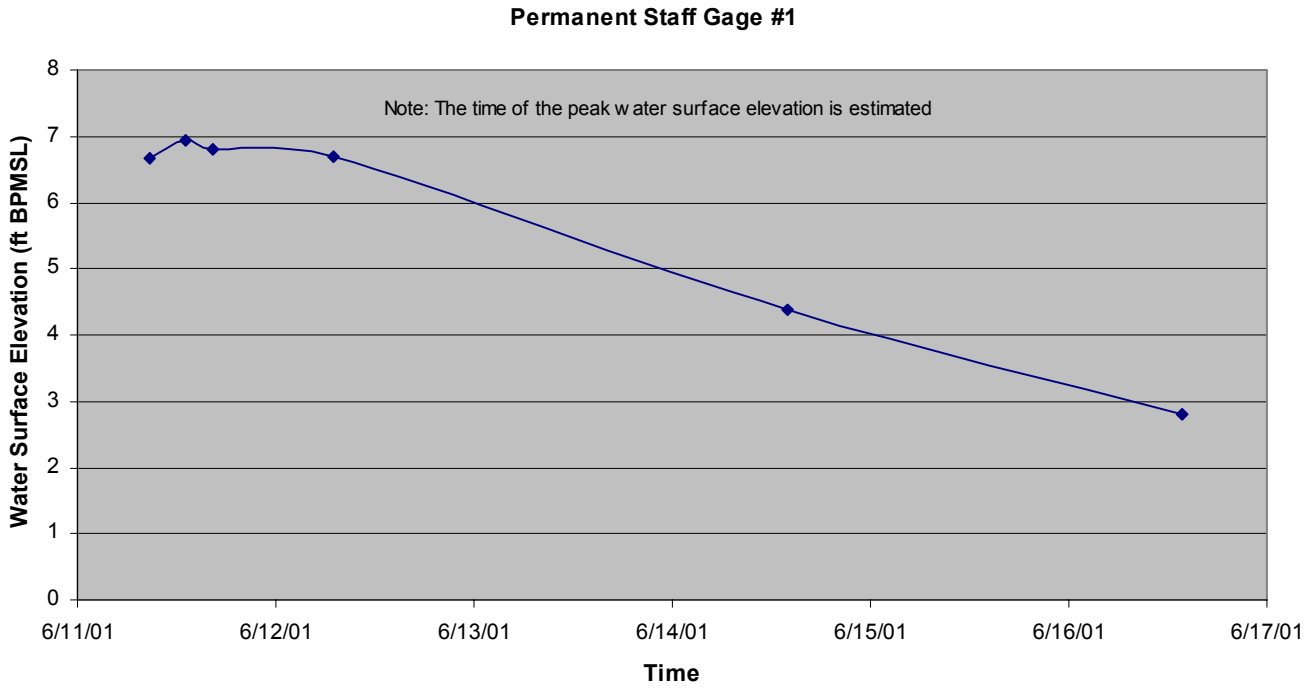

Table 2-2 Permanent Staff Gage #3, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Water Depth (feet)	Observations
6/7/01	17:45	—	—	Localized ponding only.
6/9/01	16:35	7.48	1.58	
6/10/01	7:30	7.49	1.59	
6/10/01	20:15	7.73	1.83	
6/11/01	9:07	7.7	1.8	Reading prior to discharge measurement at bridges
6/11/01	16:58	7.57	1.67	Reading after discharge measurement at bridges
High Water Mark		7.95	2.05	
6/12/01	7:38	6.43	0.53	
6/14/01	—	—	—	Localized ponding only.
6/16/01	—	—	—	Localized ponding only.

Notes

1. Coordinates for Staff Gage #3 are N 5975040.8, E 379259.2, Alaska State Plane, Zone 4, NAD 27.
2. Elevations are based on an elevation of 6.00 feet (BPMSL) located at the top of the 1-inch angle iron welded on the 5-inch drill stem staff gage support. Elevations were established by Kuukpik/LCMF Incorporated.
3. Water depths are based on ground elevations that were surveyed by Kuukpik/LCMF Incorporated.

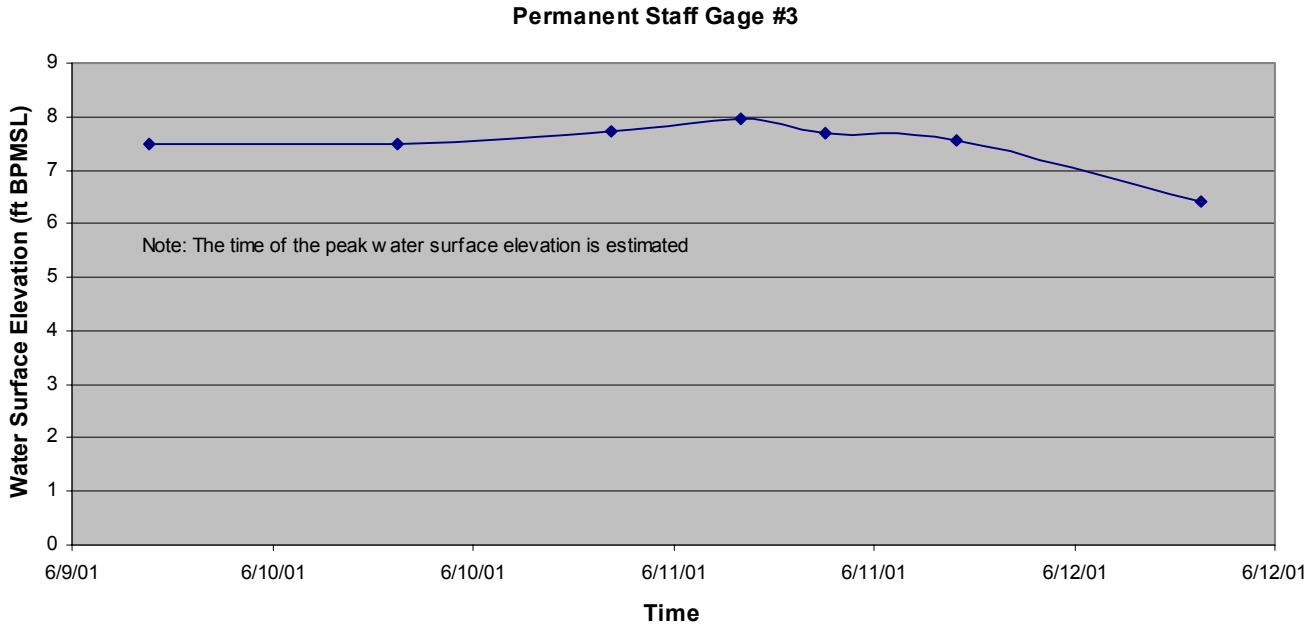

Table 2-3 Permanent Staff Gage #4, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Water Depth (feet)	Observations
6/7/01	17:45	—	—	Localized ponding only.
6/9/01	16:35	6.28	1.28	
6/10/01	7:30	6.50	1.50	
6/10/01	20:15	6.95	1.95	
6/11/01	9:07	7.14	2.14	Reading prior to discharge measurement at bridges.
6/11/01	16:58	7.00	2.00	Reading after discharge measurement at bridges.
High Water Mark		7.22	2.22	
6/12/01	7:40	6.23	1.23	
6/16/01	—	—	—	Localized ponding only.

Notes

1. Coordinates for Staff Gage #4 are N 5975173.9, E 379222.5, Alaska State Plane, Zone 4, NAD 27.
2. Elevations are based on an elevation of 6.47 feet (BPMSL) located at the top of the 1-inch angle iron welded on the 5-inch drill stem staff gage support. Elevations were established by Kuukpik/LCMF Incorporated.
3. Water depths are based on ground elevations that were surveyed by Kuukpik/LCMF Incorporated.

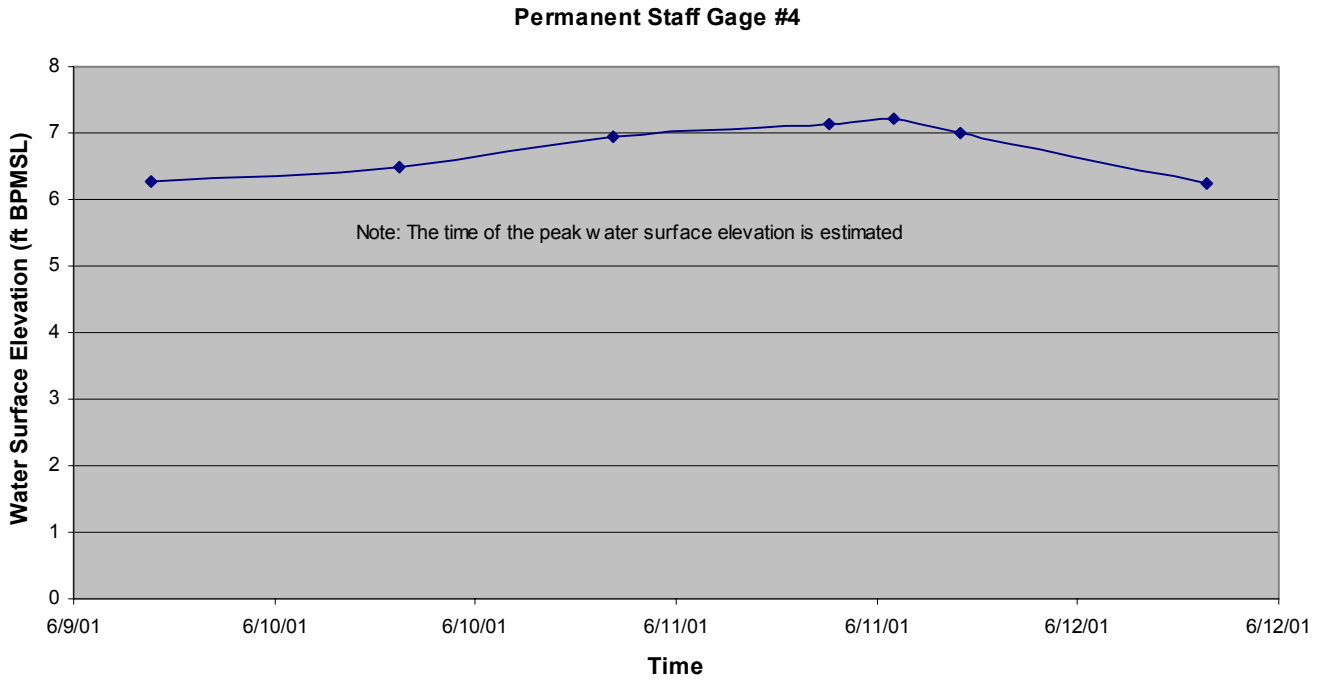

Table 2-4 Permanent Staff Gage #6, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Water Depth (feet)	Observations
6/7/01	17:45	—	—	Localized ponding only.
6/9/01	16:45	7.35	0.65	Localized ponding only.
6/10/01	7:30	7.49	0.79	
6/11/01	9:16	7.78	1.08	Reading prior to discharge measurement at bridges.
6/11/01	17:04	7.77	1.07	Reading after discharge measurement at bridges.
High Water Mark		8.03	1.33	
6/12/01	7:59	7.46	0.76	
6/14/01	14:25	7.22	0.52	Reading taken by Alpine Environmental personnel
6/16/01	—	—	—	Localized ponding only.

Notes

1. Coordinates for Staff Gage #6 are N 5974982.6, E 373555.5, Alaska State Plane, Zone 4, NAD 27.
2. Elevations are based on an elevation of 7.30 feet (BPMSL) located at the top of the 1-inch angle iron welded on the 5-inch drill stem staff gage support. Elevations were established by Kuukpik/LCMFIncorporated.
3. Water depths are based on ground elevations that were surveyed by Kuukpik/LCMFIncorporated.

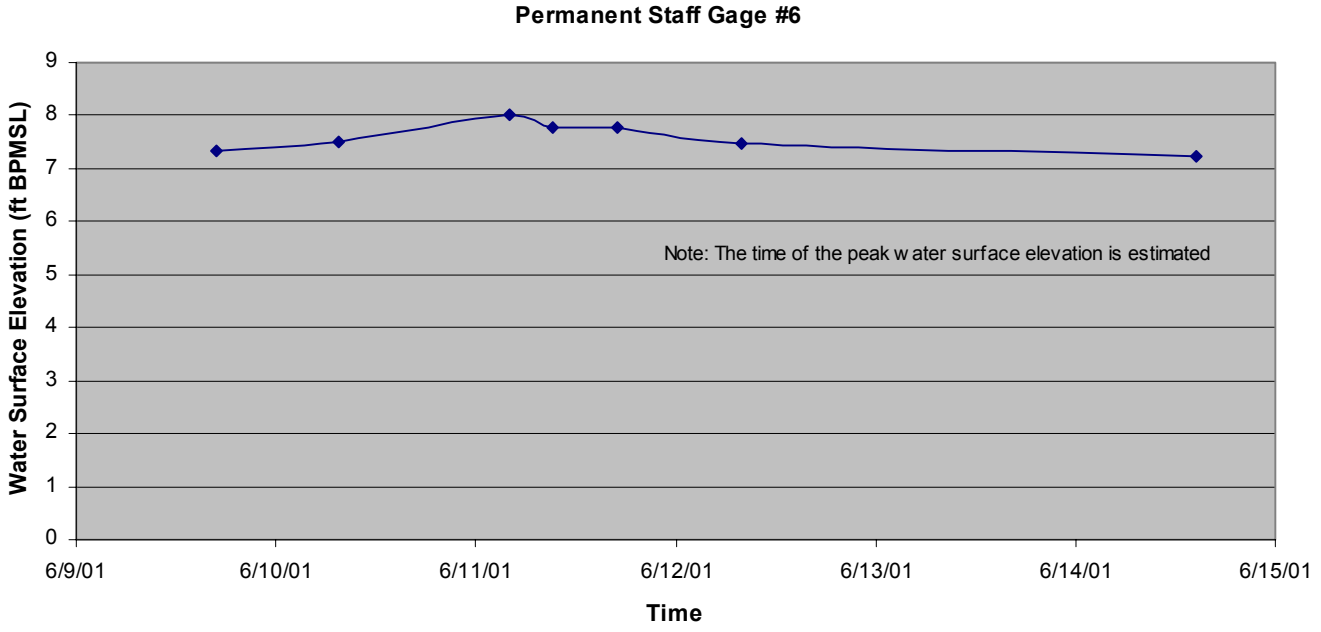

Table 2-5 Permanent Staff Gage #7, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Water Depth (feet)	Observations
6/7/01	17:45	--	--	Localized ponding only.
6/9/01	16:45	7.30	-0.20	Localized ponding only.
6/10/01	7:30	7.45	-0.05	
6/11/01	9:16	7.73	0.23	Reading prior to discharge measurement at bridges.
6/11/01	17:04	7.73	0.23	Reading after discharge measurement at bridges.
High Water Mark		7.84	0.34	
6/12/01	7:56	7.47	-0.03	
6/14/01	--	--	--	Localized ponding only.
6/16/01	--	--	--	Localized ponding only.

Notes

1. Coordinates for Staff Gage #7 are N 5975132.9, E 373586.4, Alaska State Plane, Zone 4, NAD 27.
2. Elevations are based on an elevation of 7.81 feet (BPMSL) located at the top of the 1-inch angle iron welded on the 5-inch drill stem staff gage support. Elevations were established by Kuukpik/LCMFIncorporated.
3. Water depths are based on ground elevations that were surveyed by Kuukpik/LCMFIncorporated.

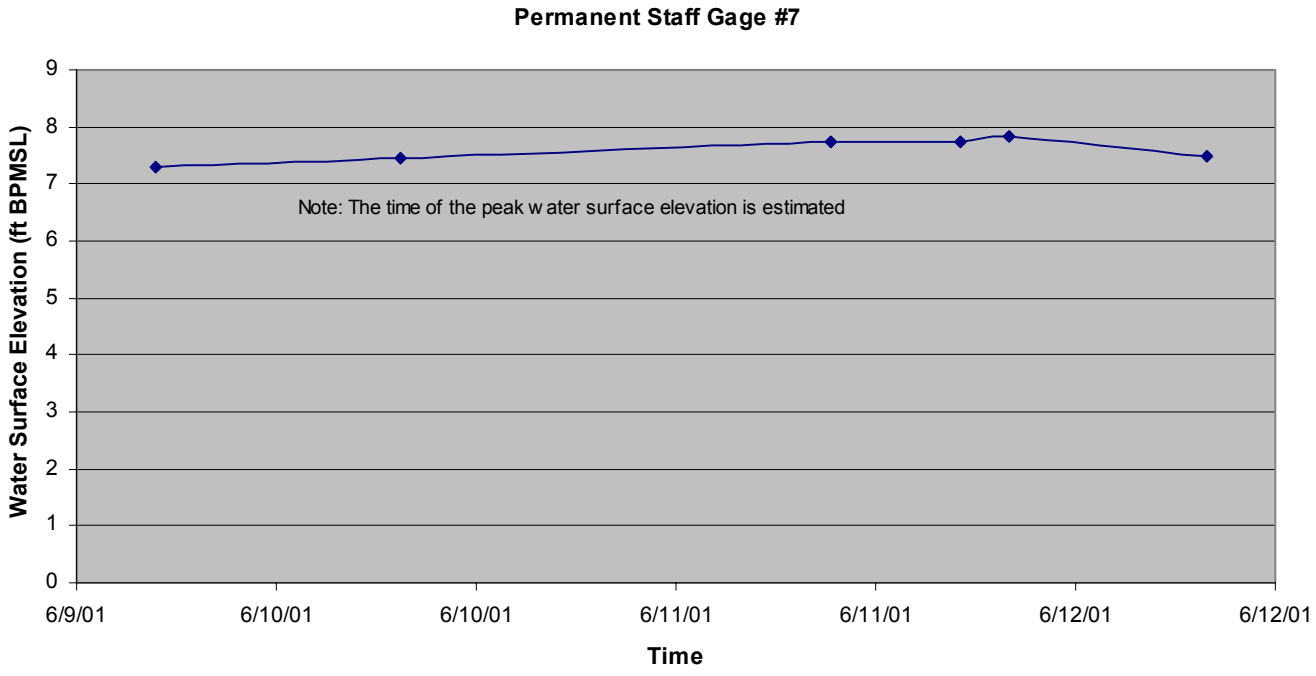

Table 2-6 Permanent Staff Gage #8, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Water Depth (feet)	Observations
6/7/01	17:45	—	—	See Note 3
6/11/01	9:26	—	—	See Note 3
6/11/01	17:15	8.49	—	See Note 3
High Water Mark		8.95	—	See Note 3
6/12/01	8:10	8.50	—	
6/14/01	14:35	8.30	—	Reading taken by Alpine Environmental personnel

Notes

1. Coordinates for Staff Gage #8 are N 5974854.9, E 371261.2, Alaska State Plane, Zone 4, NAD 27.
2. Elevations are based on an elevation of 8.76 feet (BPMSL) located at the top of the 1-inch angle iron welded on the 5-inch drill stem staff gage support. Elevations were established by Kuukpik/LCMFIncorporated.
3. Staff gage is located in snow disposal site. Staff gage was surrounded and influenced by snow for the duration of the monitoring program and readings are not considered representative of the observed breakup conditions.

