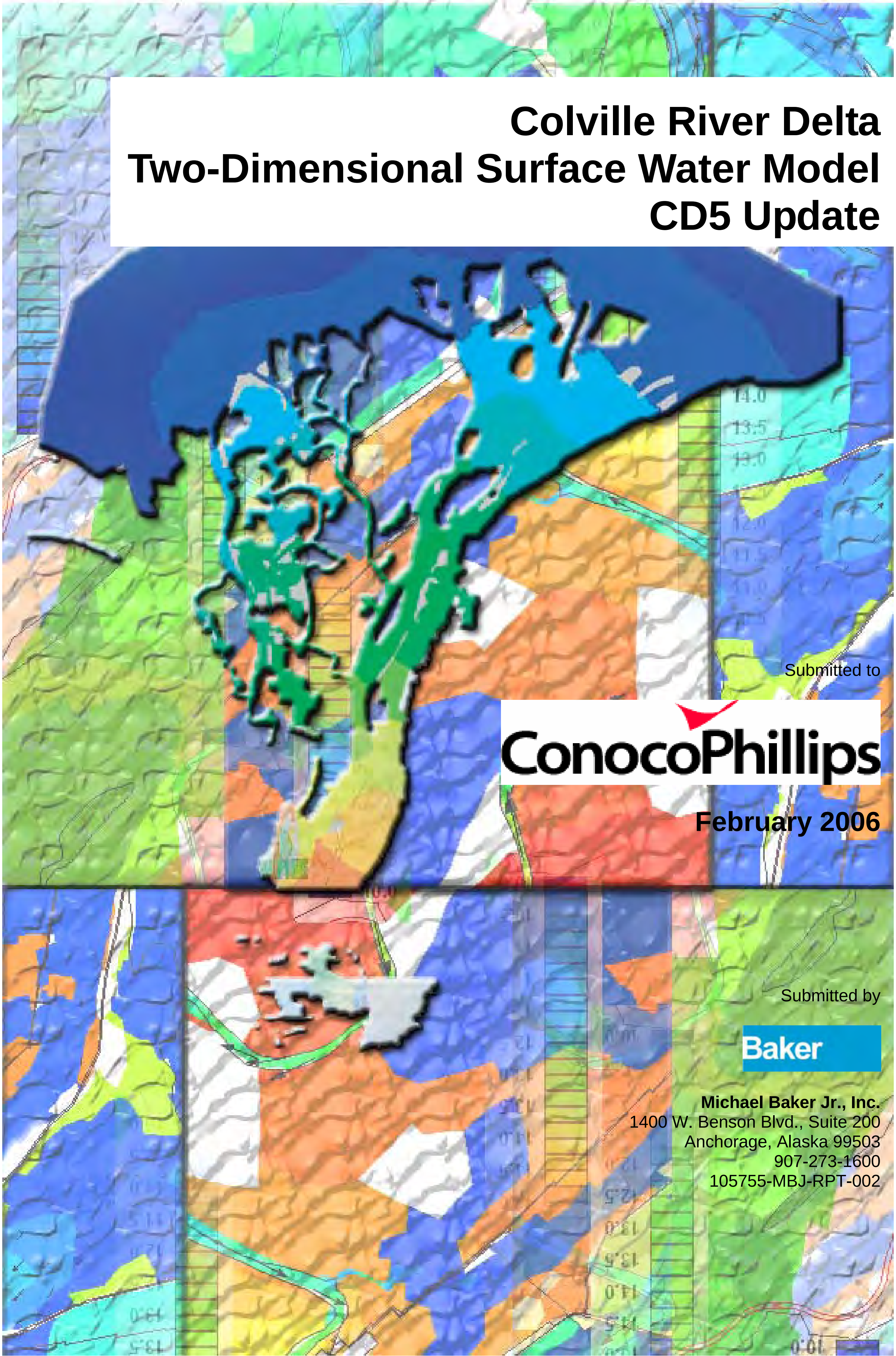
Colville River Delta Two-Dimensional Surface Water Model CD5 Update



Submitted to

ConocoPhillips

February 2006

Submitted by

Baker

Michael Baker Jr., Inc.
1400 W. Benson Blvd., Suite 200
Anchorage, Alaska 99503
907-273-1600

105755-MBJ-RPT-002

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Executive Summary

The proposed CD5 Satellite Facility is located west of the Colville River Delta in the NPRA. A road and pipeline are proposed to connect CD5 to Alpine (CD1/CD2), which is located in the Colville River Delta. The proposed road crosses the Nigliq Channel, the smaller of the two main Colville Delta channels, with a 1,250-foot combined road and pipeline bridge proposed to span the channel. A smaller 65-foot bridge (clear opening) will span a Paleo-channel located west of the Nigliq Channel. The location of the existing CD facilities and the proposed CD5 facility are shown on Figure ES-1.

The Colville River Delta two-dimensional surface water model (2-dimensional model) was originally created in 1997 to predict design flood conditions for the original CD1/CD2 facilities. In 2002, the model was updated to include the CD3/CD4 facilities. The model was once again updated in 2004 as part of the CD5 engineering and NEPA analysis. Multiple bridge openings were modeled as part of the CD5 road and bridge design and the results included as part of the Alpine Satellite Development Project Environmental Impact Statement (ASDP EIS).

In 2005, in accordance with the ASDP EIS Preferred Alternative requiring that the bridge span the 2-year floodplain, the proposed CD5 Bridge was moved approximately 1,000 feet north. The 1,200 foot bridge opening was shown to provide a good compromise between cost and hydraulic impacts. Bridge openings greater than 1,200 feet had little improvement on the hydraulic influences of the bridge, i.e., changes in predicted backwater were small as bridge length increased. The new crossing location allows the 1,250-foot bridge to span the entire bank-to-bank width of the channel.

Water surface elevation increases are predicted upstream of the proposed CD5 road for both the 50- and 200-year design events. Although the bridge spans the entire bank-to-bank width of the channel, overbank flows during these large and infrequent flood events will be diverted into the bridge opening and resulting backwater does occur. Smaller more frequent flood events, 10-year return interval or less, are not predicted to have backwater associated with the CD5 road. Predicted water surface elevations for the pre- and post-CD5 conditions during the 50- and 200-

year return intervals at selected locations are presented in Tables ES-1 and ES-2, respectively. The location ID is shown on Figure ES-1.