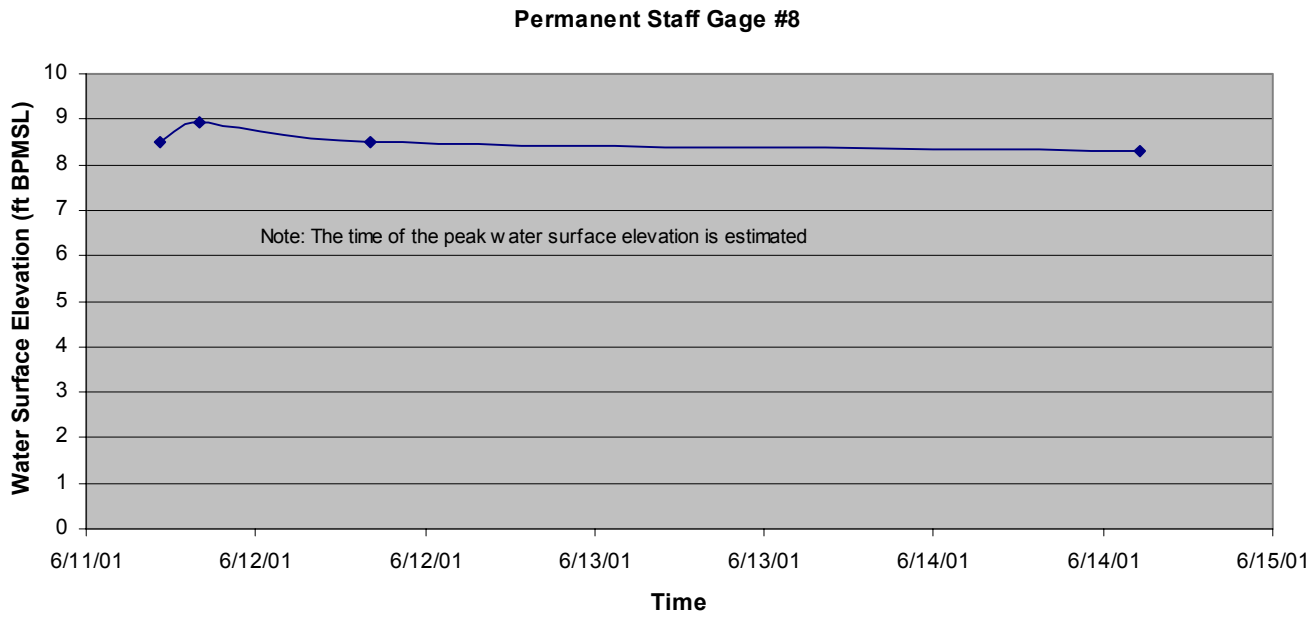

Table 2-7 Permanent Staff Gage #10 (Lake L93-13), Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Observations
6/7/01	17:45	--	Localized ponding only.
6/11/01	8:52	5.95	Reading prior to discharge measurement at bridges.
6/11/01	16:41	7.44	Reading after discharge measurement at bridges.
High Water Mark		7.67	
6/12/01	7:16	7.59	
6/14/01	13:50	6.05	Reading taken by Alpine Environmental personnel
6/16/01	13:45	5.81	

Notes

1. Coordinates for Staff Gage #10 are N 5975797.3, E 385464.0, Alaska State Plane, Zone 4, NAD 27.
2. Elevations are based on an elevation of 13.01 feet (BPMSL) at the punch mark located at the top of the 5-inch drill stem staff gage support. Elevations were established by Kuukpik/LCMFIncorporated.
3. Water depths are based on ground elevations that were surveyed by Kuukpik/LCMFIncorporated.

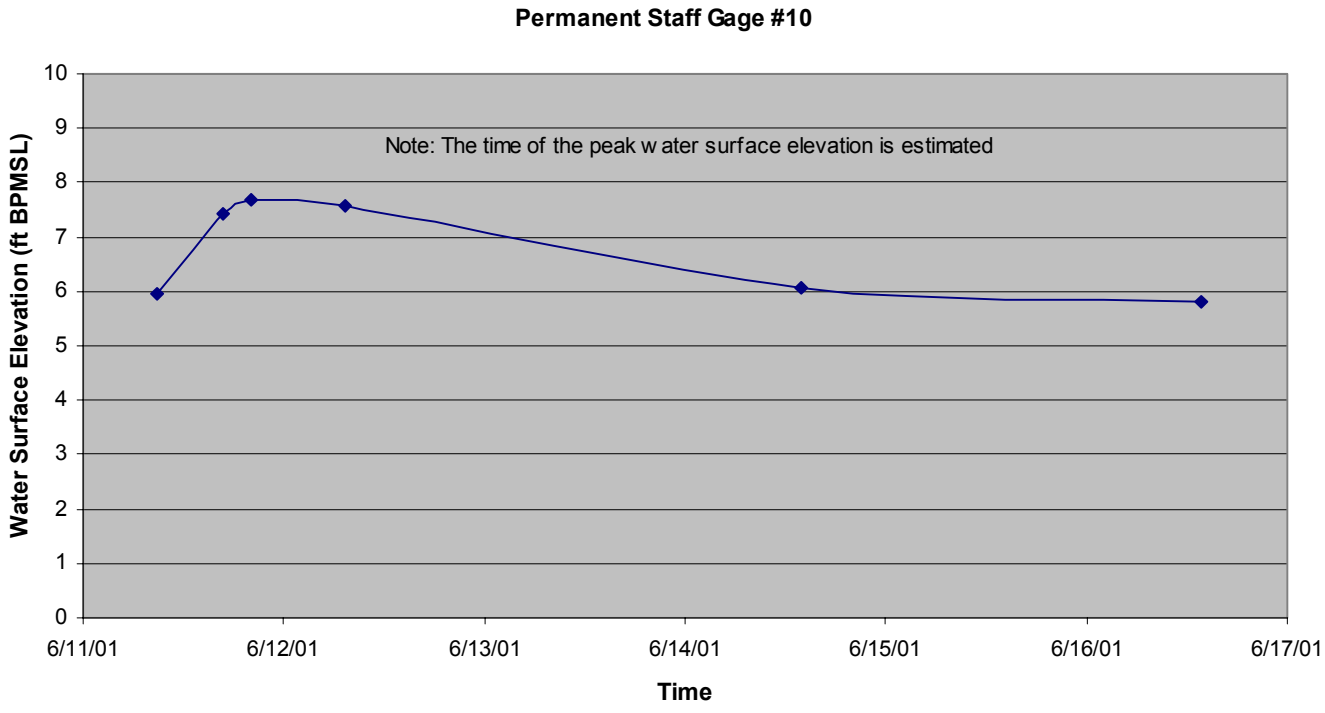

Table 2-8 Monument 01, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet)	Observations
6/6/01	14:26	11.67	Channel ice still intact along right bank. Small ice chunks floating in water near left bank.
6/7/01	7:42	12.43	Channel ice intake on right bank. Snow on left bank at water surface becoming saturated. Ice chunks floating in channel near gages.
6/7/01	15:02	12.46	Channel ice intake on right bank. Snow on left bank at water surface becoming saturated. Ice chunks floating in channel near gages.
6/7/01	18:44	12.55	Channel ice intact on right bank. Some floating ice chunks.
6/8/01	8:49	12.96	Channel ice intact along right bank.
6/8/01	16:02	13.51	Channel ice intact along right bank.
6/9/01	7:56	14.34	Channel ice intact along right bank.
6/9/01	14:10	14.96	Ice chunks floating among gages.
High Water Mark		17.37	The peak water surface elevation probably occurred the morning of 10 June
6/10/01	12:00	17.01	
6/10/01	17:55	16.52	
6/11/01	8:17	14.18	Channel ice has cleared. Ice chunks floating through section.
6/12/01	9:13	13.45	Ice chunks floating through section.
6/13/01	12:30	13.00	

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 2901 feet. The distance from Monument 01 to TBM 01D is 2928 feet.
3. GPS coordinates for Monument 01 are N70°09′50.3″ W150°056′12.7″ (NAD 27), which were surveyed by Lounsbury & Associates.

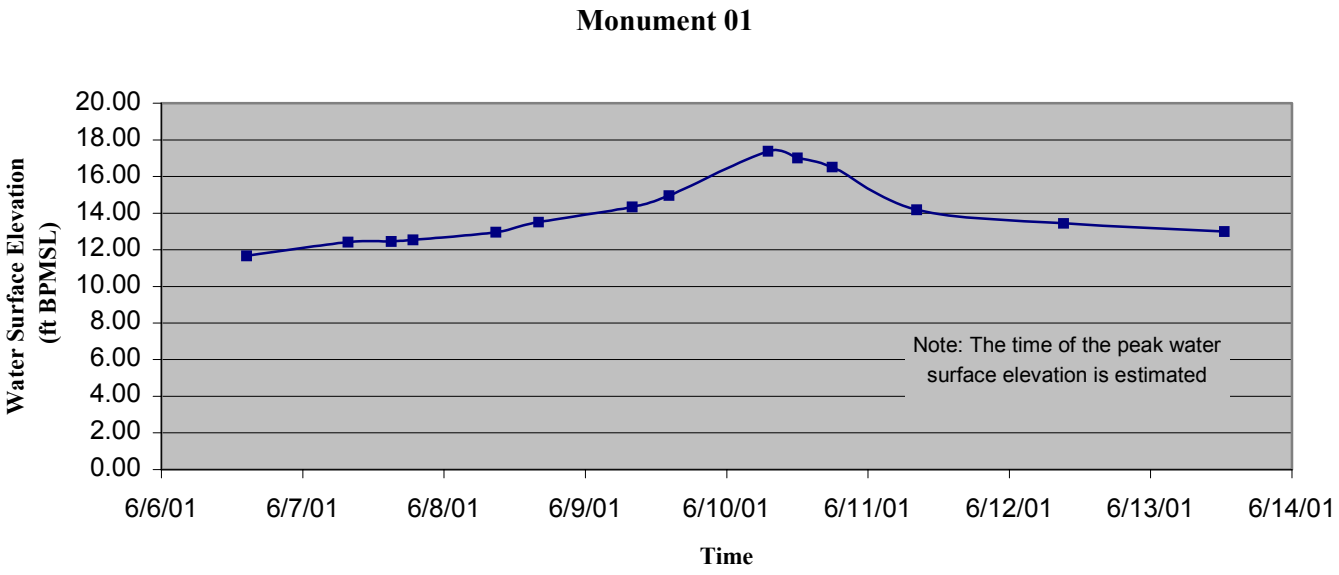

Table 2-9 Temporary Benchmark 01U, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet)	Observations
6/6/01	14:34	12.01	Channel ice still intact along right bank. Small ice chunks floating in water near left bank.
6/7/01	7:28	12.76	Channel ice intact on right bank. Snow on left bank at water surface becoming saturated. Ice chunks floating in channel near gages.
6/7/01	14:55	12.78	Channel ice intact on right bank. Snow on left bank at water surface becoming saturated. Ice chunks floating in channel near gages.
6/7/01	18:38	12.89	Channel ice intact on right bank. Some floating ice chunks.
6/8/01	8:00	13.66	Channel ice intact along right bank.
6/8/01	15:56	14.26	Channel ice intact along right bank.
6/9/01	7:51	15.34	Channel ice intact along right bank.
6/9/01	14:35	15.54	Water elevation surveyed. Ice chunks floating in channel. Channel ice intact along right bank.
High Water Mark		17.88	The peak water surface elevation probably occurred the morning of 10 June
6/10/01	11:10	17.22	Channel ice along right bank breaking up. Appears peak may have occurred, good high water indicators.
6/10/01	18:18	16.71	Water apparently receding. Less floating chunks of ice.
6/11/01	7:49	14.56	Channel ice has cleared. Ice chunks floating through section. Some grounded ice along left bank.
6/12/01	8:55	13.89	Ice chunks floating through section.
6/13/01	12:00	13.44	

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 2901 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 II Plus hand-held global positioning system.

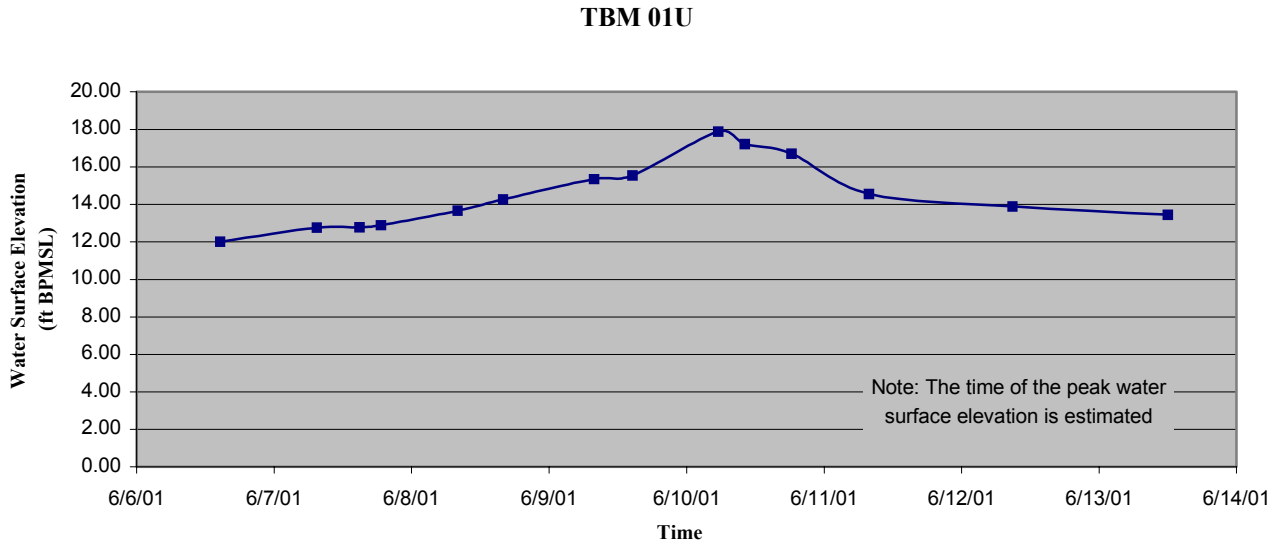

Table 2-10 Temporary Benchmark 01D, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet)	Observations
6/7/01	7:49	12.05	Channel ice intact on right bank. Snow on left bank at water surface becoming saturated. Ice chunks floating in channel near gages.
6/7/01	15:07	12.09	Channel ice intact on right bank. Snow on left bank at water surface becoming saturated. Ice chunks floating in channel near gages.
6/7/01	18:48	12.14	Channel ice intact on right bank. Some floating ice chunks.
6/8/01	8:55	12.76	Channel ice intact along right bank.
6/8/01	16:10	13.27	Channel ice intact along right bank.
6/9/01	8:05	14.05	Channel ice intact along right bank.
6/9/01	15:00	14.47	Ice chunks floating through gages.
High Water Mark		16.98	The peak water surface elevation probably occurred the morning of 10 June
6/10/01	12:44	16.72	Channel ice along right bank breaking up. Appears peak may have occurred, good high water marks on shoreline.
6/10/01	18:25	16.28	
6/11/01	8:39	13.70	Channel ice has cleared. Ice chunks floating through section.
6/12/01	9:38	12.97	
6/13/01	12:30	12.54	

Notes

1. Elevations are based on an elevation of 27.74 feet BPMSL for Monument 1, established by Lounsbury & Associates in 1996.
2. The distance from Monument 01 to TBM 01D is 2928 feet.
3. GPS coordinates for TBM 01D are N70°10′26.6″ W150°56′01.6″ (NAD 27), which were obtained with a Garmin GPS II Plus hand-held global positioning system.

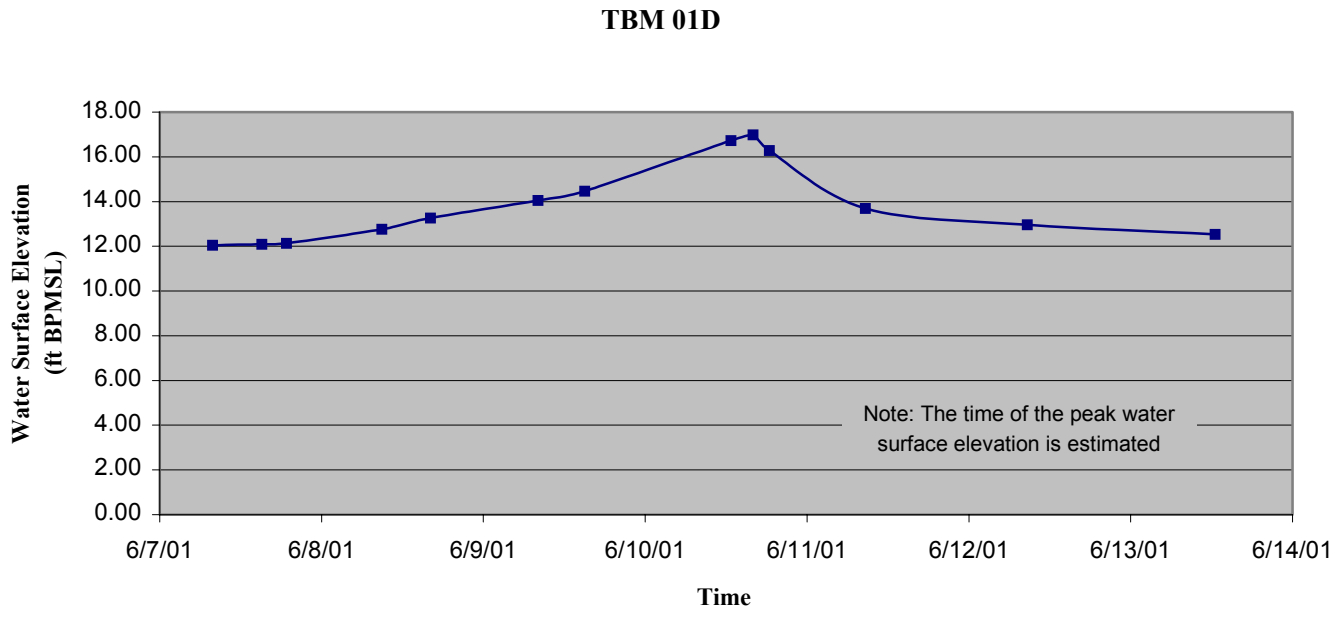

Table 2-11 Monument 12, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet)	Observations
6/6/01	15:22	7.81	Channel ice still intact.
6/7/01	8:00	8.38	Channel ice intact along left bank. Small amount of ice chunks floating in channel.
6/8/01	9:06	8.86	Channel ice intact on opposite bank. No visible floating ice chunks.
6/9/01	8:20	9.80	Channel ice intact on opposite bank. No visible floating ice chunks.
6/9/01	15:26	10.05	Channel ice intact on opposite bank. No visible floating ice chunks.
6/10/01	13:36	11.36	Water has risen two-hundredths in 10 minutes. Large floes overriding each other in the channel. Snow on east bank completely saturated.
High Water Mark		11.94	The peak water surface elevation occurred the afternoon of 10 June.
6/11/01	9:05	10.52	Lots of standed ice chunks on bank. Channel ice has cleared.
6/12/01	9:55	8.54	Ice chunks up to 30' in diameter and 5' thick stranded on bank.
6/13/01	13:55	7.80	

Notes

1. Elevations are based on an elevation of 14.60 feet BPMSL for Monument 12, established by Lounsbury & Associates in 1996.
2. GPS coordinates for Monument 12 are N70°14′58.3″ W51°01′23.50″ (NAD 27), which was surveyed by Lounsbury & Associates.
3. Staff gages were set on opposite bank from Monument 12.

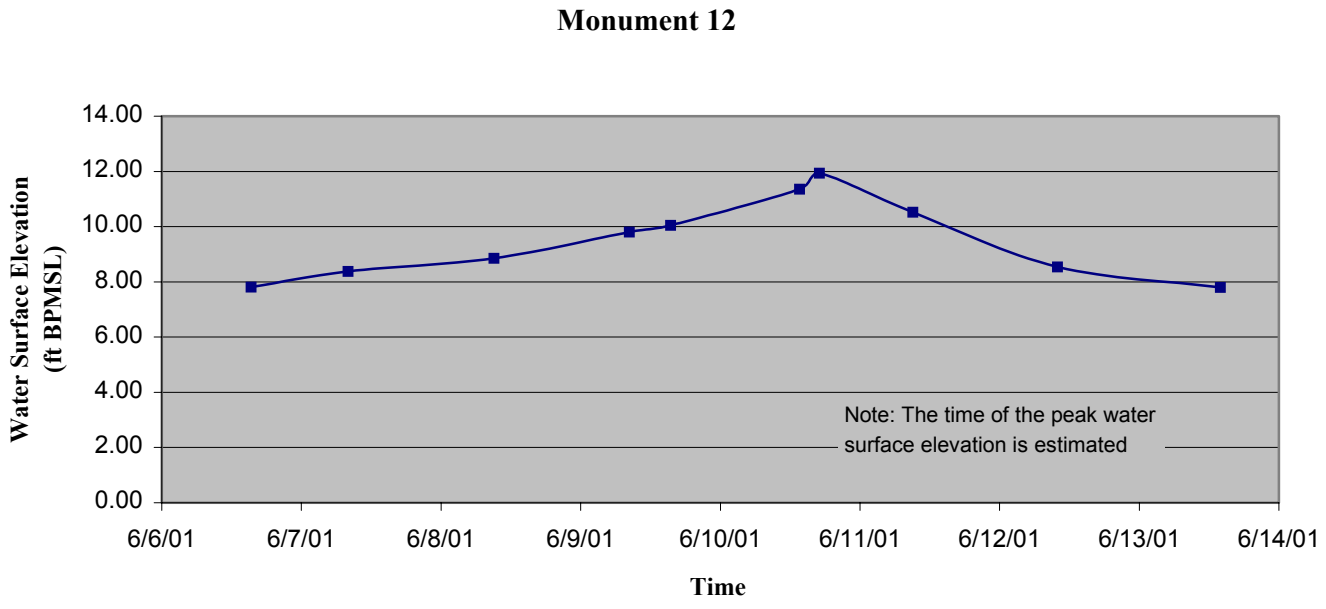

Table 2-12 Temporary Benchmark 20N Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet)	Observations
6/6/01	15:39	5.69	Channel ice intact.
6/7/01	8:11	6.83	Channel ice intact. Water is filling low channel along east bank.
6/8/01	9:18	7.54	Channel ice intact.
6/9/01	8:35	8.47	Channel ice intact.
6/9/01	8:44	8.47	Ice chunks in reach.
6/9/01	15:42	8.67	Ice chunks in reach.
6/10/01	13:58	8.99	Large ice floes floating past and through reach.
High Water Mark		10.16	
6/11/01	9:14	9.54	Grounded ice chunks on channel banks upstream and downstream. Snow on east bank gone.
6/12/01	10:16	7.59	Grounded ice chunks on banks.
6/13/01	14:15	6.48	

Notes

1. Elevations are based on an elevation of 19.17 feet BPMSL for Monument 20, established by Lounsbury & Associates in 1996.
2. GPS coordinates for TBM 20N are N70°17′29.0″ W150°59′57.8″ (NAD 27), which were obtained with a Garmin GPS II Plus hand-held global positioning system.

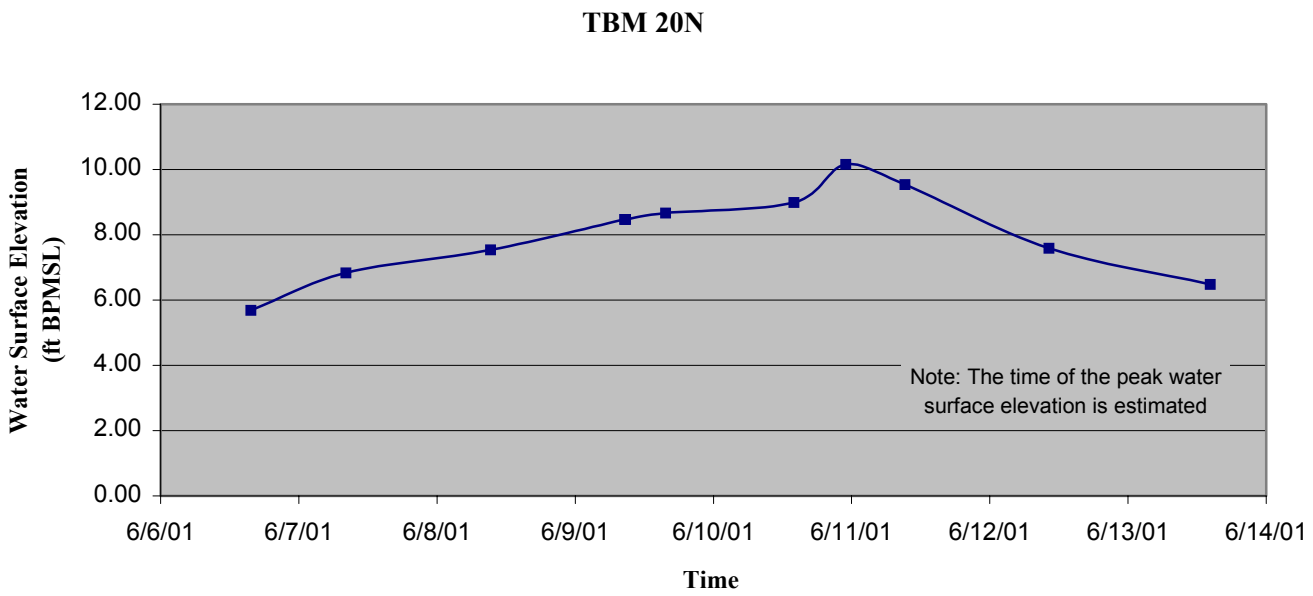

Table 2-13 Monument 22, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet)	Observations
6/6/01	9:54	4.30	
6/6/01	15:49	4.72	Channel ice intact on right bank.
6/7/01	8:20	5.83	Channel ice intact on right bank.
6/8/01	8:20	6.40	Channel ice intact on right bank.
High Water Mark		8.80	Estimated high water. See Note 2.
6/11/01	9:32	7.83	Channel is open. Ice chunks floating through reach.
6/12/01	10:24	6.31	Channel clear of ice.

Notes

1. Elevations are based on an elevation of 10.13 feet BPMSL for Monument 22, established by Lounsbury & Associates in 1996.
2. GPS coordinates for Monument 22 are N70°19′06.3″ W151°03′10.4″ (NAD 27), which were surveyed by Lounsbury & Associates.
3. Definitive high water marks were not available at Monument 22. Peak water surface elevation shown is an estimate.

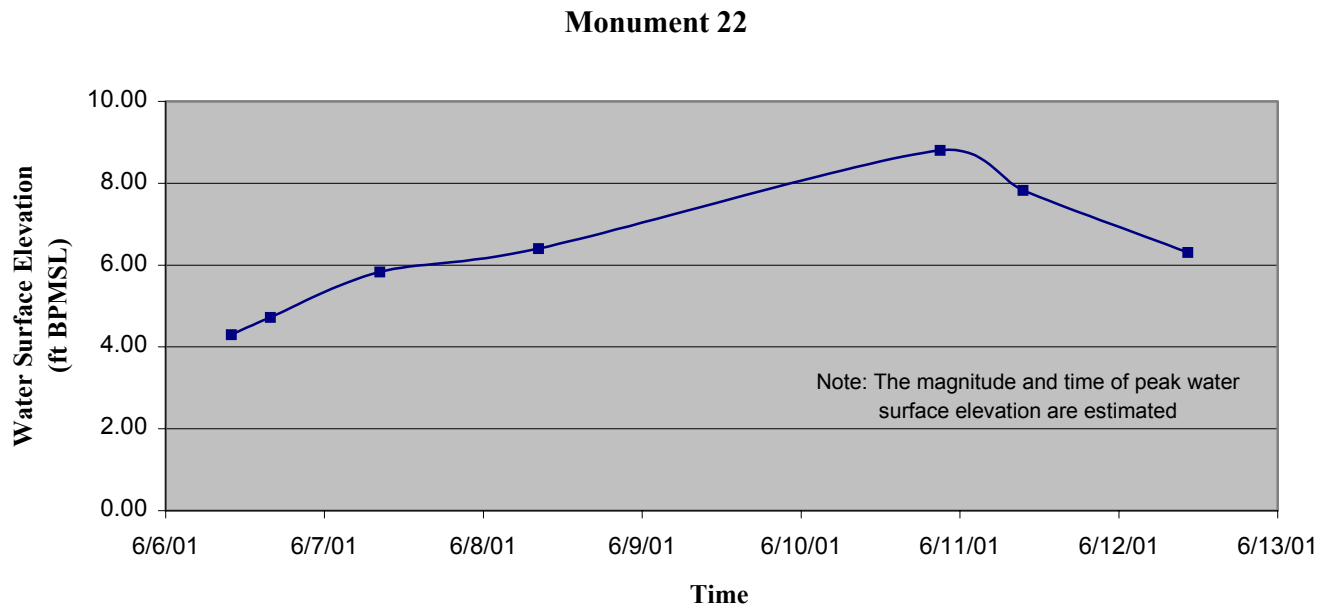

Table 2-14 Monument 28 Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet)	Observations
6/6/01	16:04	2.53	Some floating ice.
6/7/01	8:33	2.82	Very little floating ice observed in channel.
6/8/01	9:34	2.94	Channel ice is clear.
6/9/01	9:02	3.18	Channel ice is clear.
6/9/01	15:56	3.18	
6/10/01	14:14	3.53	
6/11/01	9:43	3.83	
6/12/01	10:43	3.66	
6/13/01	14:50	2.53	

Notes

1. Elevations are based on an elevation of 3.66 feet BPMSL for Monument 28, established by Lounsbury & Associates in 1998.
2. GPS coordinates for Monument 28 are N70°25′33.2″ W151°03′49.6″ (NAD 27), which were surveyed by Lounsbury & Associates.
3. Staff gages destroyed the evening of 10 June. No high water mark available. All readings from 11 June and after were surveyed from Monument 28.

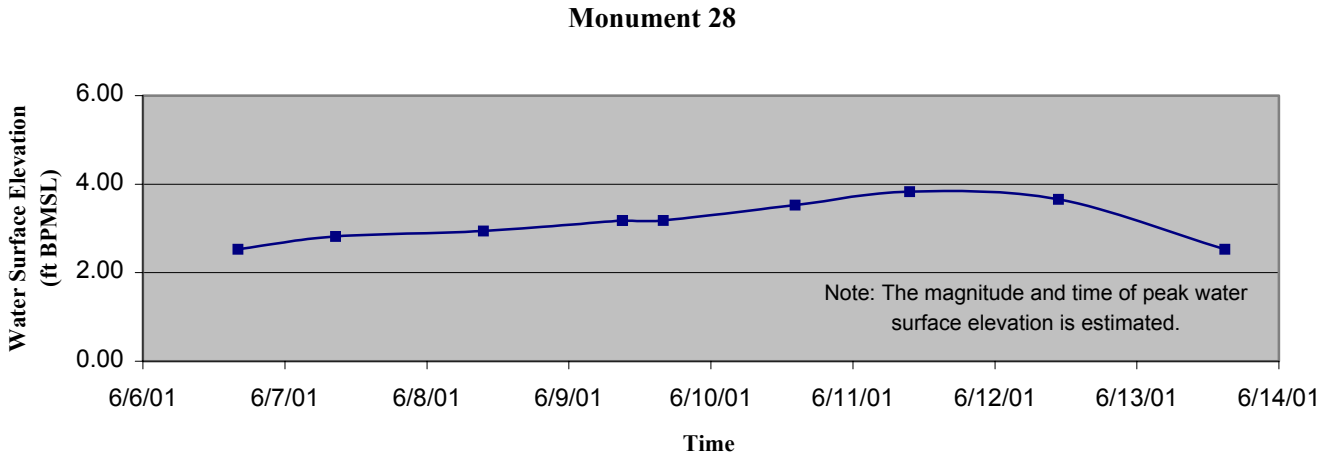

Table 2-15 Measured and Maximum Likely Depth, Velocity, and Discharge in Alpine Drainage Structures

Structure	Field Measurement				Maximum Likely Peak			
	Date	Water Depth (ft)	Average Velocity (ft/s)	Discharge (cfs)	Date	Water Depth (ft)	Average Velocity (ft/s)	Discharge (cfs)
62-ft Swale Bridge	6/11/01	6.0 (ave.)	1.8	600	6/11/01	6.1 (ave.)	1.8	620
452-ft Swale Bridge	6/11/01	3.3 (ave.)	2.4	3700	6/11/01	3.5 (ave.)	2.4	3900
Culvert C-1	6/11/01	2.5	3.76	31.1	6/11/01	2.84	4.89	46.6
Culvert C-2	6/11/01	2.5	4.41	36.4	6/11/01	2.65	4.98	44.0
Culvert C-3	6/11/01	1.8	5.13	28.1	6/11/01	1.98	5.04	31.3
Culvert C-4	6/11/01	1.8	4.06	22.2	6/11/01	1.94	4.35	26.3
Culvert C-5	6/11/01	1.0	4.5	11.0	6/11/01	0.99	4.75	11.5
Culvert C-6	6/11/01	No flow			6/11/01	No flow		
Culvert C-7	6/11/01	No flow			6/11/01	No flow		
Culvert C-8	6/11/01	No flow			6/11/01	No flow		
Culvert C-9	6/11/01	No flow			6/11/01	No flow		
Culvert C-10	6/11/01	1.1	0.85	2.4	6/11/01	1.11	2.66	7.6
Culvert C-11	6/11/01	No flow			6/11/01	No flow		
Culvert C-12	6/11/01	No flow			6/11/01	No flow		
Culvert C-13	6/11/01	No flow			6/11/01	No flow		
Culvert C-14	6/11/01	No flow			6/11/01	No flow		
Culvert C-15	6/11/01	No flow			6/11/01	No flow		
Culvert C-16	6/11/01	No flow			6/11/01	No flow		
Culvert C-17	6/11/01	No flow			6/11/01	No flow		
Culvert C-18	6/11/01	2.7	0.83	7.5	6/11/01	2.49	2.30	18.9
Culvert C-19	6/11/01	2.7	0.99	8.9	6/11/01	2.56	2.23	19.0
Culvert C-20	6/11/01	2.6	1.12	9.7	6/11/01	2.45	2.36	19.0
Culvert C-21	6/11/01	2.7	0.92	8.3	6/11/01	2.57	2.21	18.9
Culvert C-22	6/11/01	2.2	1.62	11.6	6/11/01	2.12	2.27	15.3
Culvert C-23	6/11/01	1.5	1.9	8.2	6/11/01	1.46	2.47	10.3
Culvert C-24	6/11/01	1.5	1.98	8.5	6/11/01	1.42	2.68	10.7
Culvert C-25	6/11/01	No flow			6/11/01	No flow		
Culvert C-26	6/11/01	No flow			6/11/01	No flow		

Notes

1. See Figure 2-4 for culvert and bridge site plan.
2. Culvert numbering system is based on CD-2 access road as-built survey, Kuupik/LCMF, 12/3/2000
3. It is estimated that the peak discharge and peak velocity occurred between the evening of June 11 and the morning of June 12.
4. The maximum likely peak discharge and velocity estimate for the culverts are based on a clean culvert barrel. Culverts C-6 through C-9, C-11 through C-17, C-25, and C-26 contained snow after the flood peak had receded.

Table 2-16 Summary of Breakup Data Obtained at the Head of the Colville River Delta, 1962 – 2001

Year	Approximate Date Water Began to Flow	Peak Water Surface Elevation (ft)	Date of Peak Water Surface Elevation	Peak Breakup Discharge (cfs)	Notes
2001	5 June	17.37	10 June	300,000	1
2000	8 June	19.33	11 June	580,000	1, 2
1999	22 May	13.97	30 May	203,000	1, 3, 4
1998	21 May	18.11	29 May	213,000	1, 5
1997	20 May	15.05	29 May	177,000	1
1996	15 May	17.19	26 May	160,000	1, 6
1995	8 May	15.7	16 May	233,000	7
1994	16 May	13.0	25 May	159,000	7
1993	–	20.0	31 May	379,000	7
1992	–	14.7	2 June	188,000	7
1977	–	19.9	7 June	407,000	7
1973	25 May	–	8 June	–	7
1971	23 May	–	2 June	–	7
1964	28 May	–	3 June	–	7
1962	19 May	13.2	14 June	215,000	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. Data from Michael Baker, Jr., Inc., 2000, Alpine Facilities Spring 2000 Breakup Monitoring and Hydrologic Assessment. Prepared for Phillips Alaska, Inc., Anchorage.
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.