Table ES. 1 Q50 Water Surface Elevation Changes due to CD5

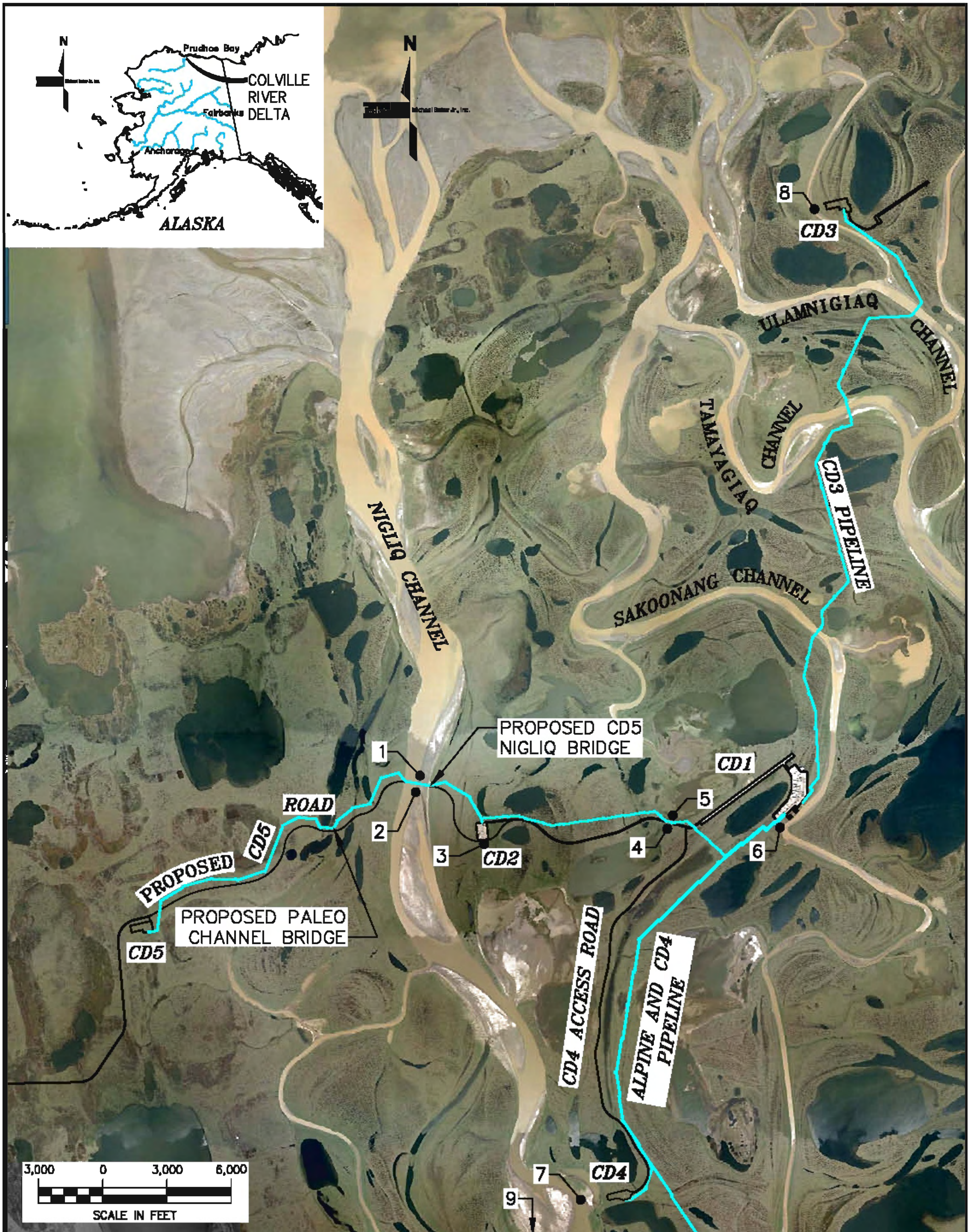
Location	ID	Pre-CD5	Post-CD5	Difference
Nigliq Channel Bridge - Downstream 500 feet	1	10.2	10.0	-0.2
Nigliq Channel Bridge - Upstream 500 feet	2	10.2	10.3	0.1
CD-2 Pad *(SW corner of pad, upstream CD5 road)*	3	11.6	12.1	0.5
Alpine Swale Upstream (PS#3)	4	11.8	12.0	0.2
Alpine Swale Downstream (PS#4)	5	10.1	10.1	0.0
Alpine Pad South *(southernmost pad corner)*	6	12.7	12.7	0.0
CD4 - Adjacent Nigliq Channel	7	13.8	14.0	0.2
CD3 - Adjacent Channel	8	7.1	7.1	0.0
Nigliq Channel near Nuiqsut	9	18.7	18.7	0.0

Table ES. 2 Q200 Water Surface Elevation Changes due to CD5

	ID	Pre-CD5	Post-CD5	Difference
Nigliq Channel Bridge - Downstream 500 feet	1	12.1	11.7	-0.4
Nigliq Channel Bridge - Upstream 500 feet	2	12.1	12.3	0.2
CD-2 Pad *(SW corner of pad, upstream CD5 road)*	3	13.5	14.4	0.9
Alpine Swale Upstream (PS#3)	4	13.9	14.4	0.5
Alpine Swale Downstream (PS#4)	5	11.7	11.7	0.0
Alpine Pad South *(southernmost pad corner)*	6	15.0	15.1	0.1
CD4 - Adjacent Nigliq Channel	7	16.0	16.3	0.3
CD3 - Adjacent Channel	8	7.9	7.9	0.0
Nigliq Channel near Nuiqsut	9	21.0	21.0	0.0

Water surface elevations are predicted to increase the greatest just upstream of the CD5 Bridge and near the CD2 facility pad. Backwater impacts decrease in magnitude away from the bridge. Although water surface elevations are predicted to increase at the existing gravel facilities, none of the original design criteria with respect to flooding has been compromised. The elevations of all gravel facilities remain above their original design criteria with respect to flooding; 200-year water surface elevation plus 1 foot of freeboard for facility pads and 50-year water surface elevation plus 3 feet of freeboard for roads. The overall area of inundation changes little due to the CD5 road.

Water velocities increase through the bridge during the 50- and 200-year model predictions. The increase in velocity through the bridge will increase the scour in the channel during flood events greater than the 10-year event. Scour due to the bridge is not predicted during the 10-year event because the bridge spans the open water and does not influence flows. Downstream of the proposed road, water velocities on the floodplains generally decrease, although the area of inundation generally remains the same.



Michael Baker Jr., Inc.

ConocoPhillips Alaska, Inc.

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Section 1.0 Introduction

Since 1997, two-dimensional surface water modeling has been used to predict water surface elevations and velocities in the Colville River Delta. The model has proven to be a reliable tool and has been integral in the design of the Alpine Oil Field (Alpine) and the proposed expansion into the National Petroleum Reserve–Alaska (NPRA). The Alpine facilities are owned and operated by ConocoPhillips, Alaska, Inc. (CPAI). CPAI plans to develop the CD5 Satellite Facility, located west of the Colville River Delta, as part of the Alpine Satellites Development Project (ASDP).

The Colville River Delta two-dimensional surface water model (2-dimensional model) was created (Shannon & Wilson 1997) to provide peak water surface elevations and velocity magnitudes for the design of the Alpine CD1 and CD2 facilities and pipeline. It was updated in 2002 to reflect the addition of the CD3 and CD4 facilities (Baker 2002). In addition to providing design values, the model was used to estimate the impact these facilities would have on the environment with respect to large spring floods.

Michael Baker, Jr., Inc. (Baker) has been involved with the model since its development. This report presents Baker's CD5 update of the 2-dimensional model. This update includes the proposed CD5 facilities and the current configurations of CD3 and CD4, which have had minor modifications since the 2002 update. The updated model was used to estimate water surface elevations and velocity magnitudes for the 2-, 10-, 50-, and 200-year spring breakup floods. Model output from the 50- and 200-year flood events was used in support of bridge design and will be used to set design criteria for the minimum elevation of the proposed CD5 gravel facilities and pipelines with respect to floodwaters.

The intent of this report is to provide the reader with an understanding of how the model was developed, what the major milestone updates have been, as well as present and discuss the recent modeling results. A background discussion of the 2-dimensional model is provided in Section 2.0. Model updates and enhancements completed for the proposed CD5 project are provided in

Section 3.0. The modeling results and discussion are described in Section 4.0. Appendices A and B present the tables and figures that illustrate these results and discussions.

The CD5 road begins at the existing CD2 pad and traverses west across the delta to the CD5 pad location. Two bridges are proposed along the access road. The first crosses the Nigliq Channel and the second crosses a smaller Paleo channel west of the Nigliq Channel. Data from the 2-dimensional model were used to develop design scour estimates for both the Nigliq Channel Bridge and Paleo Channel Bridge. A discussion on bridge scour methods and results is presented in a Project Note already submitted to CPAI and contained in this report as Appendix C.

Figure ES. 1 is an area map showing features and locations discussed in this report.

It should be noted that these predictions are for open water conditions and that the presence of ice and snow can have localized effects on flood waters. However, for the larger design flood events, localized ice and snow will have a much lower influence on overall water surface elevations.

All elevations presented in this report are in feet and are referenced to the British Petroleum Mean Sea Level (BPMSL).

Section 2.0 Background

1997. The 2-dimensional model developed in 1997 was used to predict peak water surface elevations and velocities for 50-, 100-, and 200-year flood events as part of the original Alpine facilities (CD1 and CD2) design. The original report was published in 1997 (Shannon & Wilson).

1998. CD1 and CD2. In the fall of 1997, field surveys conducted in the area of the proposed Alpine facilities showed that a portion of the ground surface elevations used to develop the original finite element mesh did not match the project datum (BPMSL) particularly well. Consequently, the ground surface elevations of the finite element mesh were improved to match the 1997 field surveys. In addition to the revised topography, the finite element mesh along the proposed facility road was updated to reflect the March 1998 proposed alignment. This included the addition of the proposed 440-foot bridge with spill-through abutments (only a single bridge was anticipated at that time). The model was rerun and the analysis presented in a project update report (Baker 1998b). The data from this publication became the hydrology design basis for the CD1 and CD2 facility designs.