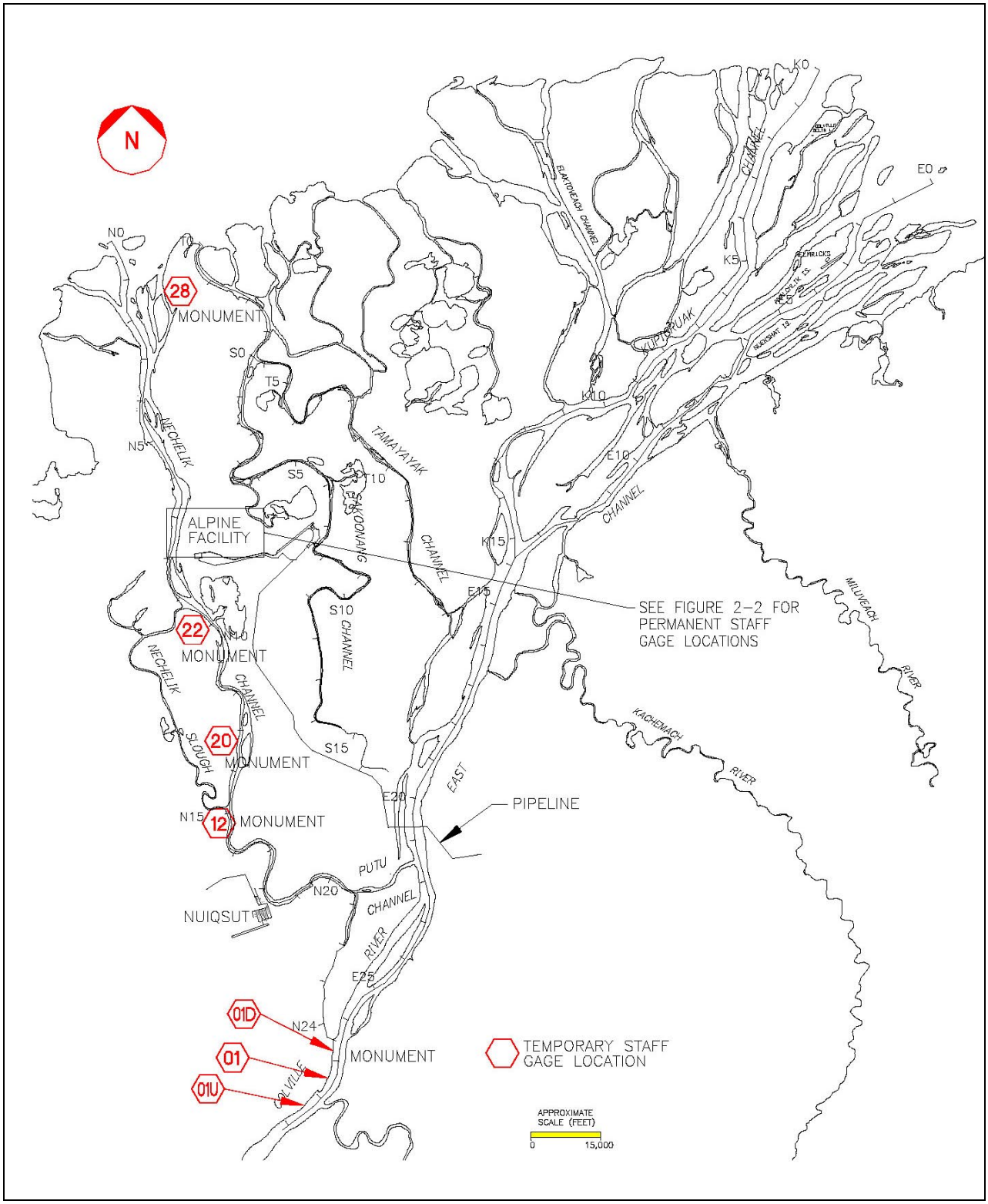

Figure 2-1 Temporary Staff Gage Locations

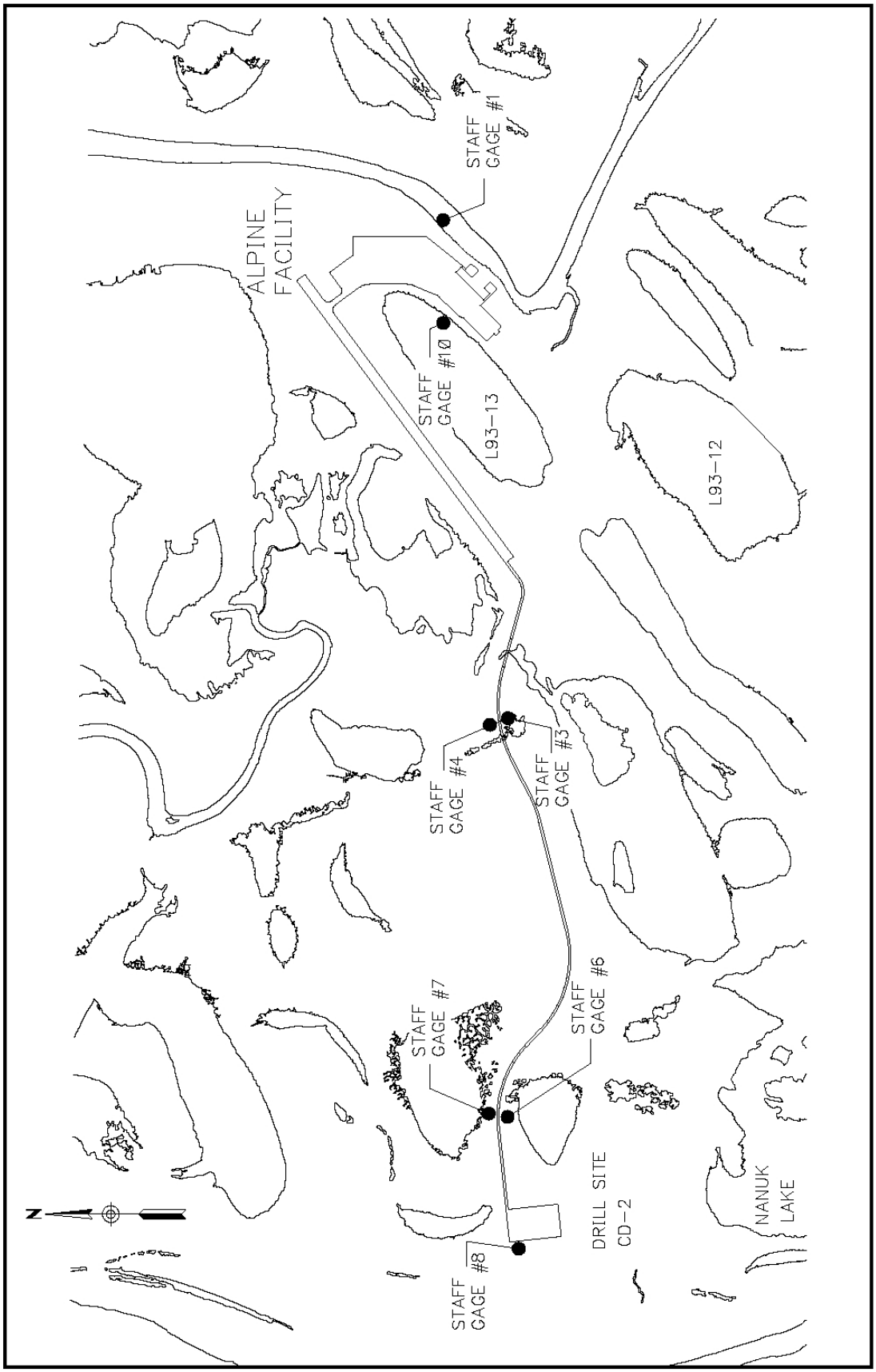

Figure 2-2 Permanent Staff Gage Locations

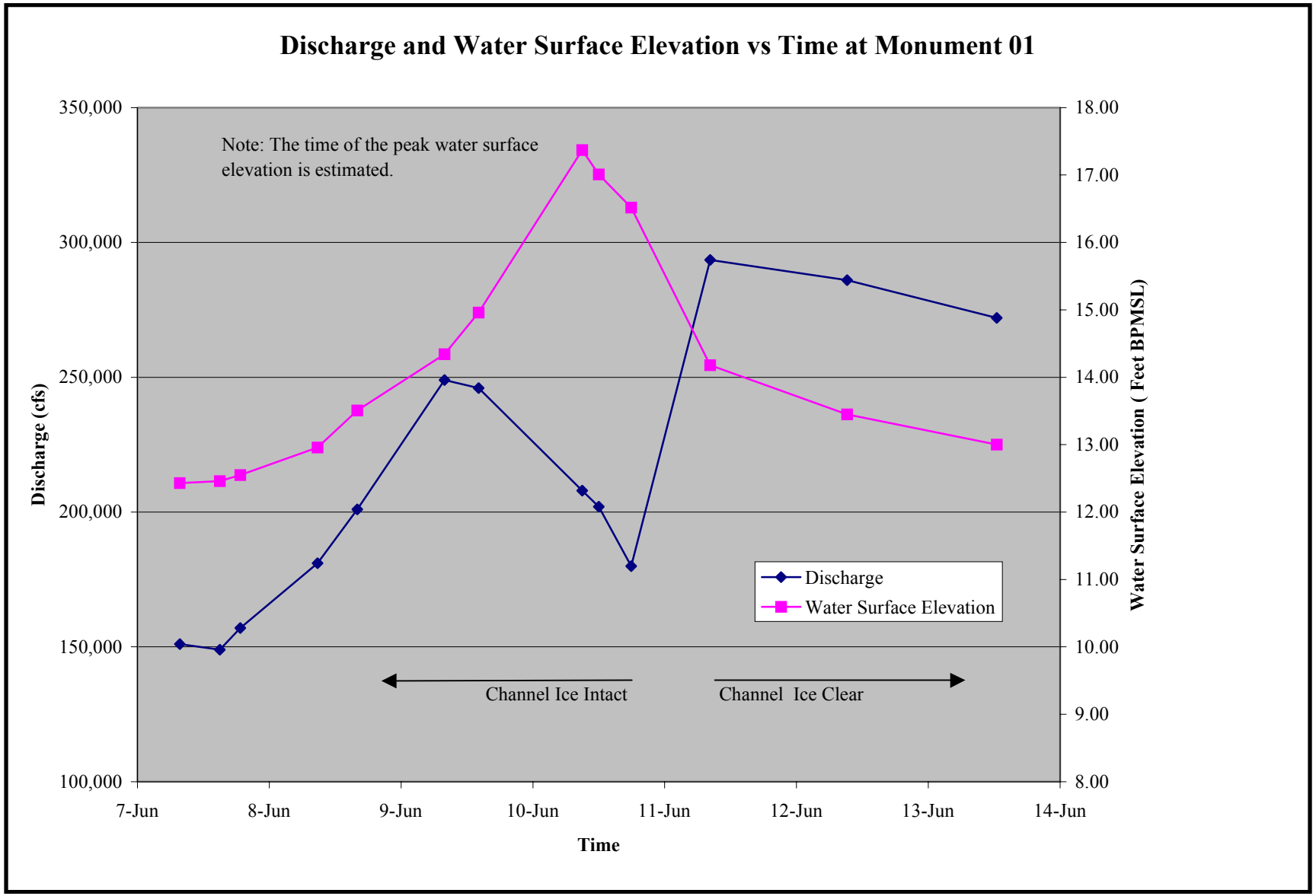

Figure 2-3 Discharge and Water Surface Elevation at Monument 01.

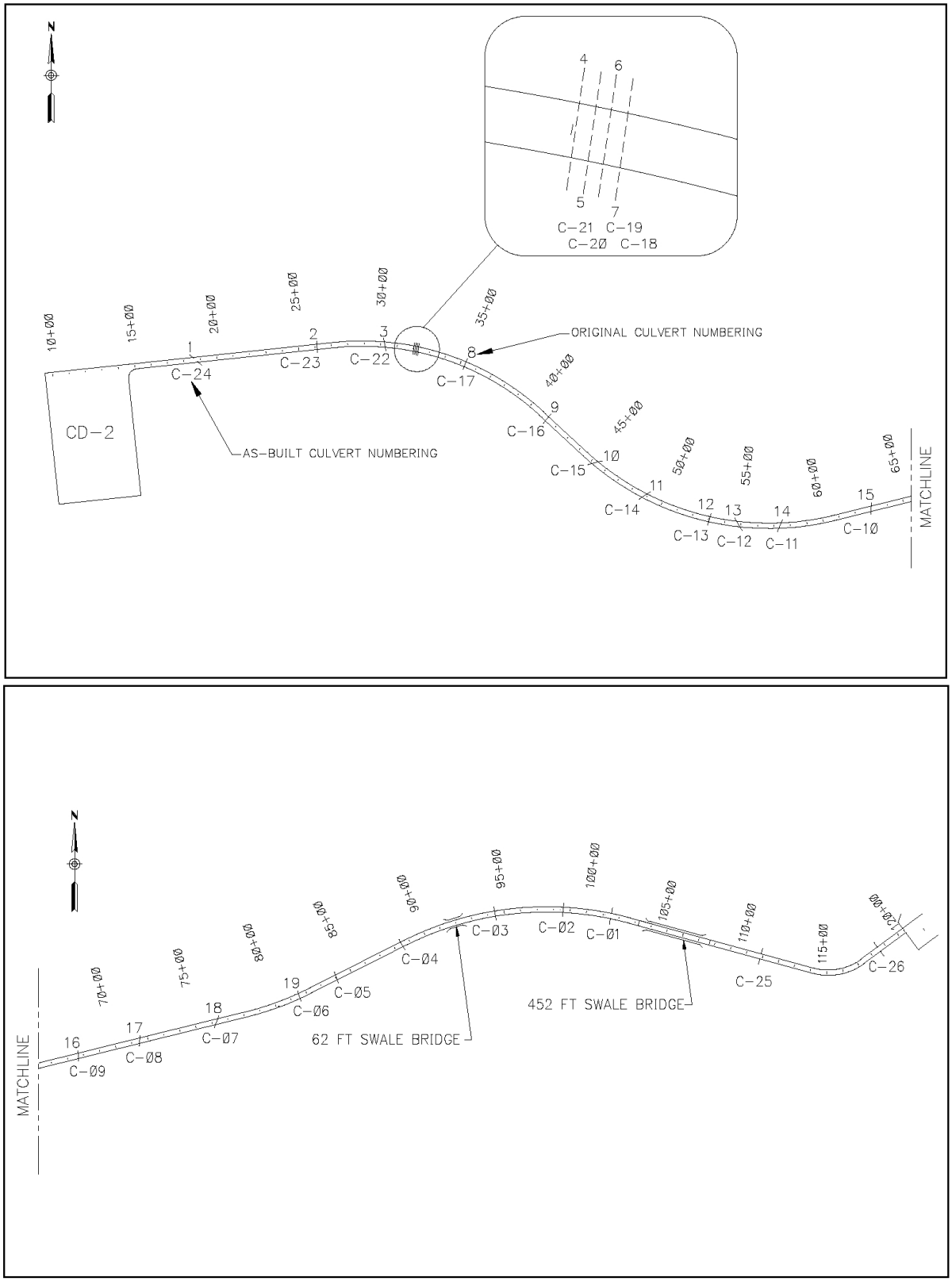

Figure 2-4 Alpine Facility Culvert Locations and Naming Convention

Photo 2-1 a Flooding Conditions at Alpine June 11, 2001, looking southwest at CD-1.

Photo 2-1 b Flooding Conditions at Alpine June 11, 2001, looking north at CD-1.

Photo 2-1 c Flooding Conditions at Alpine June 11, 2001, looking south-southwest at the end of the airstrip.

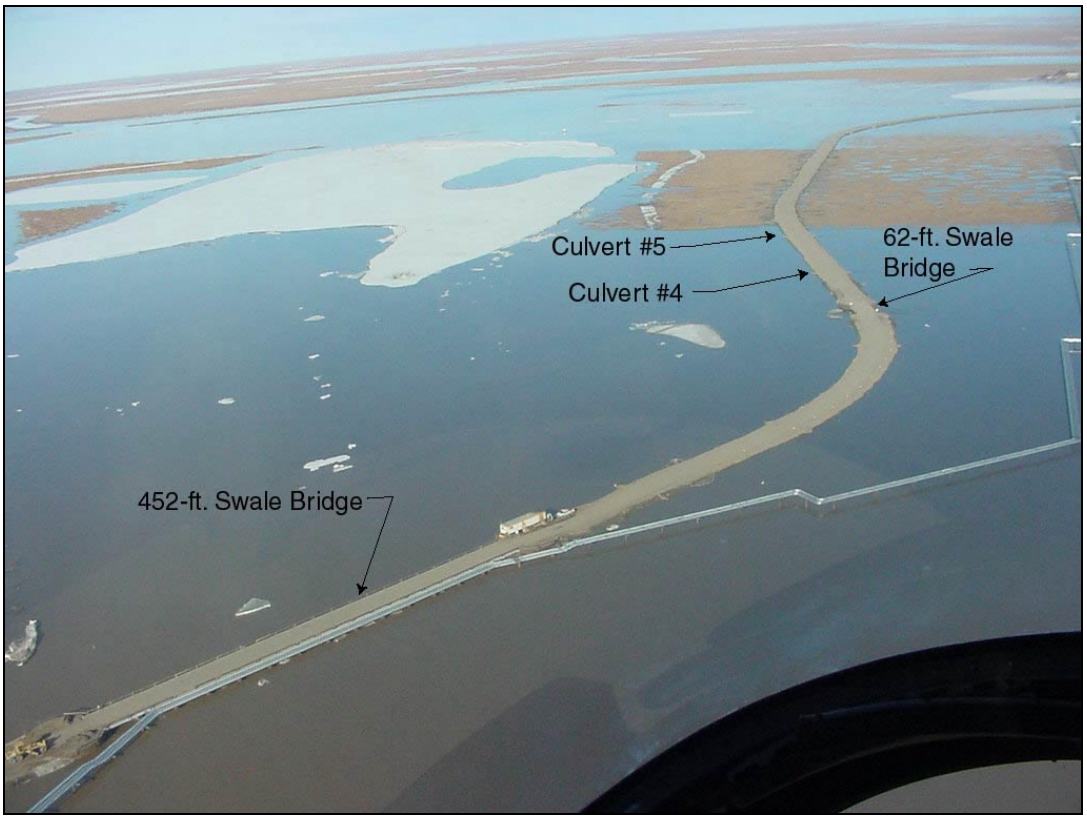

Photo 2-1 d Flooding Conditions at Alpine June 11, 2001, looking southwest along the CD-2 access road.

Photo 2-1 e Flooding Conditions at Alpine June 11, 2001, looking west along the CD-2 access road.

Photo 2-1 f Flooding Conditions at Alpine June 11, 2001, looking southwest at CD-2.

Photo 2-2 a Flooding Conditions at Alpine June 12, 2001, looking west.

Photo 2-2 b Flooding Conditions at Alpine June 12, 2001, looking southwest.

Photo 2-2 c Flooding Conditions at Alpine June 12, 2001, looking southwest.

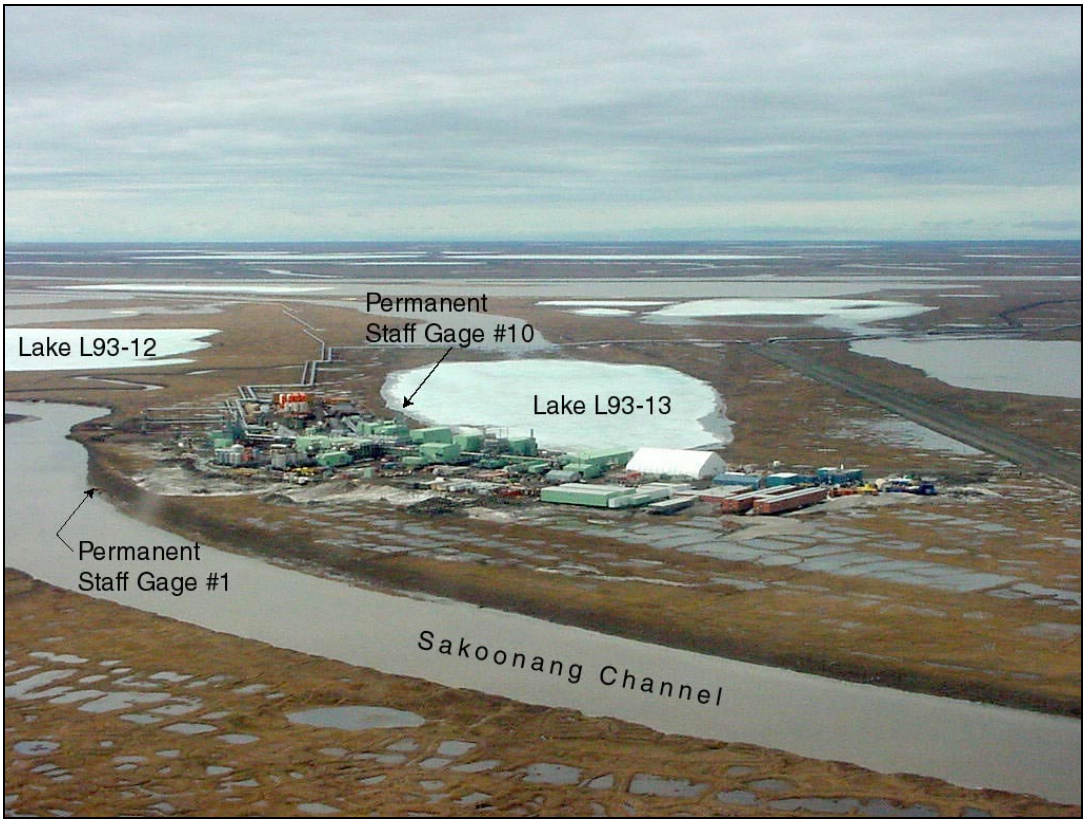

Photo 2-3 a Flooding Conditions at Alpine June 14, 2001, looking southwest.

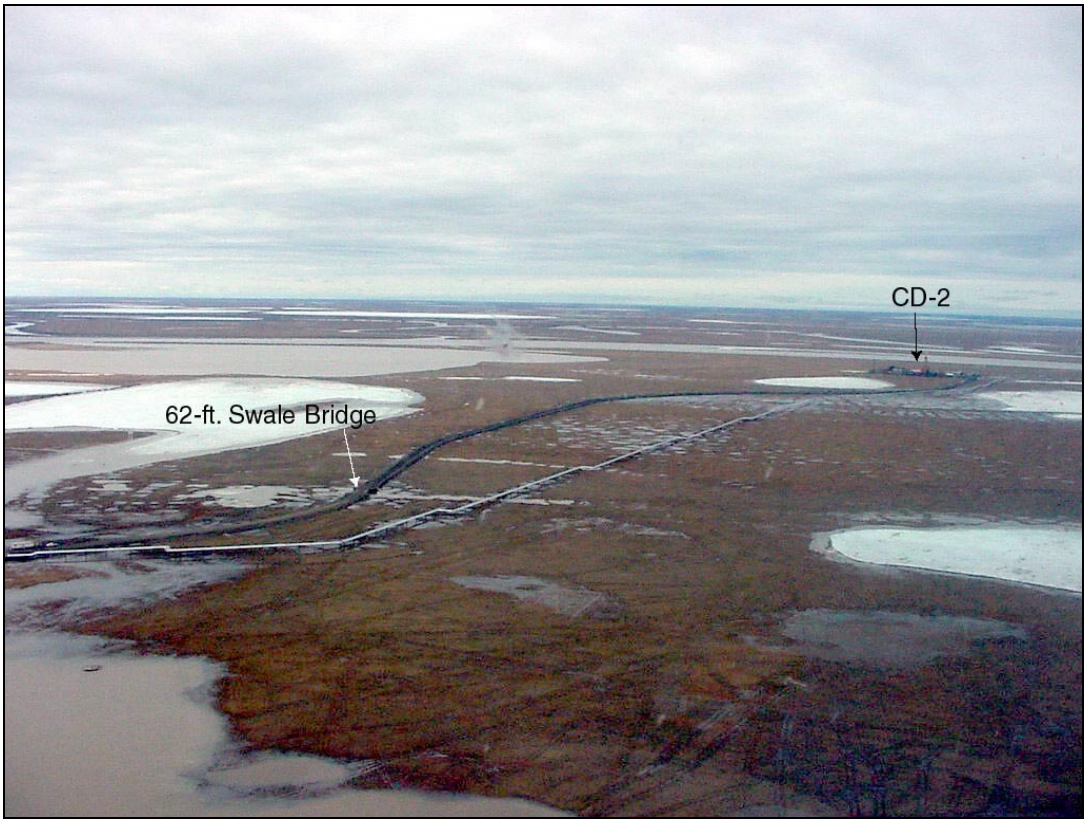

Photo 2-3 b Flooding Conditions at Alpine June 14, 2001, looking west.

Photo 2-3 c Flooding Conditions at Alpine June 14, 2001, looking southwest at the 62-ft. swale bridge.

Photo 2-3 d Flooding Conditions at Alpine June 14, 2001, looking northeast at the 452-ft. swale bridge and airstrip.

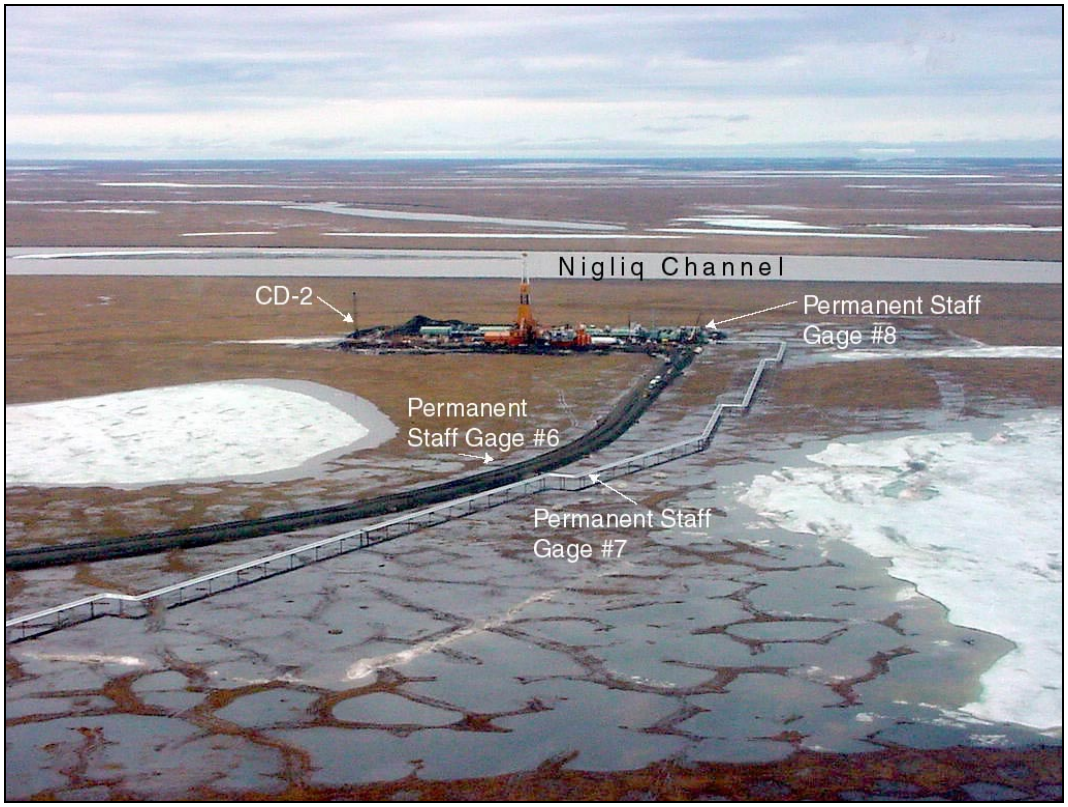

Photo 2-3 e Flooding Conditions at Alpine June 14, 2001, looking west at CD-2.

3.0 Comparison of Observed and Predicted Water Surface Elevations

The peak water surface elevations in the immediate vicinity of Alpine were compared to water surface elevations predicted by the two-dimensional surface water model developed for the Colville River Delta (Michael Baker Jr., Inc., 2001, 1998; and Shannon & Wilson, Inc., 1997) to comply with USACE 2-960874, Page 2-A, Item 6. 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 experienced this spring will likely be equaled or exceeded on average about once every 8-years. Estimated recurrence intervals ranged from 5 to 9 years at the individual staff gages located around Alpine (Permanent Staff Gages 1, 3, 4, 6, 7, and 10).

At Monument 01 (the head of the delta), the peak water surface elevation approximates a 7-year recurrence interval when compared to the predictions of the two-dimensional surface water model. Using the measured water surface slopes and normal depth computations, the magnitude of the peak discharge is estimated to have a recurrence interval of about 4 years (Section 2.2).

Observations at the time of the peak water surface elevation indicate that low water channel ice was intact in the major channels of the delta and that many of the smaller channels were blocked with snow. The two-dimensional surface water model assumes open water conditions and does not take into account channel ice or ice jams. At the time the model was constructed, it was assumed that during a large flood (such as the 50-, 100- and 200-year events for which the model was constructed), the presence of an ice sheet or ice jams would have little effect on the water surface elevation. However, channel ice and ice jams will restrict flow and cause increases in water surface elevation during smaller flood events when the flow is mainly confined within the channel banks. Thus, the water surface elevation predictions of the two-dimensional model will generally under-predict water surface elevations during small flood events when channel ice or ice jams are occurring in the delta. For this reason, the water surface elevation return period is higher than the discharge return period.

Table 3-1 Comparison of Observed and Predicted Water Surface Elevations

Observation Site	Observed Peak Water Surface Elevation (feet BPMSL)	Predicted 2-yr Water Surface Elevation (feet BPMSL)	Predicted 10-yr Water Surface Elevation (feet BPMSL)	Predicted 50-yr Water Surface Elevation (feet BPMSL)	Approximate Recurrence Interval of Observed Peak Water Surface Elevation (1) (years)
Staff Gage #1	6.95	5.50	8.4	11.2	6
Staff Gage #3	7.95	5.7 (2)	8.6	11.8	8
Staff Gage #4	7.22	5.1 (2)	7.6	9.9	9
Staff Gage #6	8.03	Dry (3)	8.8	11.9	<10
Staff Gage #7	7.84	Dry (3)	8.6	9.8	<10
Staff Gage #8	n/a (6)	Dry (3)	8.8	10.7	n/a
Staff Gage #10	7.67	6.7 (2)	9.7	10.7	5
Monument 01	17.37	13.80	19.0	23.0	7 (4)
Monument 12	11.94	8.60	12.0	14.9	9
TBM 20N	10.16	7.30	10.9	11.8	8
Monument 22	8.8 (5)	5.90	8.7	5.4	10

Notes

1. The recurrence interval was interpolated between water surface elevations predicted with the two-dimensional surface-water model of the Colville River Delta (Michael Baker Jr., Inc., 2001 and 1998 and Shannon & Wilson, Inc., 1997). The model considers open water conditions therefore, the impact of an ice cover and/or ice jams has not been considered in the model's predictions.
2. The finite element at the staff gage is turned off in the two-dimensional surface water model. The presented water surface elevation is the water surface elevation in the immediate vicinity of the staff gage.
3. The finite element at the staff gage is turned off in the two-dimensional surface water model. All elements in the immediate vicinity are turned off and the area is considered dry.
4. The presented value is based on interpolation of the predicted water surface elevation (see Note 1). The recurrence interval estimated from the computed peak discharge and the flood frequency relationship developed for the head of the delta by Michael Baker Jr., Inc. and Shannon & Wilson, 1998 is 4 years.
5. The peak water surface elevation at Monument 22 is an estimate and not a physical measurement.
6. The location of Staff Gage #8 was used as a snow disposal site and for the duration of the monitoring program Staff Gage #8 was surrounded by snow. Readings obtained from Staff Gage #8 are not representative of the observed field conditions.
7. Locations of monuments and gages are shown in Figures 2-1 and 2-2, respectively.

4.0 Gravel Pad and Road Erosion

The gravel pad and CD-2 access road were inspected for erosion 5 days after the peak water surface elevation had passed. Visual inspection of the road and pads revealed high water marks where breakup flows reached the gravel structures. High water marks were identified by grasses and other debris stranded on the gravel side slopes, or by observing where silts and fine-grained sands had settled from the gravel.

No indications of significant erosion due to breakup flows were observed anywhere along the gravel structures. Areas where inundation did occur had some minor settlement of fine-grained material from the surface course, however, no slumping or side slope deterioration was observed. At no location was 20 cubic yards of gravel estimated to have been eroded, thus the requirements of USACE 2-96087 are met and additional reporting or remedial action plans are not required at this time.

High water marks along the CD-2 access road are presented on Photo 4-1 through Photo 4-9.

Photo 4-1 **Facing east from Culvert #24 along the north side of the CD-2 access road. Photo taken June 16, 2001.**

Photo 4-2 **Facing east from Culvert #24 along the south side of the CD-2 access road. Photo taken June 16, 2001.**

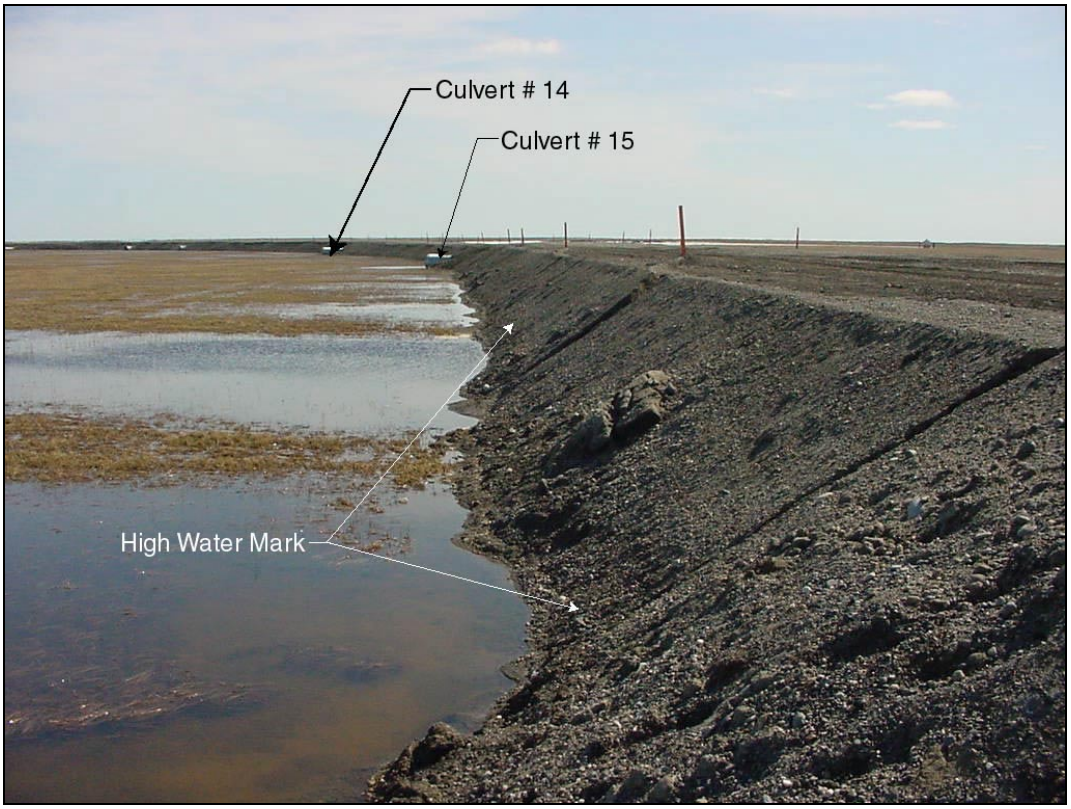

Photo 4-3 **Facing east from Culvert #16 along the north side of the CD-2 access road. Photo taken June 16, 2001.**

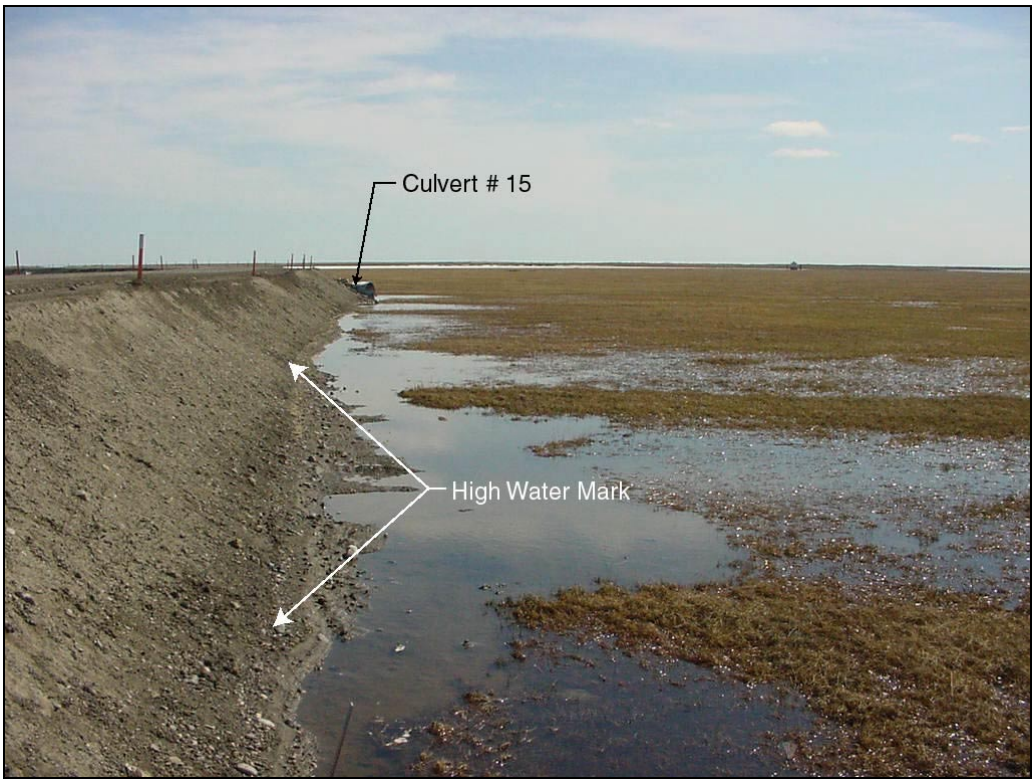

Photo 4-4 **Facing east from Culvert #16 along the south side of the CD-2 access road. Photo taken June 16, 2001.**

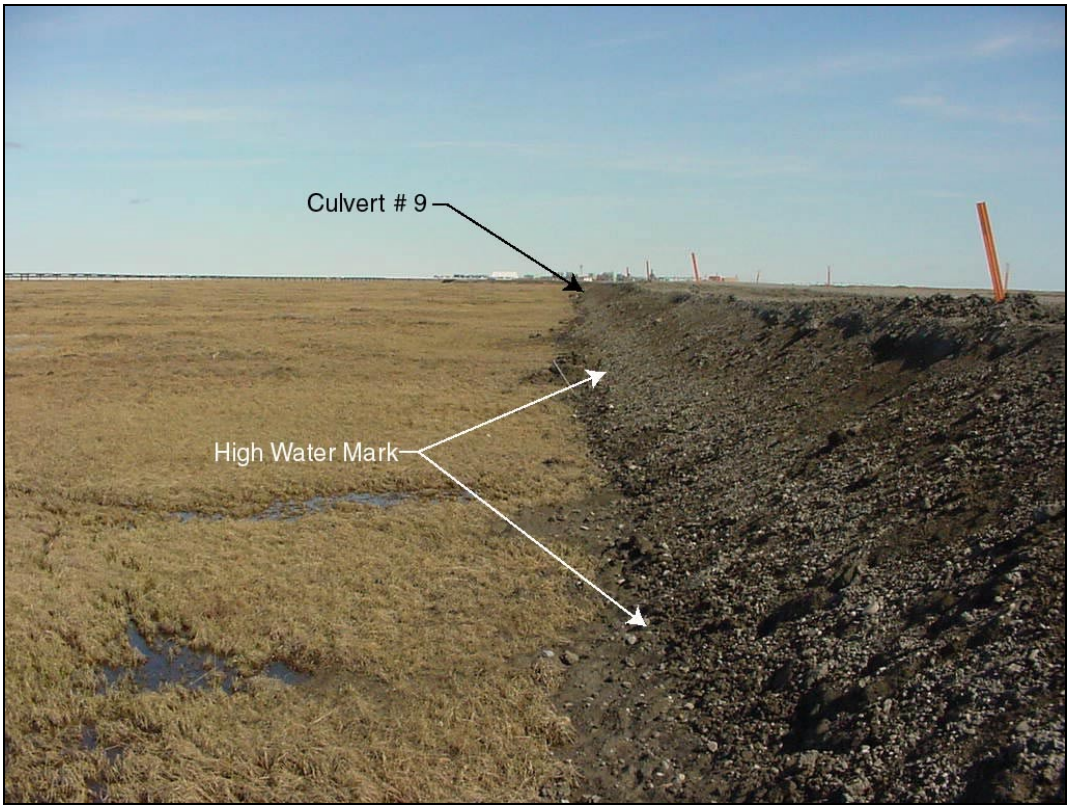

Photo 4-5 **Facing east from Culvert #10 along the north side of the CD-2 access road. Photo taken June 16, 2001.**

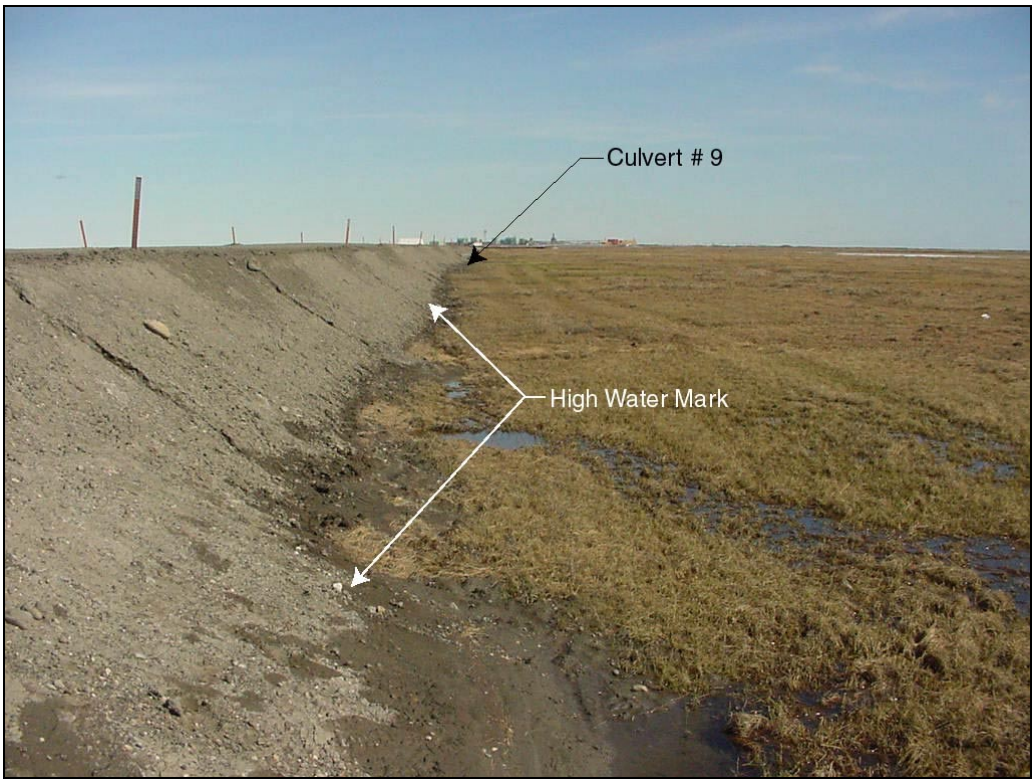

Photo 4-6 **Facing east from Culvert #10 along the north side of the CD-2 access road. Photo taken June 16, 2001.**