2001. CD1 and CD2. Model runs for the 2- and 10-year floods were completed in the spring of 2001 (Baker 2001). The purpose of this analysis was not for design, but to address permit stipulations required by the U.S. Army Corps of Engineers for floodwater monitoring in and around the CD1 and CD2 facilities. The finite element mesh that was developed in 1998 was used to initiate modeling for the 2- and 10-year flood events. A two-stage approach was adopted for this modeling program. The first stage consisted of taking the finite element mesh generated in 1998 and running the 2- and 10-year peak discharges until the convergence tolerances of the model were satisfied. The second stage was to input the as-built bridge configurations at Alpine and rerun the simulations. Modifications made to the mesh included the addition of a second smaller bridge (which was added to the design after the original model was run) and the widening of the larger bridge to account for its vertical abutments.

2002. CD3 and CD4. In 2002, the model was again updated to incorporate the proposed CD3 (CD-North) and CD4 (CD-South) satellite developments. The model was used to evaluate the impacts of the proposed facilities on water surface elevations and velocities within the existing facilities as well as the proposed facilities. Model runs for the 10-, 50-, and 200-year return events were completed. Modifications to the model included new topography at the CD3 and CD4 facility locations and modifications to the mesh to include the proposed facilities. Topography changes were made only on the floodplains and no channel modifications were made. Boundary conditions were not changed for the 2002 update. The update results were published in May 2002 (Baker).

2004. CD5. In March of 2004 another modeling report was published (Baker 2004). This modeling effort was conducted during the early stages of design for the CD5 road and bridge alignment. The modeling supported both the engineering design process and the development of the ASDP environmental impact statement (EIS) (BLM 2004). New channel topography at the proposed bridge crossing was added to the model as well as updates of the finite element mesh to simulate the proposed road. Three bridge lengths were modeled to evaluate the hydrologic and hydraulic effects of the CD5 road and bridge on the existing facilities. Eleven model runs were completed for the different bridge lengths at the 10-, 50-, and 200-year flood events.

2006. Updated CD5. At the time of the 2004 analysis, the CD5 project was still in the conceptual design stages and the initial results were published to support the alternatives analyses of the EIS. The proposed CD5 Nigliq Bridge was located due west of the CD2 pad. The current design has the CD5 Nigliq Channel Bridge approximately 1,000 feet north of the previous location. The new bridge location, modified road alignment, and the inclusion of 2005 survey data at the new bridge location are the changes to the model since the 2004 publication. The recent changes are described in detail throughout this report.

Table 2.1 Overview 2-dimensional model nomenclature

Year	Alpine Facilities	Model referred to as
1998 / 2001	CD1 and CD2	original CD1/CD2 models
2002	CD3 and CD4	CD3/CD4 model
2004 / 2006	CD5	CD5 model

Section 3.0 CD5 Model Update and Enhancements

3.1 Modeling Software

The 2-dimensional model is the product of two computer programs. The finite element mesh was developed using a pre- and post-processing software titled Surface Water Modeling System (SMS) developed by Brigham Young University. The original model was developed using version 4.1. Subsequent analyses were developed using version 6.0 and version 7.0. The current update used the most recent update to SMS, version 8.0. SMS is used to not only create the finite element mesh, but also to analyze the modeling results and generate output graphics. The computer program developed by the U.S. Geological Survey, Finite Element Surface-Water Modeling System: Two-Dimensional Flow in a Horizontal Plane (FESWMS), performs the numerical computation of the modeling system. FESWMS version 2 (modified by David Froehlich, one of the original authors, to handle a greater number of elements) was used in the original analysis and subsequent analyses through April 2001 (Froehlich 1996). Version 3.2 of FESWMS supplied by EMS-I (also the suppliers of SMS) was used for this modeling effort.

3.2 Topographic Base Map

Enhancements in the Nigliq Channel and adjacent floodplain in the CD5 road vicinity were made to the topographic base map, which was developed as part of the CD3/CD4 update (Baker 2002). The base map was also updated with topography collected in both 2004 (LCMF 2004) and July 2005 (LCMF 2005a). The extent of the new topography is shown on Figure B1.

The data were provided in vertical datum BPMSL and horizontal datum NAD83, Alaska State Plane, Zone 4. The original model and subsequent updates were in NAD27, Alaska State Plane, Zone 4 horizontal datum, and the new topography data were converted to NAD27 for inclusion. The current CD5 project horizontal coordinate system is in NAD 83, but the model has remained in NAD 27 to provide continuity and allow the use of past model data. The vertical datum was unchanged.

3.3 Finite Element Mesh

The finite element mesh was modified in two areas. The first change was to revise the CD4 road alignment in the vicinity of Lake L9323 just north of the CD4 drill pad. The proposed road alignment in 2002 went through a narrow section of the lake. Subsequent to the modeling effort, the road alignment was changed to go east around the lake before connecting to the drill pad. The finite element mesh has been updated to reflect the current CD4 road alignment.

The second change added the CD5 road. The mesh was enhanced to provide greater definition along the road alignment and in the Nigliq Channel at the proposed bridge crossing location. Material properties for each element (hydraulic roughness coefficients and kinematic eddy viscosity) and material boundaries were adjusted based on the new mesh, but were not changed spatially.

3.4 Boundary Conditions

Downstream and upstream boundary conditions were unchanged. The following sections summarize the boundary conditions.

3.4.1 Downstream Boundary

The downstream boundary condition was set at a constant water surface elevation of 3 feet (BPMSL). The water surface elevation of 3 feet was based on conditions observed during the 1996 breakup and thought to be relatively conservative. Water surface elevation measurements made near the coast since 1996 suggest that a downstream boundary of 3 feet is still reasonable. There have been no observations to date indicating a different downstream boundary condition is necessary.

3.4.2 Upstream Boundary

The upstream boundary condition is based on a steady state discharge. Discharge values are based on design flood frequency estimates for the Colville River (Baker and Hydroconsult 2002). A summary of design flood frequency estimates is presented in Table A1. Discharge due to spring flooding is generally not a steady state condition and flood peaks are attenuated by natural features of the delta (i.e., temporary floodwater storage). Thus, the steady state conditions of the 2-dimensional model are thought to be somewhat conservative.

3.5 Element Status

The tolerance limits set to define when an element turns “on” or “off’ was unchanged. An element that is turned “on” is considered in the numerical computations while an element that is turned “off” is not. The tolerance limit remains set at 1 foot. Thus, if an element was already considered on, it would be turned off when the water surface elevation fell 1 foot below the elevation of the highest node on that element. If an element was considered off, it would be turned on when the water surface elevation was 1 foot higher than the highest node on that element.

Elements that are turned off are generally those that are dry or only partially covered with water. In some cases, an element that is considered off may in fact be completely covered with water; however, the water surface elevation is below the depth tolerance to turn the element on. The depth of water for an element that is turned off, but which would be inundated based on topography, is always less than 1 foot.

Section 4.0 Results and Discussion

The CD5 model was used to complete model runs for the 2-, 10-, 50-, and 200-year flood events for both existing conditions and post-CD5 conditions. To simulate the proposed CD5 facilities, the finite element mesh (enhanced with the most recent topography) was modified to include the proposed gravel road and bridges over the Nigliq and Paleo Channels. The height of the gravel road was set so that water was prevented from flowing over it at any point. The only CD5 roadway openings simulated are the Nigliq and Paleo Channel bridges. Culverts for local drainage designed into the roadway are not included as they would not affect the overall hydrologic conditions.

The results of the updated modeling are divided into five groups: the delta, CD1 and CD2 (original Alpine development), CD3, CD4, and CD5. Discussions of each are presented in the following sections as well as illustrated in the tables and figures (Appendices A and B).

The CD5 model runs have been compared to the original CD1/CD2 (1998/2001) model runs, as well as the CD3/CD4 (2002) model runs, where applicable, to show the changes in model predictions as development has progressed in the delta. The CD5 model comparisons with the original CD1/CD2 models show the predicted CD5 development hydrologic conditions against the original model design criteria and are generally presented for information. The comparisons with the CD3/CD4 models show the predicted hydrologic changes due to CD5 against the existing conditions and the discussion text focuses on these comparisons.

4.1 Colville River Delta

Peak water surface elevations for the 10-, 50-, and 200-year floods in the main channels throughout the delta are presented in Tables A2 through A4. In addition to presenting the current modeling results with the proposed CD5 facilities, these tables present the results from the original CD1/CD2 model runs, the CD3/CD4 model runs (existing conditions), and compare each of these to the CD5 model runs. For consistency in comparing data, the tables present data at the identical channel location from the past studies. Channel locations and mile indicators are presented on Figure B2

The only notable changes in water surface elevations are in the Nigliq Channel upstream of the proposed Nigliq Channel crossing. At mile 9.47 of the Nigliq Channel (approximately 2 miles upstream of the crossing) water surface elevation increases of 0.3, 0.4, and 0.7 feet are predicted for the 10-, 50-, and 200-year flood events, respectively. At mile 12.88, water surface elevation increases of 0.1, 0.1, and 0.3 feet are predicted for the 10-, 50-, and 200-year flood events, respectively.