Photo 4-7 **Facing east from Culvert #04 along the north side of the CD-2 access road. Photo taken June 16, 2001.**

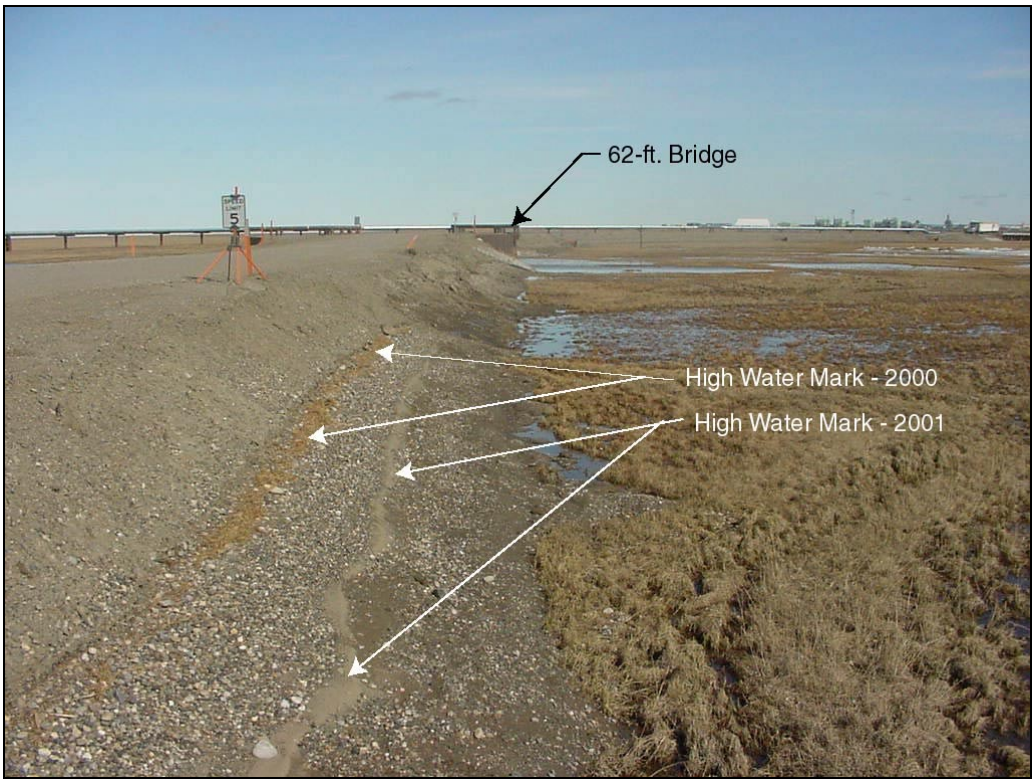

Photo 4-8 **Facing east from Culvert #04 along the south side of the CD-2 access road. Photo taken June 16, 2001.**

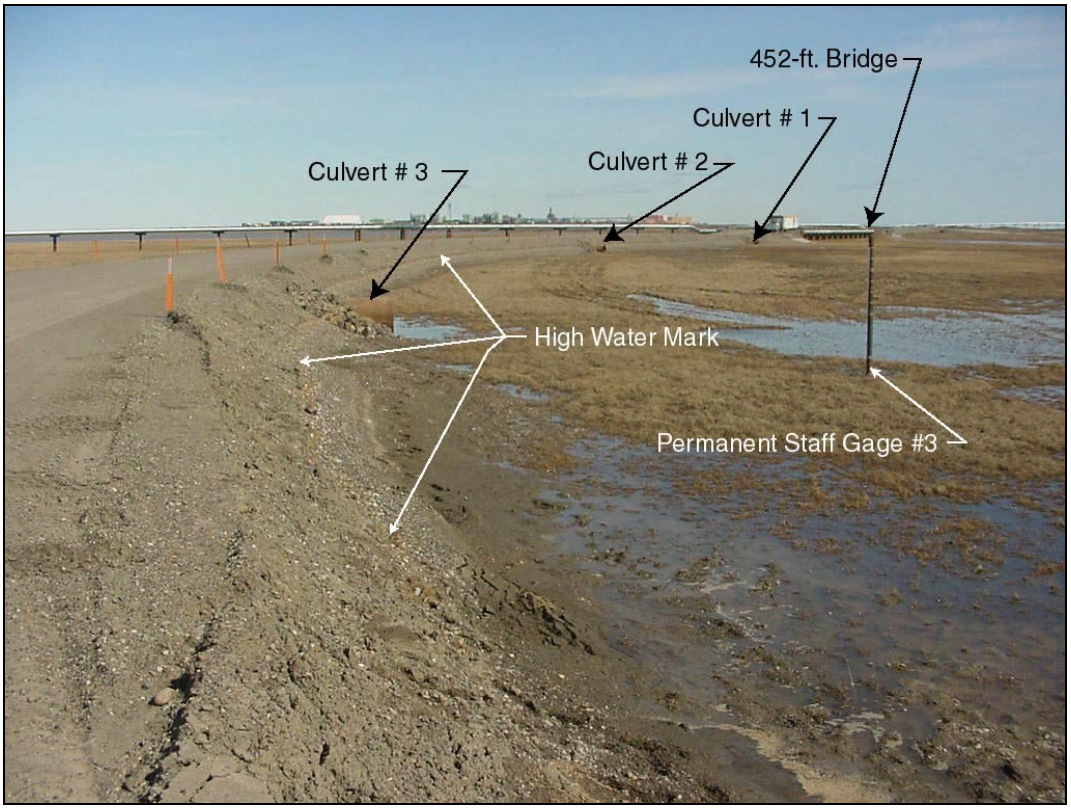

Photo 4-9 **Facing east along the south side of the CD-2 access road from the 62-foot bridge. Photo taken June 16, 2001.**

5.0 Lake Recharge

Lakes L93-12 and L93-13 were monitored during breakup to comply with the permits listed below and to assess lake recharge and the mechanism causing recharge. In addition, monitoring was conducted on Lake L93-42.

- AK 9703-030G, Page 8, Item 16
- FG99-111-0051, Page 2, Item 3
- FG97-111-0190-Amendment 1, Page 2, Item 1

Water surface elevations were measured with permanent staff gages installed in Lakes L93-12 and L93-13 and with a temporary staff gage installed in Lake L93-42. Summaries of field observations are provided below and in the accompanying tables and photographs. Elevations for Lake L93-12 and L93-13 are referenced to BPMSL. For consistency, elevations at Lake L93-42 are referenced to the same assumed datum that was used by Alpine personnel to measure water surface elevations in that lake during winter 2000-2001.

5.1 Lake L93-12

Prior to breakup, the water surface elevation in Lake L93-12 was 7.20 feet, measured on 12 May. A water surface elevation of 7.55 was recorded on 16 June. There was no high water mark on the staff gage (the staff gages had been chalked to capture high water marks) indicating that the water surface elevation in the lake had risen to this level and stabilized.

5.2 Lake L93-13

Prior to breakup, the water surface elevation in Lake L93-13 was 5.55 feet, measured on 12 May. On 11 June, water was observed flowing from the Sakoonang Channel into Lake M9525 and then into Lake L93-13 through the low divide separating these lakes. The water surface elevation reached a peak of 8.31 feet sometime late on 11 June or early on 12 June. The water surface elevation then began to recede as river waters dropped. Recharge into Lake L93-13 is shown in Photographs 5-1 through 5-4.

5.3 Lake L93-42

Prior to breakup, the water surface elevation in Lake L93-42 was 95.95 feet (assumed datum), measured on 12 May. A water surface elevation of 96.08 was recorded on 8 June, and a water surface elevation of 96.11 was recorded on 16 June. As with Lake L93-12, there was no high water mark, indicating that the water surface elevation had risen but did not recede. The temporary staff gage was removed from Lake L93-42 on 16 June.

5.4 Conclusions

It is apparent from the observations and readings that Lake L93-13 was recharged by river overflow. The water surface elevation of Lake L93-13 was increased by 2.76 feet during breakup. It is also apparent that Lake L93-42 did not receive any recharge from river water. The water surface elevation increase in Lake L93-42 was only 0.17 feet and this increase was likely from local snowmelt and runoff.

Lake L93-12 likely had some recharge from river water; however, the magnitude of recharge was not nearly as significant as seen in Lake L93-13. The water surface elevation in Lake L93-12 increased 0.35 feet. The water surface elevation of Lake L93-12 when compared to the peak water surface elevation of Lake L93-13 (-0.76 feet) suggests that small amounts of flow likely occurred due to the differential gradient between these systems. Although river recharge was not visually observed, surface recharge to Lake L93-12 probably occurred for a short duration and in low volumes. This recharge was probably through small surface channels and/or through grass. Based on the available data it cannot be concluded with certainty that Lake L93-12 received recharge from river water, however, the increase in water surface elevation suggests that recharge to Lake L93-12 can probably be attributed to more than local snowmelt runoff.

Table 5-1 Lake L93-12 Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Observations
5/12/01		7.2 (1)	Lake is frozen. Ice thickness measured at 6.4 feet.
6/8/01	15:35	--	Chalked gage. No open water on gage. Localized ponding on shoreline only. No gage reading taken.
6/16/01	9:22	7.55	No high water mark present.
6/23/01		7.40	See note 3.
6/29/01		7.60	See note 3.
7/6/01		7.62	See note 3.

Notes:

1. Water surface elevation measured by drilling a hole in lake ice and surveying from a reference elevation of 14.54 located on TBM L99-32-59 at the fresh water pump house. The elevation of L99-32-59 was confirmed by Lounsbury and Associates.
2. Water surface elevation readings were taken from Permanent Staff Gage #9 unless noted otherwise. The face plate and reference mark elevations on Permanent Staff Gage #9 were conformed to match the BPMSL datum by surveying datum with respect to TBM L99-32-59. Survey was completed on May 12, 2001.
3. Readings provided by Alpine Environmental personnel.

Table 5-2 Lake L93-13 Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Observations
5/12/01		5.55 (1)	Lake is frozen. Ice thickness measured at 6.1 feet.
6/7/01	17:45	—	Chalked gage. Localized ponding only. No gage reading taken.
6/11/01	8:52	6.59	Reading taken prior to discharge measurement at bridges.
6/11/01	16:41	8.08	Reading taken after discharge measurement at bridges.
High Water Mark		8.31	Based on chalk.
6/12/01	7:16	8.23	
6/14/01	13:50	6.69	See Note 3.
6/16/01	13:45	6.45	
6/23/01		5.84	See Note 3.
6/29/01		6.14	See Note 3.
7/6/01		6.04	See Note 3.

Notes:
1. Water surface elevation measured by drilling a hole in lake ice and surveying from a reference elevation of 16.00 located on TBM L99-32-60 at the fresh water pump house. The elevation of L99-32-60 was confirmed by Lounsbury and Associates.
2. Water surface elevation readings were taken from Permanent Staff Gage #10 unless noted otherwise. A difference of 0.64 feet was measured between the face plate readings on Permanent Staff gage #10 and the BPMSL datum as determined by TBM L99-32-60. All water surface elevation readings have been converted to BPMSL with respect to TBM L99-32-60.
3. Readings provided by Alpine Environmental personnel.

Table 5-3 Lake L93-42 Water Surface Elevations and Observations

Date	Time	Water Surface Elevation	Observations
5/12/01		95.95 (2)	Lake is frozen. Ice thickness measured at 6.3 feet.
6/8/01	15:43	96.08	Open water on shoreline. 98% of lake surface still frozen. Chalked gage.
6/16/01	9:10	96.11	No high water mark present. Water is at highest point on gage.

Notes:
1. All water surface elevations based on an assumed datum referenced to TBM L01-05-37-1 set by Lounsbury and Associates.
2. Water surface elevation measured by drilling a hole in lake ice.
3. Water surface elevations recorded on a temporary staff gage referenced to TBM L01-05-37-1.

Photo 5-1 Looking south at recharge into Lake L93-13. Photo taken June 11, 2001.

Photo 5-2 Looking north at Lake L93-13. Note hydraulic connection into lake. Photo taken June 11, 2001.

Photo 5-3 Looking south at Lake L93-13 and Lake L93-12. Photo taken June 12, 2001.

Photo 5-4 Looking north at Lake L93-13. Note hydraulic connection into lake. Photo taken June 14, 2001.

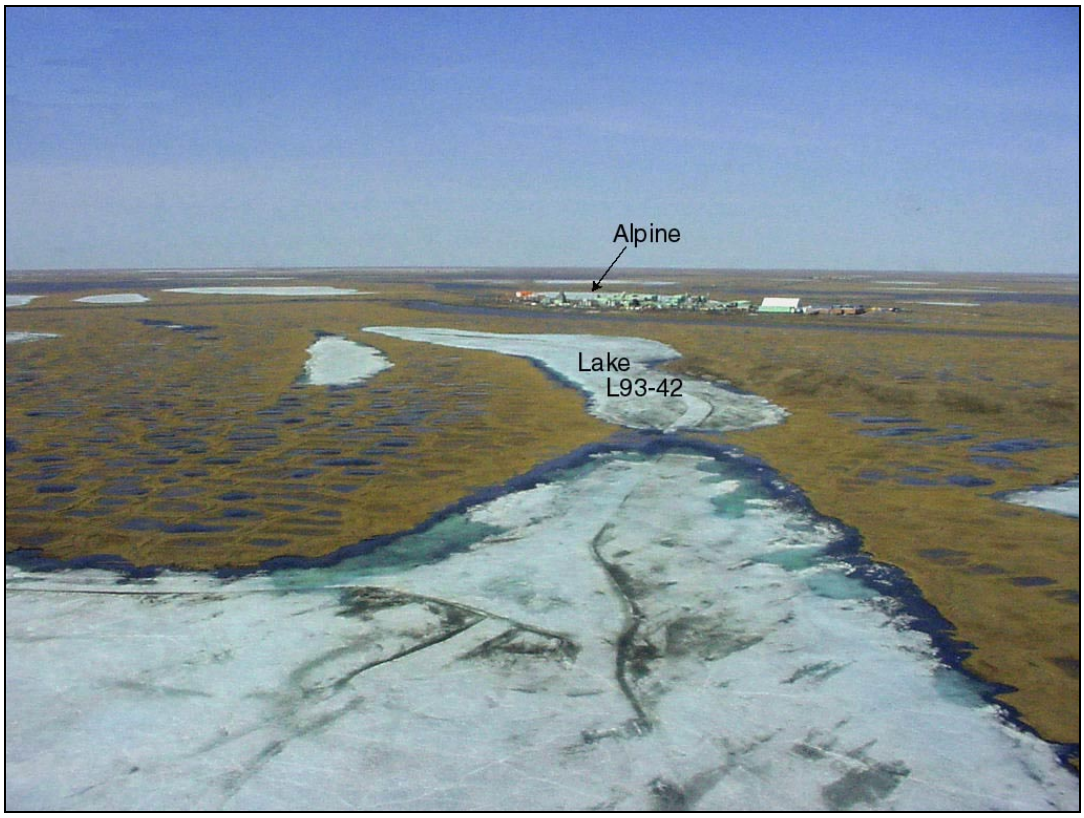

Photo 5-5 **Looking west at Lake L93-42. Note Alpine in the distance. Photo taken June 16, 2001.**

6.0 Channel Ice Observations

Channel ice surveys began on 5 June when water was first observed flowing on the delta. Channel ice surveys were performed daily until 12 June and all the major channels of the delta were clear of channel ice and ice jams. The progression of the channel ice clearing and ice jamming is shown on Figures 6-1 through 6-8.

6.1 Channel Ice

Large areas of intact floating channel ice characterized the early stages of breakup in the main channels of the delta. On 5 and 6 June, floating channel ice on the East Channel appeared to be diverting a large percentage of flow into the Nigliq Channel. As breakup progressed and water levels rose, the influence of the East Channel ice appeared to lessen. The smaller channels (e.g. the Sakoonang and Tamayayak) contained discontinuous floating channel ice and large portions of those channels were filled with drifted snow that prevented flow. As breakup progressed, the snow in the smaller channels began to erode and in many cases flow was observed over the top of or cutting through the snow. By 9 June, the upper Sakoonang was clear well downstream of Alpine, but the lower portions were still blocked with ice and snow. Channel ice in the main channels (East and Nigliq) remained relatively intact until the evening of 10 June when much of the intact channel ice was dislodged. Approximately 90 percent of the channel ice had cleared by the morning of 11 June. By 12 June, all surface ice, with the exception of a small ice jam located just east of Alpine on the Sakoonang Channel, had cleared.

6.2 Ice Jams

Ice jams were observed at various locations in the delta. A surface ice jam formed above the village of Nuiqsut at the confluence of the Putu and Nigliq channels on 6 June and remained in place until 11 June. Ice jams were also noted on the Nigliq channel west of the proposed CD South facility location, and on the upper portions of the Sakoonang, Tamayayak, and Kupigruak channels. All observed ice jams appeared to be surface ice jams rather than

grounded jams. In no case did the observed ice jams appear to cause significant backwater, blockage, or diversions of flow.

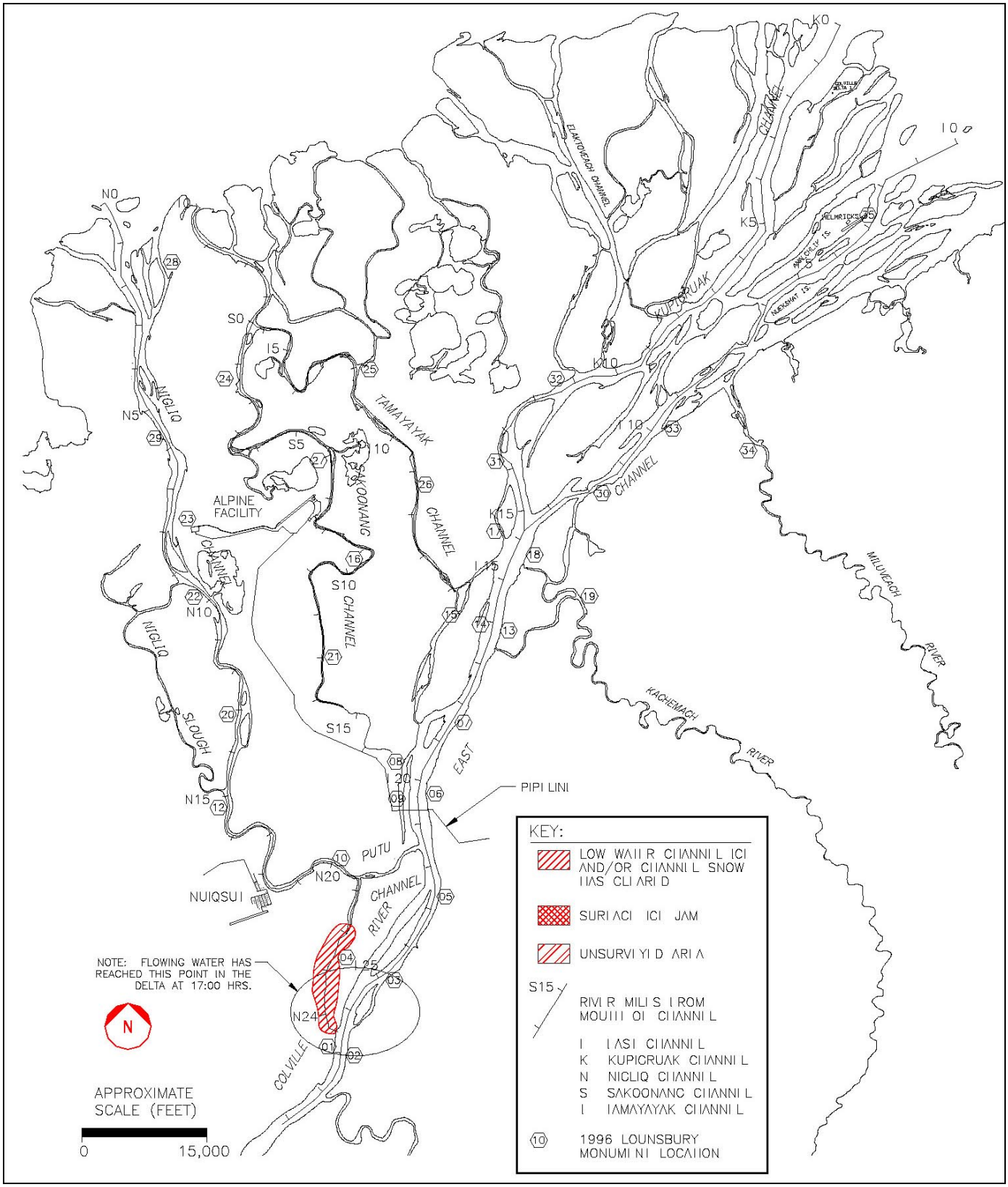

Figure 6-1 Low Water Channel Ice Survey, June 5, 2001

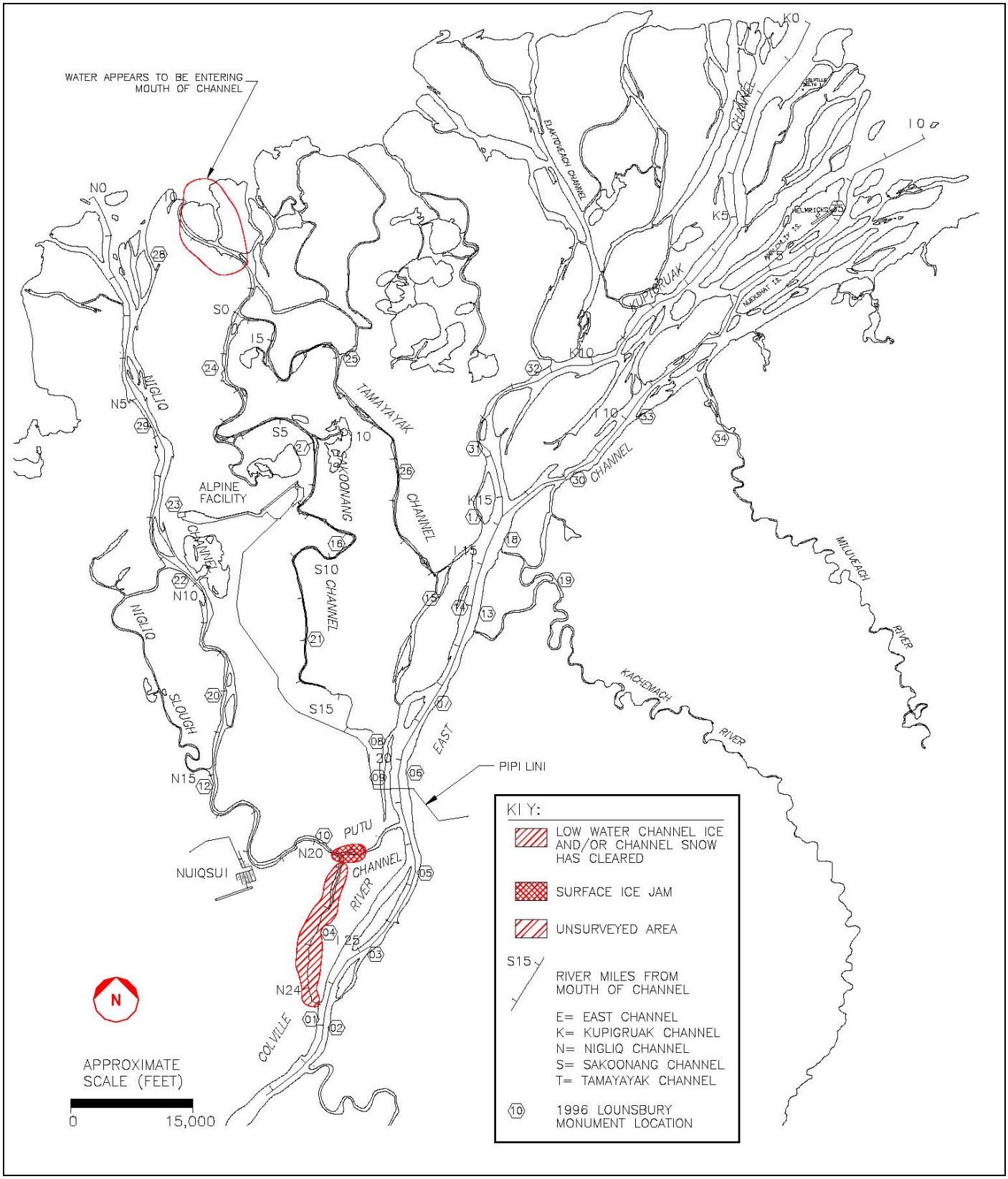

Figure 6-2 Low Water Channel Ice Survey, June 6, 2001

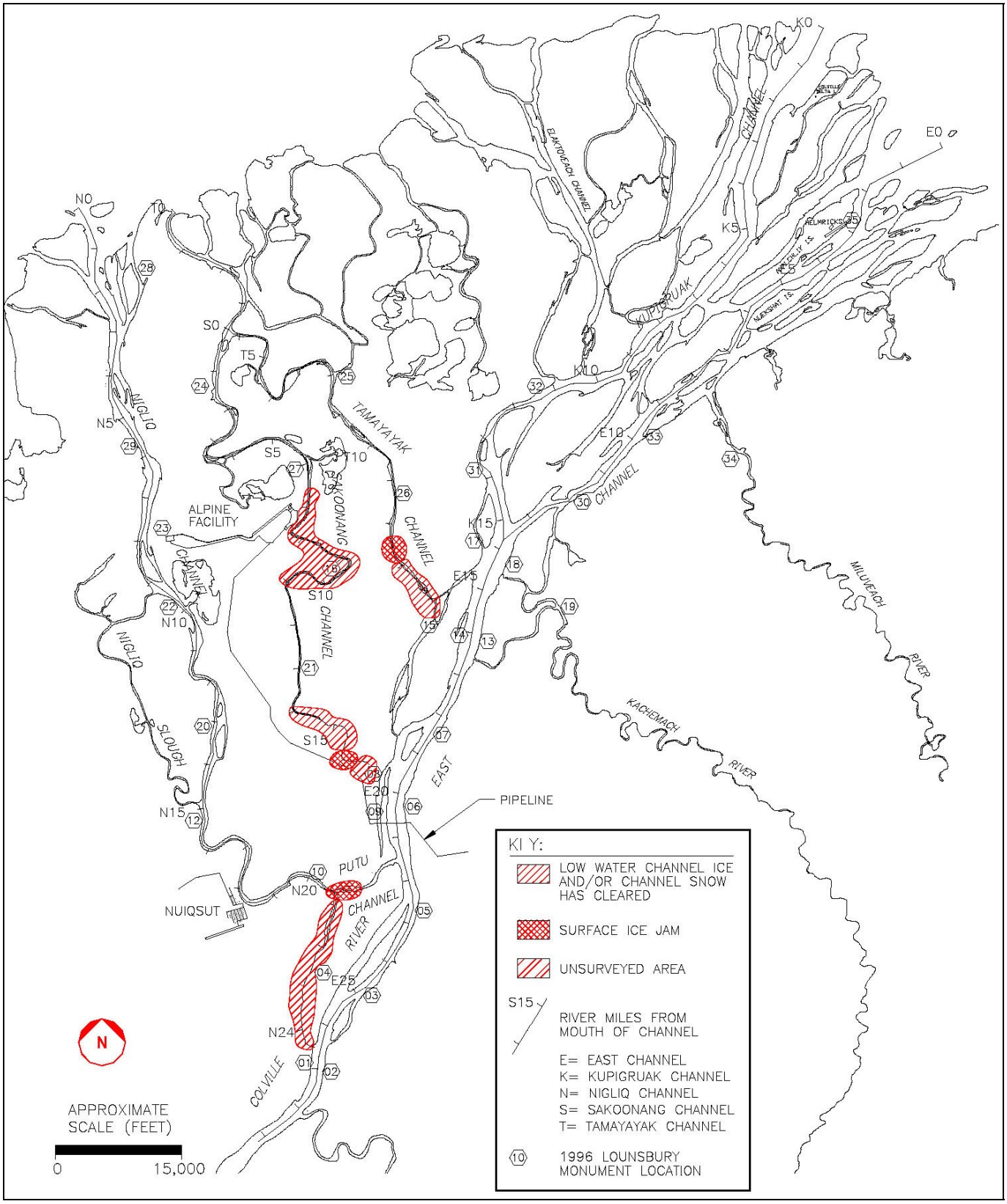

Figure 6-3 Low Water Channel Ice Survey, June 7, 2001

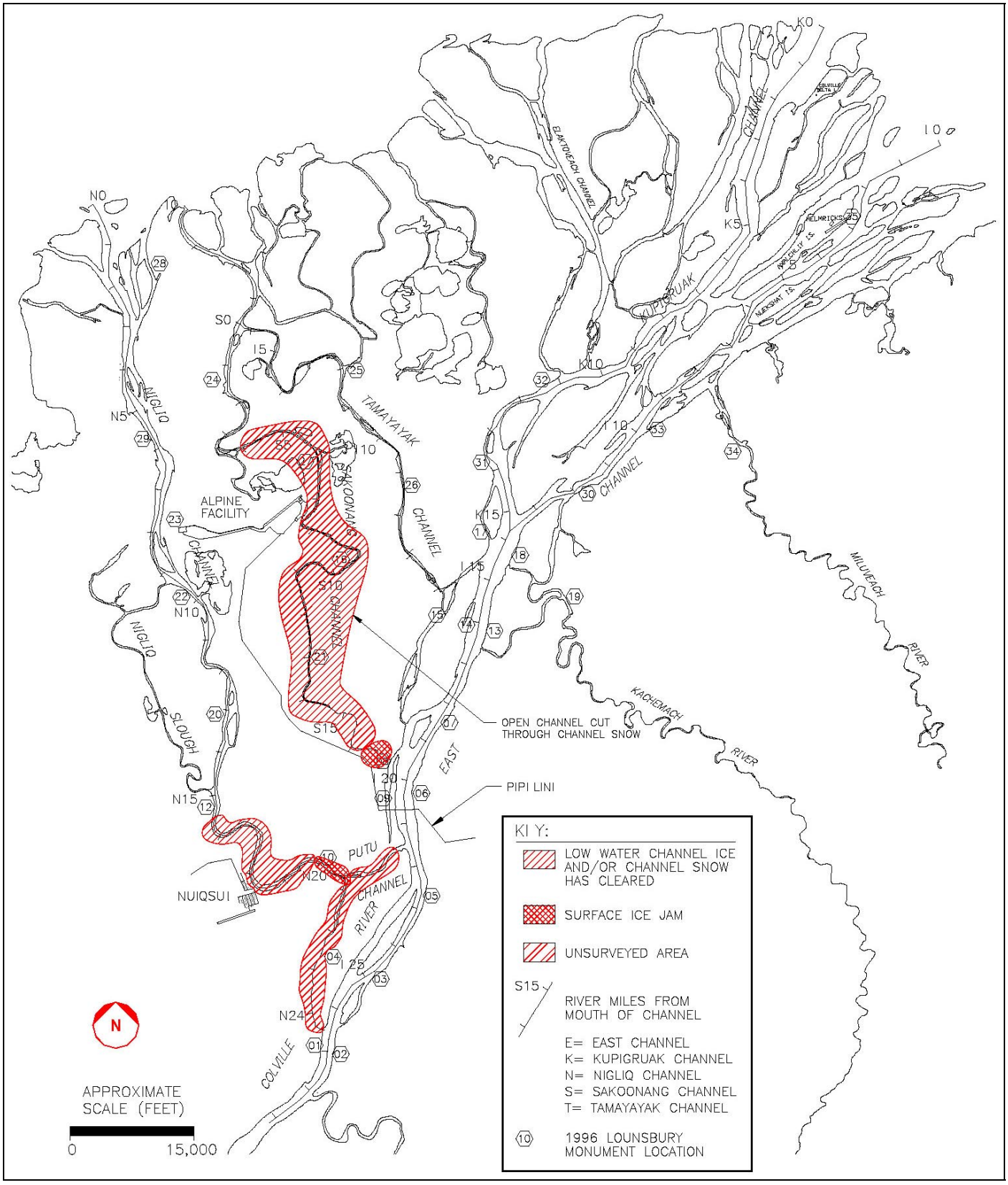

Figure 6-4 Low Water Channel Ice Survey, June 8, 2001

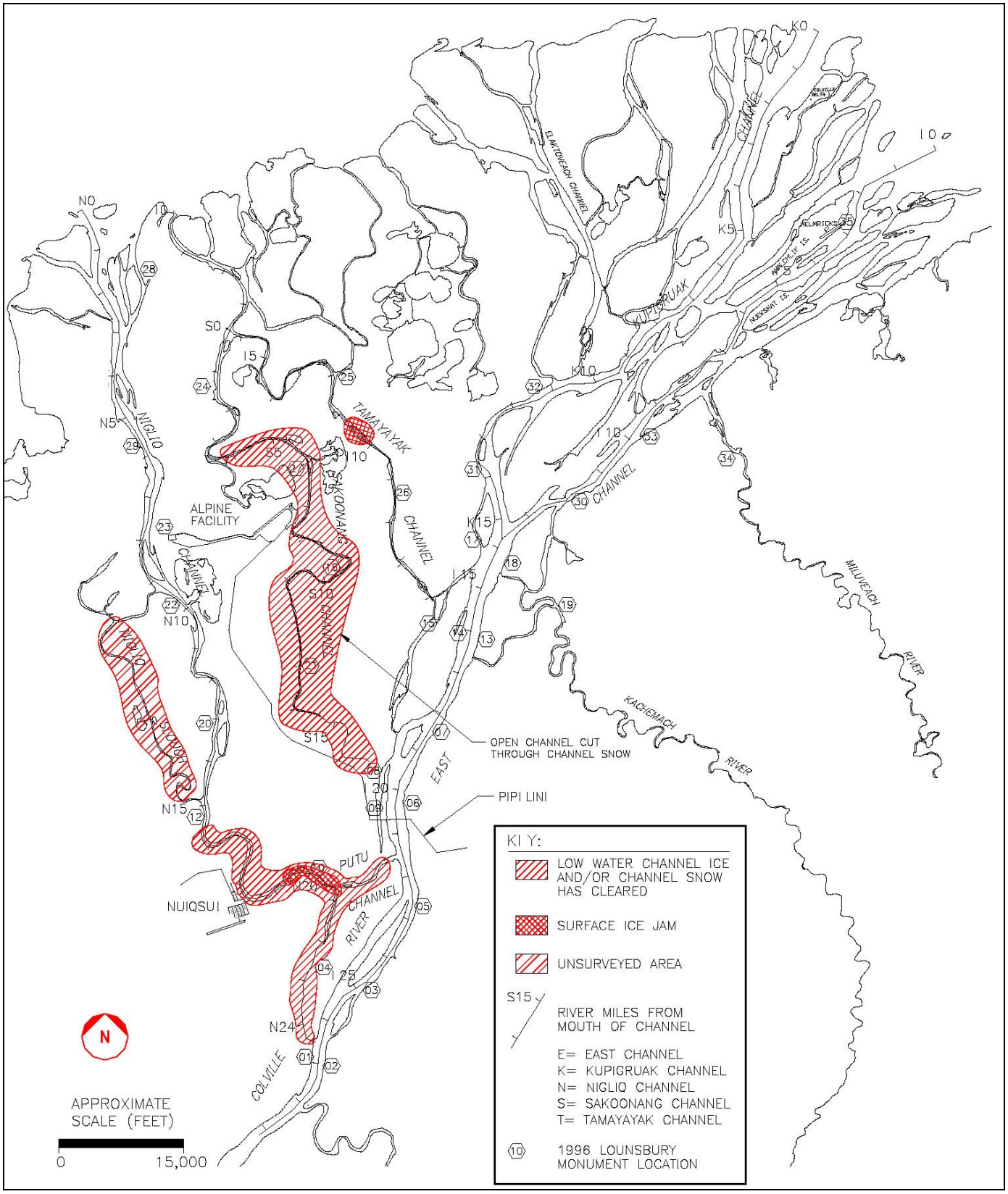

Figure 6-5 Low Water Channel Ice Survey, June 9, 2001

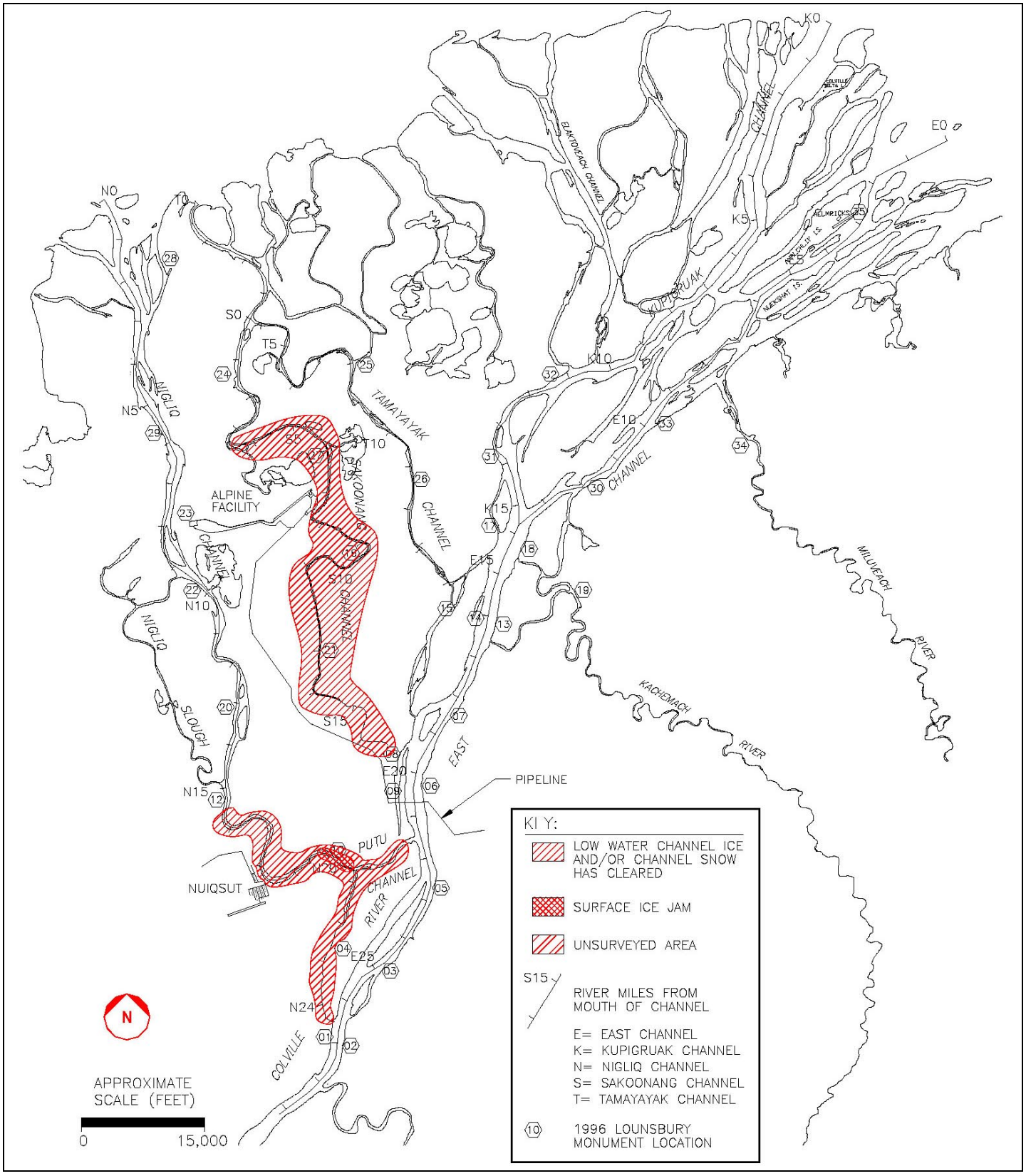

Figure 6-6 Low Water Channel Ice Survey, June 10, 2001

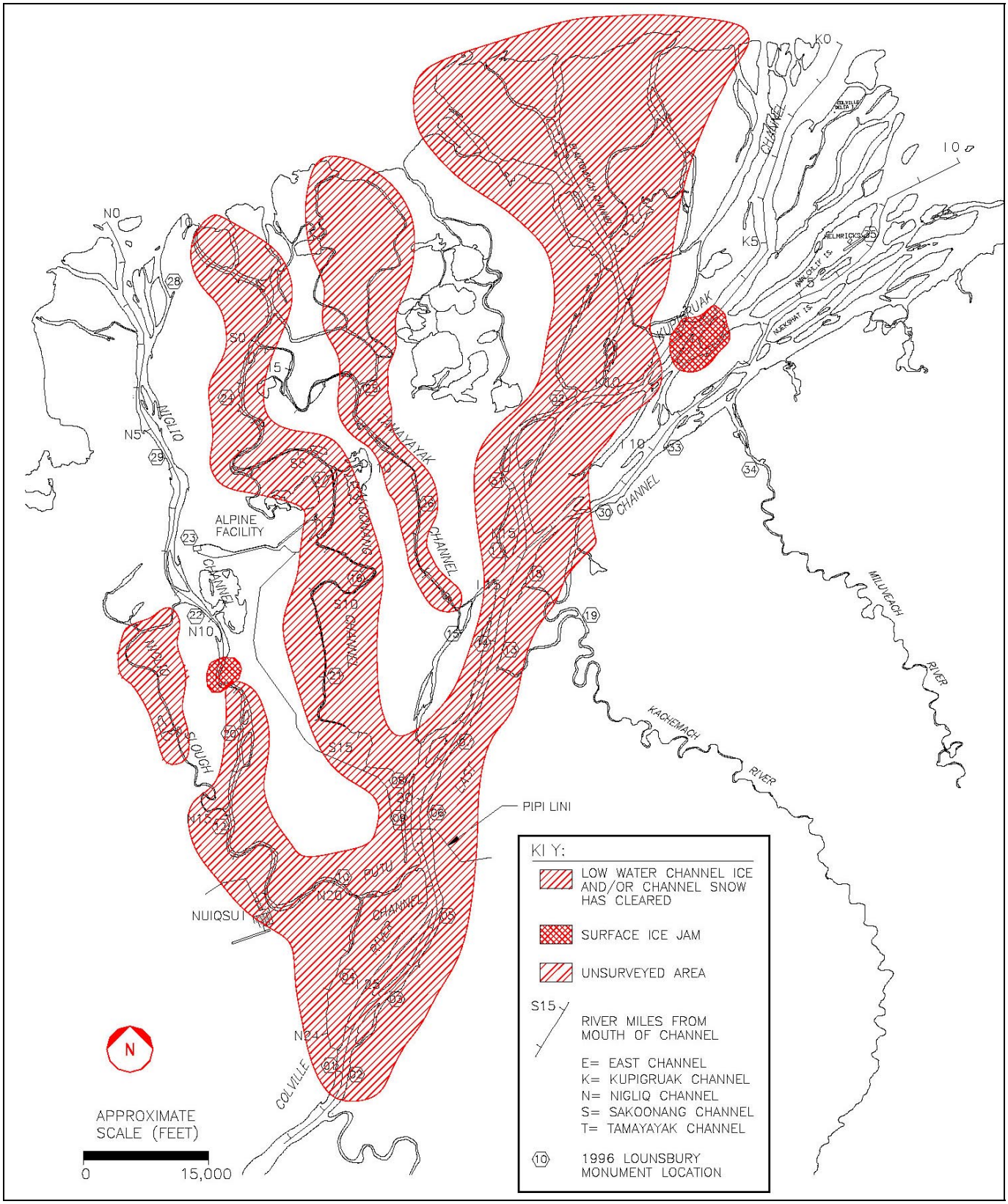

Figure 6-7 Low Water Channel Ice Survey, June 11, 2001

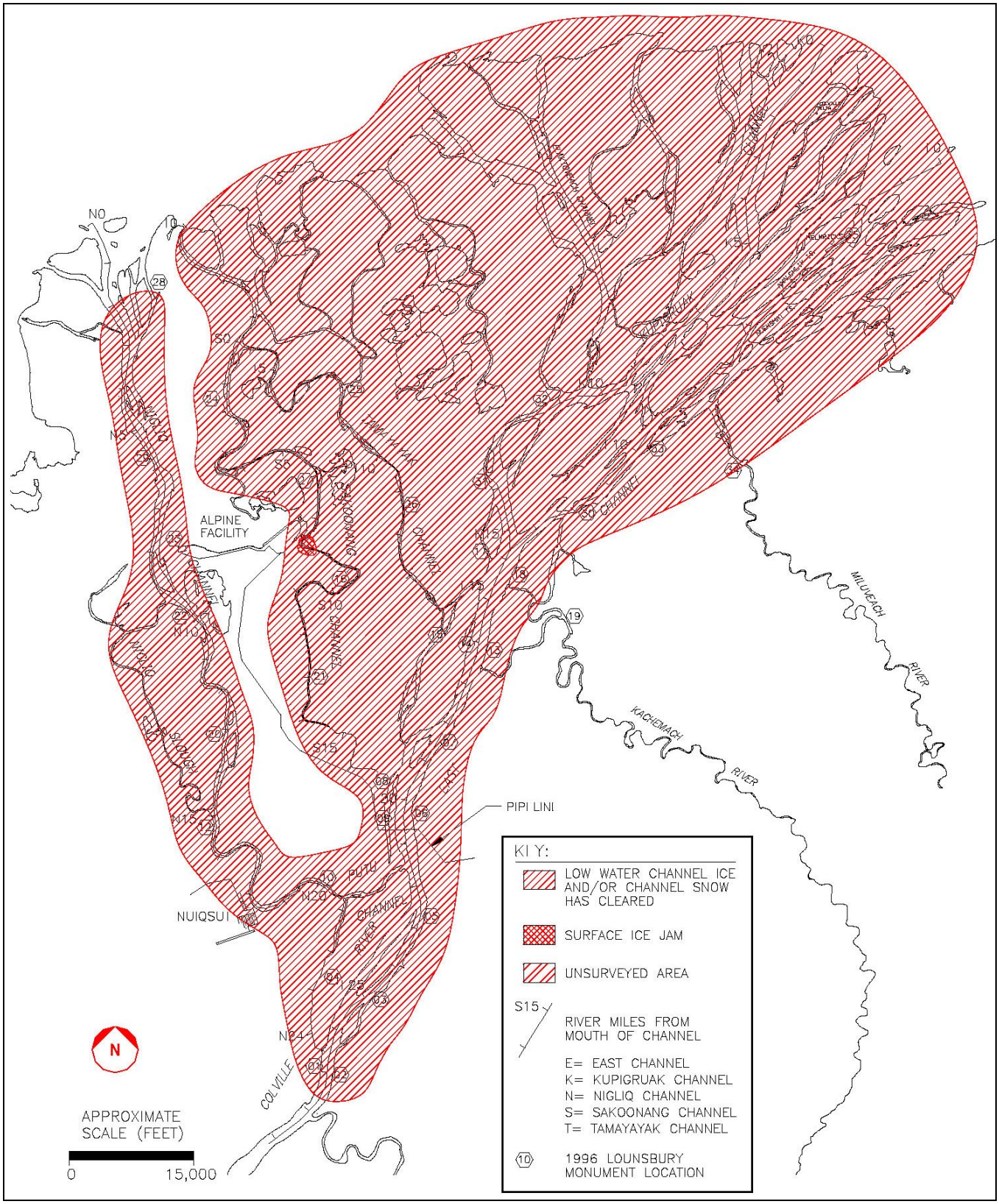

Figure 6-8 Low Water Channel Ice Survey, June 12, 2001

7.0 References

Michael Baker Jr., Inc. 1998. *Colville River Delta Two-Dimensional Surface Water Model, Project Update.* Prepared for: ARCO Alaska, Inc., Anchorage. *[Ongoing work to be published in 2001.]*

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 and Hydrologic Assessment.* Prepared for: Phillips Alaska, Inc., Anchorage.

Shannon & Wilson, 1996. *1996 Colville River Delta, Channel Assessment, Colville River Delta North Slope, Alaska*, Prepared for Michael Baker Jr. Inc., Anchorage, Alaska

Alaska Biological Research and Shannon & Wilson, 1994. *Geomorphology and Hydrology of the Colville River Delta, Alaska, 1993*. Prepared for ARCO Alaska, Inc., Anchorage, Alaska

Appendix A Discharge Measurement Notes

DISCHARGE MEASUREMENT NOTES

LOCATION: Alpine 452 Swale Bridge

Date: June 11, 2001 **Party:** Jon Wolf, Corey Parrent

Width: 460 **ft** **Area:** 1538.0 **ft^2** **Vel:** 2.40 **fps** **G.H.:** **Discharge:** 3696 **cfs**

No Secs. **G.H. change:** **in.:** **hrs.:** **Susp.:**

Method coef.: **Hor. Angle coef.** **Sus. Coef.:** **Meter No.**

Type of meter: Price AA

Date rated:

Meter: 0.5 **ft. above bottom of weight.**

Spin before meas. 2 min **after** 2 min

Method:

30lb lead weight with bridge boom & reel

Gage Readings

Time	Recorder	Inside	Outside
	See Tables 2-1 through 2-7		
Weighted M.G.H.			
G.H. corrections			
Correct M.G.H.			

Levels obtained: Yes, before and after

Measurement rated: Good **Rating based on following conditions:**

Cross section: Very uniform channel

Flow: Uniform & steady **Weather:** **Air oF@:** 40 degrees F

Gage: **Water oF@:** ~33 degrees F

Other:

Record Removed: **Intake flushed:** N/A

Observer

Control Two large chunks of ice upstream of bridge. Also ice beneath the bridge on downstream side, right bank

Remarks All measurements conducted at 0.6 depth due to tall grass in the channel. Number of intervals reduced due to uniformity of channel and flow

G.H. of zero flow: **ft.**

Page 1 of 2

Angle Coef. (deg)	Dist. From Initial Point (ft)	Width (ft)	Depth (ft)	Observa-tion depth (ft)	Revo-lutions	Time (sec)	VELOCITY		Adjust for Angle Coef.	Adjusted Velocity (fps)	Area (s.f.)	Discharge (cfs)	Description
							At Point (fps)	Mean in-vertical (fps)					
30	0	30.0	3.4	0.6	57	40	3.1	3.1	0.866	2.704	102	276	LEW @ bridge abutment
30	30	30.0	3.4	0.6	59	40	3.2	3.2	0.866	2.798	102	285	Tall grass
30	60	30.0	3.4	0.6	56	40	3.1	3.1	0.866	2.657	102	271	Tall grass
30	90	30.0	3.4	0.6	49	40	2.7	2.7	0.866	2.328	102	237	Tall grass
30	120	30.0	3.4	0.6	44	40	2.4	2.4	0.866	2.093	102	214	Tall grass
30	150	30.0	3.1	0.6	45	40	2.5	2.5	0.866	2.140	93	199	Tall grass
30	180	30.0	3.1	0.6	45	40	2.5	2.5	0.866	2.140	93	199	Tall grass
30	210	30.0	3.2	0.6	47	40	2.6	2.6	0.866	2.234	96	214	Tall grass
30	240	30.0	3.6	0.6	58	40	3.2	3.2	0.866	2.751	108	297	Tall grass
20	270	30.0	3.6	0.6	15	40	0.8	0.8	0.940	0.787	108	85	Tall grass, Eddy, D.Stream Ice
20	300	30.0	3.5	0.6	50	40	2.7	2.7	0.940	2.577	105	271	Tall grass
20	330	30.0	3.3	0.6	51	40	2.8	2.8	0.940	2.628	99	260	Tall grass
20	360	30.0	3.4	0.6	50	40	2.7	2.7	0.940	2.577	102	263	Tall grass
N/A	390	30.0	3.2	0.6	51	40	2.8	2.8	1.0	2.797	96	268	Tall grass
N/A	420	27.5	3.2	0.6	51	40	2.8	2.8	1.0	2.797	88	246	Tall grass
N/A	445	12.5	3.2	0.6	50	40	2.7	2.7	1.0	2.743	40	110	REW @ bridge abutment
TOTAL		**460.0**									**1538**	**3696**	**Page 2 of 2**

DISCHARGE MEASUREMENT NOTES

LOCATION: Alpine 62 Swale Bridge

Date: June 11, 2001 **Party:** Jon Wolf, Corey Parrent

Width: 56 **ft** **Area:** 335.6 **ft²** **Vel:** 1.79 **fps** **G.H.:** **Discharge:** 599 **cfs**

No Secs. **G.H. change:** **in.:** **hrs.:** **Susp.:**

Method coef.: **Hor. Angle coef.** **Sus. Coef.:** **Meter No.**

Type of meter: Price AA

Date rated:

Meter: 0.5 **ft. above bottom of weight.**