4.2 CD1 and CD2 Facilities and Alpine Pipeline

Pipeline. The differences in peak water surface elevations between the original CD1/CD2 model, CD3/C4 model, and the post-CD5 conditions along the Alpine pipeline for the 50- and 200-year floods are presented in Tables A5 and A6, respectively. The locations of the CD1 and CD2 facilities and pipeline are shown on Figure B3. Water surface elevation decreases north of PI 06 are predicted for the 50- and 200-year flood events and are likely the result of the changes made to the CD4 road geometry. The water surface elevation increases south of PI 06 are 0.2 feet or less along the remaining length of pipeline.

Permanent Staff Gages. The differences in peak water surface elevations between the CD3/CD4 model results and the post-CD5 conditions for the 10-year flood event at the Alpine permanent staff gage locations are presented in Table A7. Locations of the permanent staff gages are shown on Figure B4. These permanent staff gages were installed to monitor water surface elevations during spring floods. A maximum peak water surface elevation increase of 0.3 feet occurs at Staff Gage 3 and Staff Gage 6, both located on the upstream side of the CD2 access road. Water surface elevation decreases are noted at Staff Gage 5 and Staff Gage 8, both downstream of the CD2 and CD5 access roads.

Gravel Facilities. The differences in peak water surface elevations between the CD3/CD4 model results and the post-CD5 conditions along the gravel facilities for the 50- and 200-year floods are presented in Tables A8 and A9, respectively. Stationing along the CD2 access road is shown on Figure B5.

Water surface elevation increases on the order of 0.6 feet and 1.1 feet on the upstream side of the CD5 access road are predicted at the CD2 pad during the 50- and 200-year events, respectively. Increases in water surface elevation on the order of 0.4 and 0.7 feet are predicted on the upstream side of the CD2 access road west of the CD4 road intersection during the 50-and 200-year events, respectively.

East of the CD4 road intersection, increases in water surface elevations do not occur and a 0.1 foot decrease in water surface elevation is predicted for both the 50- and 200-year flood events. This is due to the alignment of the CD4 access road which prevents cross flow from the west limiting the hydrologic effects of CD5 east of the CD4 road. Water surface elevation decreases from 0.7 to 0.1 feet are predicted downstream of the CD2 access road during the 50-year event and 0.9 to 0.1 during the 200-year event. The greatest water surface elevation decreases occur near the CD2 pad and lessen progressing to the east.

The CD5 access road creates backwater, which increases the water surface elevations upstream of the road while at the same time diverting flow downstream of the facilities and lowering water surface elevations in these areas. Flood extents, water surface elevation contours, and velocity vectors in the vicinity of the existing CD1/CD2 facilities and the proposed CD5 facilities are shown for both the pre- and post-CD5 conditions on Figures B6 through B21.

During lower magnitude flood events (i.e., the 10-year event and under), the CD5 access road is not predicted to cause significant changes to the hydrologic flow patterns around the existing facilities since the proposed bridge spans the bank-to-bank width of the active flow and does not cause backwater to occur. This is illustrated on the water surface elevation and depth averaged velocity Figures B9 through B12.

Of particular importance are the effects of the proposed CD5 facility on the design flood elevations of the existing facilities. The design elevations of the original CD1/CD2 facilities and subsequent CD3/CD4 were based on three criteria; design flood elevations, thermal design conditions, and wind wave requirements. The greatest elevation based on these three criteria ultimately determined the design heights of the facilities. The 2-dimensional modeling provided the design flood elevations.

Gravel facilities were designed for flood elevations based on the 200-year flood event plus 1 foot of freeboard. The CD1 design elevation was 19.0 feet (Baker 1998a) and is generally governed by thermal design. The highest predicted 200-year flood elevation at the CD1 pad is 15.4 feet during the post-CD5 condition. Including the 1 foot of freeboard the CD1 pad elevation remains above the design flood elevation criteria. The CD2 design elevation was 15.9 feet (Baker 1998a) and the post-CD5 predicted flood elevation is 14.6 feet. Adding the 1 foot of freeboard puts the CD2 design elevation criteria at 15.6 feet. The CD2 pad remains above the flood elevation criteria with freeboard. Both the CD1 and CD2 gravel pads maintain the design criteria during the post-CD5 condition.

The design criterion for the CD2 access road, with the exception of the Swale Area (portion of road between the existing Swale Bridges), was the 50-year flood elevation plus 3 feet of freeboard. The highest predicted flood elevation along the CD2 road during the post-CD5 condition is 12.3 feet. Including 3 feet of freeboard, the design elevation would be 15.3 feet. The design elevation of the road (Baker 1998a) is 15.9 feet and maintains the original design criteria with respect to flood elevations.

The Swale Area of the CD2 access road was designed to a lower elevation than the rest of the road and did not have the same criteria with respect to flood elevations. The low cord of the swale bridges (design elevation 10.8 feet) were designed lower than the 50-year flood elevation and the bridge deck (design elevation 13.0 feet) was designed to be overtopped during a 200-year event, but not the 50-year event. An increase in water surface elevation of 0.2 and 0.5 feet is predicted in the Swale Area during the post-CD5, 50-, and 200-year events, respectively. Based on the predictions from the post-CD5 runs, the bridges will be not be overtopped during a 50-year event (water surface elevation of 12.0), but will be during the 200-year event (water surface elevation of 14.4). While the water surface elevation increases by 0.5 feet during the 200-year event, there is no change in the Swale Area design conditions.

4.3 CD3 Facilities

Gravel Facilities. The peak water surface elevations and water velocities for the 200-year flood event for both the CD3/CD4 model conditions and proposed CD5 conditions and their relative differences at the CD3 gravel facilities are presented in Table A10. Only the 200-year flood conditions are presented since the pad and runway are based on the 200-year design criteria and no major roads are present.

In general, the CD5 development had very little effect on the hydrology at CD3. CD3 is far enough downstream of CD5 to be out of the influence of the bridge. In addition, the CD3 area is heavily influenced by the Sakoonang and Tamayayak Channels which diverge off the East Channel.

The average water surface elevation during the 200-year flood event in the vicinity of the facility pad decreased from 7.4 feet to 7.3 feet and the maximum predicted water surface elevation on the upstream (southern) side of the pad decreased from 8.3 to 8.2 feet for the post-CD5 condition. The largest change in predicted water surface elevations was a decrease of 0.3 feet at the southwest corner of the pad and the largest velocity change was an increase of 0.2 feet per second at the same location. The maximum predicted water velocity predicted is 2.5 feet per second at the northwest corner of the pad during the 200-year flood event.

The CD3 pad and airstrip sit on the floodplain between the West Ulamnigiaq and East Ulamnigiaq Channels. This area is not predicted to be inundated during lower magnitude flood events (10-year and smaller). Water depths in this area are generally less than 2.0 feet during the 200-year flood event. Recharge to the floodplain on the northern side of the facilities is expected during large flood events due to the floodplain proximity with the surrounding channels and the local topography.

Pipeline. The peak water surface elevations and water velocities for the 200-year flood event along the CD3 pipeline are presented in Table A11 and the location of and stationing along the pipeline is presented on Figure B22. Decreases in water surface elevations on the order of 0.1 to 0.2 feet are predicted along the entire length of the pipeline. The influence of CD5 on the CD3 pipeline is minimal since the entire pipeline is downstream of the CD2 and CD5 access roads and is also influenced by the East Channel flows.

4.4 CD4 Facilities

The peak water surface elevations and water velocities for the 50- and 200-year flood event for both the CD3/CD4 model conditions and proposed CD5 conditions and their relative differences along the CD4 gravel road and pad are presented in Tables A12 and A13, respectively. The location and stationing of the CD4 access road and pipeline are presented on Figure B23.

The average water surface elevation during the 200-year flood event (the design event for the pad) in the vicinity of the proposed pad location changed from 16.1 feet to 16.3 feet and the maximum predicted water surface elevation changed from 16.4 feet to 16.7 feet. The water surface elevation increases are the result of backwater in the Nigliq Channel from the proposed CD5 Nigliq Channel Bridge. A review of the CD4 As-Built Survey (LCMF 2005b) shows the average pad elevation at approximately 19.5 feet. The pad elevation remains well above the minimum design flood elevation based on the CD5 model runs of 17.7 feet (Q200 plus 1 foot freeboard). Predicted water velocities at the pad remain relatively unchanged.

Water surface elevations along the east side of the CD4 access road during the 50-year flood event (the design event for the road) range from 14.5 feet at the southern end to 10.7 feet at the junction with the existing CD2 access road to the north and generally decrease 0.1 to 0.2 feet from the CD3/CD4 model runs. Water surface elevations along the west side of the road range from 14.0 feet at the southern end to 11.8 feet at the northern end representing a general increase of 0.4 to 0.3 feet from the CD3/CD4 model runs. The water surface elevation increases on the west side of the road are due to the backwater generated from the CD5 Nigliq Channel Bridge. The decreases on the east side of the road are likely due to the changes in road configuration modeled to reflect the existing road conditions. Predicted water velocities along the road remain relatively unchanged.

4.4 CD5 Facilities

The peak water surface elevations for the 50- and 200-year flood event for both the CD3/CD4 model conditions and proposed CD5 conditions and their relative differences along the CD5 gravel road are presented in Tables A15 and A16, respectively. Water velocities for both the 50- and 200-year flood event are presented on Table A17. The location and stationing of the CD5 access road and CD5 pipeline are presented on Figure B24.

The presence of the CD5 access road blocks flow across the floodplain west of CD2 and causes increases in predicted water surface elevations for both the 50- and 200-year floods upstream (south) of the road. The maximum increase in water surface elevation for the 50-year flood is 0.7 feet and the maximum increase for the 200-year flood is 1.2 feet. Because the CD5 Nigliq Channel Bridge spans the entire bank-to-bank width of the Nigliq Channel, backwater effects are only predicted for floods greater than the 10-year event. Flooding extents for the 10-year event are generally within the main channel and the presence of the bridge does not cause additional backwater. Predicted flooding extents are shown on Figures B6 through B21.

Water surface elevations downstream of the road decrease with the inclusion of the CD5 access road. The road blocks flow on the floodplain and diverts the overbank flows through the bridge opening. Consequently, water surface elevations on the floodplain downstream of the bridge are reduced. Water still inundates approximately the same area; however, water velocities are lower and the water surface elevation is lower by approximately 1 foot.

Water surface elevations and velocities along the proposed CD5 pipeline for 50- and 200-year flood events are presented in Table A18. The pipeline alignment was provided by NANA-Colt Engineering and represents the 30% design package (NANA-Colt 2005). The CD5 pipeline is located downstream of the proposed CD5 access road and water velocities are relatively low due to the blockage of flow on the floodplain. Pipeline PI locations are shown on Figure B24.

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Appendix A   Tables

Table A1: Design Flood Frequency Relationship at Head of Delta

Table A2: Comparison of the 10-Year Flood Water Surface Elevations Within the Channels

Table A3: Comparison of the 50-Year Flood Water Surface Elevations Within the Channels

Table A4: Comparison of the 200-Year Flood Water Surface Elevations Within the Channels

Table A5: Comparison of the 50-Year Flood Water Surface Elevations Along the Alpine Pipeline

Table A6: Comparison of the 200-Year Flood Water Surface Elevations Along the Alpine Pipeline

Table A7: Comparison of the 10-Year Flood Water Surface Elevations At Permanent Staff Gage Locations

Table A8: Comparison of the 50-Year Flood Water Surface Elevations Along the Alpine Facilities Road

Table A9: Comparison of the 200-Year Flood Water Surface Elevations Along the Alpine Facilities Road

Table A10: Water Surface Elevations and Water Velocities Along the CD3 Pad, Road, and Runway During the 200-Year Flood

Table A11: Water Surface Elevations and Water Velocities Along the CD3 Pipeline During the 200-Year Flood

Table A12: Water Surface Elevations and Water Velocities Along the CD4 Access Road During the 50-Year Flood

Table A13: Water Surface Elevations and Water Velocities Along the CD4 Access Road During the 200-Year Flood

Table A14: Water Surface Elevations and Water Velocities Along the CD4 Pipeline During the 200-Year Flood

Table A15: Comparison of the 50-Year Flood Water Surface Elevations Along the CD5 Access Road

Table A16: Comparison of the 200-Year Flood Water Surface Elevations Along the CD5 Access Road

Table A17: Water Velocities Along the CD5 Access Road During the 50-Year and 200-Year Flood

Table A18: Water Surface Elevations and Water Velocities Along the CD5 Pipeline During the 50-Year and 200-Year Flood

Table A1: Design Flood Frequency Relationship at Head of Delta

Return Period	Design Flood-Peak Discharge (cfs)
2-Year	240,000
5-Year	370,000
10-Year	470,000
25-Year	610,000
50-Year	730,000
100Year	860,000
200-Year	1,000,000
500-Year	1,300,000

Table A2: Comparison of the 10-Year Flood Water Surface Elevations Within the Channels

Location	State Plane Coordinates (1)		Peak Water Surface Elevation (ft)			Water Surface Elevation	
	Northing	Easting	2001 CD1 & CD2 Facilities (2)	2002 CD3 & CD4 Facilities (3)	2005 Proposed CD5 Facilities (4)	2005 Proposed CD5 vs 2001 CD1 & CD2	2005 Proposed CD5 vs 2002 CD3 & CD4
East Channel							
Near E27.09	5,909,644	385,761	19.4	19.4	19.3	0.1	**-0.1**
Near E24.92	5,919,492	390,811	18.2	18.3	18.3	-0.1	**0.0**
Near E22.75	5,929,386	397,802	17.2	17.3	17.3	-0.1	**0.0**
Near E20.56	5,940,315	396,669	15.7	15.7	15.7	0.0	**0.0**
Near E18.47	5,949,082	400,872	14.5	14.6	14.6	-0.1	**0.0**
Near E16.32	5,959,033	406,361	13.2	13.3	13.3	-0.1	**0.0**
Near E14.32	5,969,545	410,047	11.8	11.9	11.8	0.0	**-0.1**
Near E09.76	5,984,872	427,058	9.0	9.0	9.0	0.0	**0.0**
Near E03.00	6,007,417	456,601	4.3	4.3	4.3	0.0	**0.0**
Kupigruik Channel							
Near K11.65	5,988,634	414,617	9.5	9.5	9.5	0.0	**0.0**
Nechelik Channel							
Near N22.65	5,922,041	385,366	17.5	17.5	17.6	0.1	**0.1**
Near N19.95	5,933,329	386,019	16.5	16.6	16.6	0.1	**0.0**
Near N17.8	5,934,291	377,889	14.4	14.4	14.5	0.1	**0.1**
Near N15.07	5,941,514	373,720	12.2	12.3	12.4	0.2	**0.1**
Near N12.88	5,952,813	375,779	10.7	10.9	11.0	0.3	**0.1**
Near N09.47	5,968,025	370,955	8.6	8.6	8.9	0.3	**0.3**
Near N07.47	5,976,223	368,261	7.2	7.2	7.1	-0.1	**0.0**
Near N05.42	5,987,622	367,793	5.8	5.8	5.9	0.1	**0.0**
Near N02.03	6,006,506	368,960	3.4	3.4	3.4	0.0	**0.0**
Sakoonang Channel							
Near S16.52	5,946,219	393,958	15.3	15.3	15.3	0.0	**0.0**
Near S13.07	5,957,945	385,965	11.5	11.2	11.0	-0.5	**-0.2**
Near S09.80	5,968,672	390,519	9.8	9.6	9.6	-0.2	**0.0**
Near S05.07	5,985,818	384,698	8.2	8.2	8.2	0.0	**0.0**
Near S01.38	5,991,840	377,691	7.1	7.1	7.1	0.0	**0.0**
Tamayayak Channel							
Near T12.62	5,972,400	397,793	11.3	11.3	11.3	0.0	**0.0**
Near T08.20	5,992,255	391,674	8.9	8.9	8.8	-0.1	**-0.1**

Notes:
1. All elevations are reported in BPMSL, and coordinates are reported in Alaska State Plane, Zone 4, NAD27.
2. Water surface elevations from the report: Michael Baker Jr., Inc., 2001. *Colville River Delta, 2- and 10-Year Flood Models* , Prepared for Phillips Alaska, Inc., Anchorage, Alaska.
3. Existing CD3 & CD4 Facilities water surface elevations based on 2002 model output: 10_New_Facilities_d(2).flo.
4. Proposed CD5 Facilities water surface elevations based on model output: 10_CD5_d(1).flo.