Spin before meas. 2.25 min **after** 2.25 min

Method:

30lb lead weight with bridge boom & reel

Gage Readings

Time	Recorder	Inside	Outside
	See Tables 2-1 through 2-7		
Weighted M.G.H.			
G.H. corrections			
Correct M.G.H.			

Levels obtained: Yes, before and after

Measurement rated: Good

Rating based on following conditions:

Cross section: Fairly uniform channel

Flow: Uniform & steady **Weather:** **Air oF@:** 40 degrees F

Gage: **Water oF@:** ~33 degrees F

Other:

Record Removed: **Intake flushed:** N/A

Observer

Control Two large chunks of ice upstream of bridge. Also ice beneath the bridge on downstream side, right bank

Remarks Likely that some of the 0.8 velocities are biased low due to tall grass across the reach. A method coefficient of 0.88 of the 0.2 depth velocity was used in those intervals where the 0.8 velocities are unreliable.

G.H. of zero flow: **ft.**

Page 1 of 2

Angle Coef. (deg)	Dist. From Initial Point (ft)	Width (ft)	Depth (ft)	Observation depth (ft)	Revolutions	Time (sec)	VELOCITY		Adjust for Angle Coef.	Adjust for Method Coef.	Adjusted Velocity (fps)	Area (s.f.)	Discharge (cfs)	Description
							At Point (fps)	Mean in-vertical (fps)						
45	14	2.0	3.0	0.2	47	40	2.6	2.8	0.71	1.00	2.0	6.0	12	LEW @ bridge abutment
				0.8	54	40	3.0							
45	18	4.0	3.6	0.2	74	40	4.0	3.3	0.71	1.00	2.3	14.4	33	Tall grass
				0.8	45	40	2.5							
40	22	4.0	3.9	0.2	65	40	3.6	3.7	0.77	1.00	2.8	15.6	44	Tall grass
				0.8	69	40	3.8							
40	26	4.0	4.2	0.2	69	40	3.8	3.6	0.77	1.00	2.7	16.8	46	Tall grass
				0.8	62	40	3.4							
40	30	4.0	6.2	0.2	66	40	3.6	3.6	0.77	0.88	2.4	24.8	60	Tall grass, eddy
				0.8	17	40	0.9							
40	34	4.0	6.2	0.2	63	40	3.4	3.4	0.77	1.00	2.6	24.8	64	Tall grass
				0.8	60	40	3.3							
30	38	4.0	7.2	0.2	25	40	1.4	1.5	0.87	1.00	1.3	28.8	37	Tall grass, eddy
				0.8	28	40	1.5							
30	42	4.0	5.2	0.2	12	40	0.7	0.6	0.87	1.00	0.6	20.8	12	Tall grass, eddy
				0.8	11	40	0.6							
40	46	4.0	5.4	0.2	0	40	0.0	0.0	0.77	1.00	0.0	21.6	0	Tall grass, eddy
				0.8	0	40	0.0							
40	50	4.0	5.4	0.2	0	40	0.0	1.1	0.77	1.00	0.8	21.6	18	Tall grass, eddy
				0.8	39	40	2.1							
45	54	4.0	7.0	0.2	49	40	2.7	2.2	0.71	1.00	1.5	28.0	43	Tall grass
				0.8	30	40	1.7							
45	58	4.0	7.9	0.2	46	40	2.5	2.5	0.71	0.88	1.6	31.6	50	Tall grass
				0.8	13	40	0.7							
40	62	4.0	8.2	0.2	58	40	3.2	3.2	0.77	0.88	2.1	32.8	70	Tall grass
				0.8	37	40	2.0							
30	66	4.0	8.0	0.2	55	40	3.0	2.8	0.87	1.00	2.4	32.0	77	Tall grass
				0.8	46	40	2.5							
30	70	2.0	8.0	N/A	51	40	2.8	2.8	0.87	0.88	2.1	16.0	34	REW @ bridge abutment
				N/A	15	40	0.8							
TOTAL		**56.0**										**335.6**	**599**	**Page 2 of 2**

CD-2 Access Road, Culvert Discharge Measurements on June 11, 2001

Culvert Number	Time	Culvert Diameter (ft)	Water Depth (ft)	Observation depth (ft)	Revolutions[1]	Time (sec)	VELOCITY		Area (s.f.)	Discharge (cfs)	Description
							At Point (fps)	Mean in-vertical (fps)			
1	18:26	4	2.5	0.6	--	40	3.76	3.76	8.3	31.1	Water flowing from south to north.
2	18:22	4	2.5	0.6	--	40	4.41	4.41	8.3	36.4	Water flowing from south to north.
3	18:19	4	1.8	0.6	--	40	5.13	5.13	5.5	28.1	Water flowing from south to north.
4	18:15	4	1.8	0.6	--	40	4.06	4.06	5.5	22.2	Water flowing from south to north.
5	18:13	4	1.0	0.6	--	40	4.5	4.50	2.4	11.0	Water flowing from south to north.
6											Snow in culvert, no flow.
7											Snow in culvert, no flow.
8											Snow in culvert, no flow.
9											Snow in culvert, no flow.
10	18:03	4	1.1	0.6	--	40	0.85	0.85	2.8	2.4	Water flowing from south to north.
11											Snow in culvert, no flow.
12											Snow in culvert, no flow.
13											Snow in culvert, no flow.
14											Snow in culvert, no flow.
15											Snow in culvert, no flow.
16											Snow in culvert, no flow.
17											Snow in culvert, no flow.
18	17:54	4	2.7	0.6	--	40	0.83	0.83	9.0	7.5	Water flowing from south to north.
19	17:52	4	2.7	0.6	--	40	0.99	0.99	9.0	8.9	Water flowing from south to north.
20	17:49	4	2.6	0.6	--	40	1.12	1.12	8.6	9.7	Water flowing from south to north.
21	17:46	4	2.7	0.6	--	40	0.92	0.92	9.0	8.3	Water flowing from south to north.
22	17:43	4	2.2	0.6	--	40	1.62	1.62	7.2	11.6	Water flowing from south to north.
23	17:39	4	1.5	0.6	--	40	1.9	1.90	4.3	8.2	Water flowing from south to north.
24	17:34	4	1.5	0.6	--	40	1.98	1.98	4.3	8.5	Water flowing from south to north.
25											Snow in culvert, no flow.
26											Snow in culvert, no flow.
Total									**84.3**	**194.0**	

Notes:

1 - A current meter digitizer was used, revolutions were not recorded.