Table A3: Comparison of the 50-Year Flood Water Surface Elevations Within the Channels

Location	State Plane Coordinates (1)		Peak Water Surface Elevation (ft)			Water Surface Elevation	
	Northing	Easting	1998 CD1 & CD2 Facilities (2)	2002 CD3 & CD4 Facilities (3)	2005 Proposed CD5 Facilities (4)	2005 Proposed CD5 vs 1998 CD1 & CD2	2005 Proposed CD5 vs 2002 CD3 & CD4
East Channel							
Near E27.09	5,909,644	385,761	23.4	23.4	23.4	0.0	**0.0**
Near E24.92	5,919,492	390,811	22.1	22.1	22.1	0.0	**0.0**
Near E22.75	5,929,386	397,802	20.8	20.8	20.8	0.0	**0.0**
Near E20.56	5,940,315	396,669	18.8	18.8	18.7	-0.1	**-0.1**
Near E18.47	5,949,082	400,872	17.6	17.5	17.5	-0.1	**0.0**
Near E16.32	5,959,033	406,361	16.0	15.9	15.9	-0.1	**0.0**
Near E14.32	5,969,545	410,047	14.1	14.1	14.1	0.0	**0.0**
Near E09.76	5,984,872	427,058	10.7	10.6	10.6	-0.1	**0.0**
Near E03.00	6,007,417	456,601	4.9	4.8	4.8	-0.1	**0.0**
Kupigruik Channel							
Near K11.65	5,988,634	414,617	11.3	11.2	11.0	-0.3	**-0.2**
Nechelik Channel							
Near N22.65	5,922,041	385,366	21.5	21.5	21.5	0.0	**0.0**
Near N19.95	5,933,329	386,019	19.7	19.7	19.7	0.0	**0.0**
Near N17.8	5,934,291	377,889	17.4	17.5	17.5	0.1	**0.0**
Near N15.07	5,941,514	373,720	15.0	15.1	15.2	0.2	**0.1**
Near N12.88	5,952,813	375,779	14.0	14.2	14.3	0.3	**0.1**
Near N09.47	5,968,025	370,955	11.8	11.8	12.2	0.4	**0.4**
Near N07.47	5,976,223	368,261	10.3	10.3	10.3	0.0	**0.0**
Near N05.42	5,987,622	367,793	8.1	8.2	8.2	0.1	**0.0**
Near N02.03	6,006,506	368,960	3.9	4.0	3.9	0.0	**-0.1**
Sakoonang Channel							
Near S16.52	5,946,219	393,958	18.3	18.3	18.3	0.0	**0.0**
Near S13.07	5,957,945	385,965	14.3	14.9	14.9	0.6	**0.0**
Near S09.80	5,968,672	390,519	12.2	13.2	13.4	1.2	**0.2**
Near S05.07	5,985,818	384,698	10.2	10.7	10.6	0.4	**-0.1**
Near S01.38	5,991,840	377,691	8.1	8.3	8.2	0.1	**-0.1**
Tamayayak Channel							
Near T12.62	5,972,400	397,793	13.2	13.1	13.0	-0.2	**-0.1**
Near T08.20	5,992,255	391,674	10.1	10.0	9.9	-0.2	**-0.1**

Notes:
1. All elevations are reported in BPMSL, and coordinates are reported in Alaska State Plane, Zone 4, NAD27.
2. Water surface elevations from the report: Michael Baker Jr., Inc., 1998. *Colville River Delta, Two-Dimensional Surface Water Model, Project Update* , Prepared for ARCO Alaska, Inc., Anchorage, Alaska.
3. Existing CD3 & CD4 Facilities water surface elevations based on 2002 model output: 50_New_Facilities_c(1).flo .
4. Proposed CD5 Facilities water surface elevations based on model output: 50_CD5_g(1).flo.

Table A4: Comparison of the 200-Year Flood Water Surface Elevations Within the Channels

Location	State Plane Coordinates (1)		Peak Water Surface Elevation (ft)			Difference in Peak Water Surface Elevation	
	Northing	Easting	1998 CD1 & CD2 Facilities (2)	2002 CD3 & CD4 Facilities (3)	2005 Proposed CD5 Facilities (4)	2005 Proposed CD5 vs 1998 CD1 & CD2	2005 Proposed CD5 vs 2002 CD3 & CD4
East Channel							
Near E27.09	5,909,644	385,761	26.4	26.4	26.4	0.0	**0.0**
Near E24.92	5,919,492	390,811	24.9	24.9	24.9	0.0	**0.0**
Near E22.75	5,929,386	397,802	23.4	23.4	23.4	0.0	**0.0**
Near E20.56	5,940,315	396,669	21.0	21.0	21.0	0.0	**0.0**
Near E18.47	5,949,082	400,872	19.7	19.7	19.7	0.0	**0.0**
Near E16.32	5,959,033	406,361	17.8	17.9	17.8	0.0	**-0.1**
Near E14.32	5,969,545	410,047	15.7	15.8	15.7	0.0	**-0.1**
Near E09.76	5,984,872	427,058	11.8	11.9	11.8	0.0	**-0.1**
Near E03.00	6,007,417	456,601	5.3	5.4	5.3	0.0	**-0.1**
Kupigruik Channel							
Near K11.65	5,988,634	414,617	12.1	12.4	12.1	0.0	**-0.3**
Nechelik Channel							
Near N22.65	5,922,041	385,366	24.3	24.3	24.3	0.0	**0.0**
Near N19.95	5,933,329	386,019	22.0	22.0	22.0	0.0	**0.0**
Near N17.8	5,934,291	377,889	19.7	19.7	19.8	0.1	**0.1**
Near N15.07	5,941,514	373,720	17.3	17.4	17.6	0.3	**0.2**
Near N12.88	5,952,813	375,779	16.4	16.4	16.7	0.3	**0.3**
Near N09.47	5,968,025	370,955	14.1	13.9	14.6	0.5	**0.7**
Near N07.47	5,976,223	368,261	12.3	12.3	12.3	0.0	**0.0**
Near N05.42	5,987,622	367,793	9.8	9.7	9.7	-0.1	**0.0**
Near N02.03	6,006,506	368,960	4.4	4.4	4.4	0.0	**0.0**
Sakoonang Channel							
Near S16.52	5,946,219	393,958	20.5	20.5	20.5	0.0	**0.0**
Near S13.07	5,957,945	385,965	16.4	16.9	17.0	0.6	**0.1**
Near S09.80	5,968,672	390,519	14.8	15.8	15.6	0.8	**-0.2**
Near S05.07	5,985,818	384,698	11.9	12.4	12.1	0.2	**-0.3**
Near S01.38	5,991,840	377,691	9.5	9.7	9.5	0.0	**-0.2**
Tamayayak Channel							
Near T12.62	5,972,400	397,793	14.2	14.3	14.3	0.1	**0.0**
Near T08.20	5,992,255	391,674	10.8	10.9	10.6	-0.2	**-0.3**

Notes:
1. All elevations are reported in BPMSL, and coordinates are reported in Alaska State Plane, Zone 4, NAD27.
2. Water surface elevations from the report: Michael Baker Jr., Inc., 1998. *Colville River Delta, Two-Dimensional Surface Water Model, Project Update* , Prepared for ARCO Alaska, Inc., Anchorage, Alaska.
3. Existing CD3 & CD4 Facilities water surface elevations based on 2002 model output: 200_New_Facilities_i(1).flo.
4. Proposed CD5 Facilities water surface elevations based on model output: 200_CD5_g(1).flo.

Table A5: Comparison of the 50-Year Flood Water Surface Elevations Along the Alpine Pipeline

Location	State Plane Coordinates (1)		Peak Water Surface Elevation (ft)			Difference in Water Surface Elevation (5)	
	Northing	Easting	1998 CD1 & CD2 Facilities (2)	2002 Facilities - CD3 & CD4 (3)	2005 Proposed CD5 Facilities (4)	2005 Proposed CD5 vs 1998 CD1 & CD2	2005 Proposed CD5 vs 2002 CD3 & CD4
PI 01B	5,977,102	385,426	12.1	13.0	12.9	0.8	**-0.1**
PI 03	5,973,060	382,705	12.1	13.0	12.9	0.8	**-0.1**
PI 04	5,969,486	378,985	12.1	13.1	12.9	0.8	**-0.2**
PI 05	5,963,244	377,899	12.5	13.1	12.9	0.4	**-0.2**
PI 06	5,960,993	378,208	12.8	13.3	12.9	0.1	**-0.4**
PI 07	5,954,169	382,629	14.7	14.6	15.0	0.3	**0.4**
PI 08	5,952,674	382,609	14.8	15.0	15.1	0.3	**0.1**
PI 09	5,951,162	383,482	14.8	15.0	15.1	0.3	**0.1**
PI 10	5,949,730	384,843	15.3	15.4	15.5	0.2	**0.1**
PI 11	5,946,188	392,113	15.9	15.9	16.0	0.1	**0.1**
PI 12A	5,944,918	393,140	15.9	15.9	16.0	0.1	**0.1**
PI 13A	5,939,750	393,804	18.9	19.0	19.0	0.1	**0.0**
PI 14A	5,939,641	398,674	18.8	18.6	18.6	-0.2	**0.0**
PI 15A	5,935,517	401,684	20.0	20.0	20.0	0.0	**0.0**

Notes:
1. All elevations are reported in BPMSL, and coordinates are reported in Alaska State Plane, Zone 4, NAD27.
2. Water surface elevations from the report: Michael Baker Jr., Inc., 1998. *Colville River Delta, Two-Dimensional Surface Water Model, Project Update* , Prepared for ARCO Alaska, Inc., Anchorage, Alaska.
3. Existing CD3 & CD4 Facilities water surface elevations based on 2002 model output: 50_New_Facilities_c(1).flo.
4. Proposed CD5 Facilities water surface elevations based on model output: 50_CD5_g(1).flo.
5. The difference in water surface elevation is positive when the more recent year's value (e.g. 2002) is higher than the previous year's value (e.g. 1998) and negative when the more recent year's value (e.g. 2002) is lower than the previous year's value (e.g. 1998)

Table A6: Comparison of the 200-Year Flood Water Surface Elevations Along the Alpine Pipeline

Location	State Plane Coordinates (1)		Peak Water Surface Elevation (ft)			Difference in Water Surface Elevation (5)	
	Northing	Easting	July 1998 CD1 & CD2 Facilities (2)	2002 Facilities - CD3 & CD4 (3)	2005 Proposed CD5 Facilities (4)	2005 Proposed CD5 vs 1998 CD1 & CD2	2005 Proposed CD5 vs 2002 CD3 & CD4
PI 01B	5,977,102	385,426	14.4	15.5	15.4	1.1	**-0.1**
PI 03	5,973,060	382,705	14.4	15.6	15.4	1.2	**-0.2**
PI 04	5,969,486	378,985	14.4	15.7	15.5	1.3	**-0.2**
PI 05	5,963,244	377,899	14.8	15.7	15.5	0.9	**-0.2**
PI 06	5,960,993	378,208	15.2	15.8	15.5	0.6	**-0.3**
PI 07	5,954,169	382,629	16.6	17.0	17.1	0.4	**0.1**
PI 08	5,952,674	382,609	16.6	17.0	17.1	0.4	**0.1**
PI 09	5,951,162	383,482	16.6	17.0	17.1	0.4	**0.1**
PI 10	5,949,730	384,843	17.4	17.6	17.8	0.2	**0.2**
PI 11	5,946,188	392,113	18.3	18.5	18.6	0.2	**0.1**
PI 12A	5,944,918	393,140	18.3	18.5	18.6	0.2	**0.1**
PI 13A	5,939,750	393,804	21.2	21.3	21.3	0.1	**0.0**
PI 14A	5,939,641	398,674	21.0	20.9	20.9	-0.1	**0.0**
PI 15A	5,935,517	401,684	22.3	22.4	22.4	0.1	**0.0**

Notes:

1. All elevations are reported in BPMSL, and coordinates are reported in Alaska State Plane, Zone 4, NAD27.
2. Water surface elevations from the report: Michael Baker Jr., Inc., 1998. *Colville River Delta, Two-Dimensional Surface Water Model, Project Update* , Prepared for ARCO Alaska, Inc., Anchorage, Alaska.
3. Existing CD3 & CD4 Facilities water surface elevations based on 2002 model output: 200_New_Facilities_i(1).flo.
4. Proposed CD5 Facilities water surface elevations based on model output: 200_CD5_g(1).flo.
5. The difference in water surface elevation is positive when the more recent year's value (e.g. 2002) is higher than the previous year's value (e.g. 1998) and negative when the more recent year's value (e.g. 2002) is lower than the previous year's value (e.g. 1998)

Table A7: Comparison of the 10-Year Flood Water Surface Elevations At Permanent Staff Gage Locations

Permanent Staff Gage Number	State Plane Coordinates (1)(2)		Ground Surface Elevation	Peak Water Surface Elevation (ft)		Difference in Water Surface Elevation
	Northing	Easting		2002 Existing Facilities - CD3 & CD4 (5)	2005 Proposed CD5 Facilities (6)	
1	5,975,948	386,920	1.9 [3]	8.8	8.8	0.0
2	5,974,961	380,306	3.7 [4]	8.2	8.3	0.1
3	5,975,040	379,259	5.9 [3]	8.7	9.0	0.3
4	5,975,173	379,222	5.0 [4]	8.1	8.2	0.1
5	5,975,031	379,071	5.2 [4]	-	-	-
6	5,974,982	373,555	6.3 [4]	8.9	9.2	0.3
7	5,975,132	373,586	7.5 [3]	8.6	8.0	-0.6
8	5,974,855	371,261	8.2 [3]	8.7	8.0	-0.7
9	5,972,643	383,030	8.0 [3]	9.7	9.8	0.1
10	5,975,797	385,464	6.7 [3]	-	-	-

Notes:
1. All elevations are reported in BPMSL.
2. Coordinates are shown Alaska State Plane, Zone 4, NAD 27 and were surveyed by LCMF Inc., (Doc. LCMF-018, 5/17/00)
3. Ground surface elevations survey by LCMF Inc., (Doc. LCMF-018, 5/17/00).
4. Ground surface elevations are from finite element mesh dated 4/27/98.
5. Existing CD3 & CD4 Facilities water surface elevations based on 2002 model output: 10_New_Facilities_d(3).flo.
6. Proposed CD5 Facilities water surface elevations based on model output: 10_CD5_d(1).flo.

Table A8: Comparison of the 50-Year Flood Water Surface Elevations Along the Alpine Facilities Road

Location	State Plane Coordinates (1)		2002 Facilities CD3 & CD4 Water Surface Elevations (2)		2005 Proposed Facilities - CD 5 Water Surface Elevations (3)		Difference in Water Surface Elevation (4)	
	Northing	Easting	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities
SW Corner CD2 Pad	5,974,116	371,389	11.6	-	12.1	-	0.5	-
SE Corner CD2 Pad	5,974,149	371,920	11.9	-	12.2	-	0.3	-
10+00	5,974,900	371,367	-	10.4	-	9.7	-	-0.7
20+00	5,975,006	372,362	11.9	10.0	-	9.7	-	-0.3
30+00	5,975,087	373,357	11.9	9.9	12.3	9.7	0.4	-0.2
40+00	5,974,720	374,270	11.9	9.9	12.3	9.7	0.4	-0.2
50+00	5,974,119	375,062	11.9	9.9	12.3	9.7	0.4	-0.2
60+00	5,974,017	376,041	11.8	9.9	12.2	9.7	0.4	-0.2
70+00	5,974,256	377,012	11.8	10.0	12.2	9.8	0.4	-0.2
80+00	5,974,506	377,980	11.8	10.1	12.2	10.1	0.4	0.0
90+00	5,974,938	378,881	11.7	10.1	12.1	10.1	0.4	0.0
100+00	5,975,071	379,861	11.6	10.1	12.0	10.1	0.4	0.0
103+00	5,975,010	380,154	11.1	10.0	11.5	10.1	0.4	0.1
108+00	5,974,878	380,637	11.4	10.0	11.7	10.0	0.3	0.0
110+00	5,974,826	380,829	11.5	10.0	11.8	10.0	0.3	0.0
120+00	5,974,848	381,741	13.0	10.1	12.9	10.1	-0.1	0.0
130+00	5,975,442	382,545	13.0	10.1	12.9	10.2	-0.1	0.1
140+00	5,976,036	383,350	13.0	10.1	12.9	10.2	-0.1	0.1
150+00	5,976,630	384,154	13.0	10.1	12.9	10.2	-0.1	0.1
160+00	5,977,223	384,959	13.0	10.1	12.9	10.2	-0.1	0.1
170+00	5,977,817	385,763	-	10.1	-	10.2	-	0.1
NW Corner CD1 Pad	5,977,146	386,066	13.0	-	12.9	-	-0.1	-
NE Corner CD1 Pad	5,977,312	386,800	11.8	-	11.8		0.0	-
SW Corner CD1 Pad	5,975,266	385,196	12.9	-	12.9		0.0	-
SE Corner CD1 Pad	5,975,054	385,408	12.8	-	12.8		0.0	-

Notes:
1. All elevations are reported in BPMSL, and coordinates are reported in Alaska State Plane, Zone 4, NAD27.
2. Existing CD3 & CD4 Facilities water surface elevations based on 2002 model output: 50_New_Facilities_c(1).flo.
3. Proposed CD5 Facilities water surface elevations based on model output: 50_CD5_g(1).flo.
4. The difference in water surface elevation is positive when the 2005 value is higher than the 2002 value and negative when the more 2005 value is lower than the 2002 value.

Table A9: Comparison of the 200-Year Flood Water Surface Elevations Along the Alpine Facilities Road

Location	State Plane Coordinates (1)		2002 Facilities CD3 & CD4 Water Surface Elevations (2)		2005 Proposed Facilities - CD 5 Water Surface Elevations (3)		Difference in Water Surface Elevation (4)	
	Northing	Easting	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities
SW Corner CD2 Pad	5,974,116	371,389	13.5	-	14.4	-	0.9	-
SE Corner CD2 Pad	5,974,149	371,920	13.9	-	14.6	-	0.7	-
10+00	5,974,900	371,367	-	12.2	-	11.3	-	-0.9
20+00	5,975,006	372,362	13.9	11.8	-	11.3	-	-0.5
30+00	5,975,087	373,357	13.9	11.7	14.6	11.3	0.7	-0.4
40+00	5,974,720	374,270	13.9	11.7	14.6	11.3	0.7	-0.4
50+00	5,974,119	375,062	13.9	11.7	14.6	11.4	0.7	-0.3
60+00	5,974,017	376,041	13.9	11.7	14.6	11.4	0.7	-0.3
70+00	5,974,256	377,012	13.9	11.7	14.6	11.5	0.7	-0.2
80+00	5,974,506	377,980	13.9	11.8	14.5	11.6	0.6	-0.2
90+00	5,974,938	378,881	13.8	11.8	14.5	11.6	0.7	-0.2
100+00	5,975,071	379,861	13.7	11.7	14.3	11.6	0.6	-0.1
103+00	5,975,010	380,154	13.1	11.7	13.7	11.6	0.6	-0.1
108+00	5,974,878	380,637	13.4	11.7	14.0	11.6	0.6	-0.1
110+00	5,974,826	380,829	13.6	11.7	14.2	11.6	0.6	-0.1
120+00	5,974,848	381,741	15.6	11.8	15.4	11.7	-0.2	-0.1
130+00	5,975,442	382,545	15.5	11.8	15.4	11.7	-0.1	-0.1
140+00	5,976,036	383,350	15.5	11.8	15.4	11.8	-0.1	0.0
150+00	5,976,630	384,154	15.5	11.8	15.4	11.8	-0.1	0.0
160+00	5,977,223	384,959	15.5	11.8	15.4	11.8	-0.1	0.0
170+00	5,977,817	385,763	-	11.8	-	11.8	-	0.0
NW Corner CD1 Pad	5,977,146	386,066	15.5	-	15.4	-	-0.1	-
NE Corner CD1 Pad	5,977,312	386,800	14.0	-	14.0	-	0.0	-
SW Corner CD1 Pad	5,975,266	385,196	15.5	-	15.3	-	-0.2	-
SE Corner CD1 Pad	5,975,054	385,408	15.3	-	15.1	-	-0.2	-

Notes:
1. All elevations are reported in BPMSL, and coordinates are reported in Alaska State Plane, Zone 4, NAD27.
2. Existing CD3 & CD4 Facilities water surface elevations based on 2002 model output: 200_New_Facilities_i(1).flo.
3. Proposed CD5 Facilities water surface elevations based on model output: 200_CD5_g(1).flo.
4. The difference in water surface elevation is positive when the 2005 value is higher than the 2002 value and negative when the more 2005 value is lower than the 2002 value.

Table A10: Water Surface Elevations and Water Velocities Along the CD3 Pad, Road, and Runway During the 200-Year Flood

Location	State Plane Coordinates (1)			2002 Facilities CD3 & CD4 (3)		2005 Proposed Facilities CD 5 (4)		Difference in Water Surface Elevation and Velocity (5)	
	Northing	Easting	Approximate Ground Elevation (2)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)
NW Corner of Pad	6,003,909	387,495	6.2	7.7	2.4	7.4	2.5	-0.3	0.1
NE Corner of Pad	6,004,197	388,672	6.0	7.0	0.1	7.1	0.1	0.1	0.0
SW Corner of Pad	6,003,595	387,552	6.1	7.9	1.4	7.6	1.6	-0.3	0.2
SE Corner of Pad	6,003,545	388,891	6.0	7.0	0.1	7.1	0.1	0.1	0.0
Access Road (south)	6,002,751	389,409	7.7	8.3	1.1	8.2	1.2	-0.1	0.1
Access Road (north)	6,002,856	389,443	7.6	-	-	-	-	-	-
West End of Runway (south)	6,003,176	390,564	6.5	7.9	0.4	8.1	0.3	0.2	-0.1
West End of Runway (north)	6,003,606	390,261	6.6	7.0	0.1	7.1	0.1	0.1	0.0
Mid-Point Runway (south)	6,004,323	391,635	6.0	7.8	0.4	8.1	0.4	0.3	0.0
Mid-Point Runway (north)	6,004,458	391,559	6.0	7.0	0.1	7.2	0.3	0.2	0.2
East End Runway (south)	6,005,402	393,244	6.0	7.7	0.5	7.9	0.6	0.2	0.1

Notes:
1. All elevations are reported in BPMSL. Horizontal coordinates are reported in Alaska State Plane, Zone 4, NAD27.
2. Ground elevations are from photogramic contour data provided by Aeromap U.S., 6/30/99.
3. Water surface elevations and velocities for model results without CD5 Facilities based on model output: 200_New_Facilities_i(1).flo.
4. Water surface elevations and velocities for model results with CD5 Facilities based on model output: 200_CD5_g(1).flo.
5. The difference in water surface elevation or velocity is positive when the 2005 value is higher than the 2002 value and negative when the more 2005 value is lower than the 2002 value.
6. Empty cells are areas where the model indicates dry ground.

Table A11: Water Surface Elevations and Water Velocities Along the CD3 Pipeline During the 200-Year Flood

Location	State Plan Coordinates (1)			2002 Facilities CD3 & CD4 (3)		2005 Proposed Facilities CD 5 (4)		Difference in Water Surface Elevation and Velocity (7)	
	Northing	Easting	Ground Elevation (2)	Water Surface Elevation (5,6)	Water Velocity (ft/s) (6)	Water Surface Elevation (5,6)	Water Velocity (ft/s) (6)	Water Surface Elevation	Water Velocity (ft/s)
10+00	6,003,675	388,518	6.7	8.1	0.4	7.9	0.5	-0.2	0.1
20+00	6,002,868	389,005	7.3	8.3	1.5	8.1	1.4	-0.2	-0.1
30+00	6,002,373	389,781	7.9	8.3	1.6	8.3	1.9	0.0	0.3
40+00	6,001,801	390,524	6.7	8.5	2.0	8.4	2.1	-0.1	0.1
50+00	6,001,096	391,247	6.7	8.6**	0.7**	8.5**	0.6**	-0.1	-0.1
60+00	6,000,238	391,659	8.1	8.6**	0.7**	8.5**	0.6**	-0.1	-0.1
70+00	5,999,455	392,049	5.5	8.8	3.0**	8.8	3.3**	0.0	0.3
Crossing 5	-	-	-	8.8	4.3	8.8	4.5	0.0	0.2
80+00	5,998,615	391,684	7.8	8.9**	1.0**	8.9**	1.0**	0.0	0.0
90+00	5,998,335	390,779	7.4	8.9**	1.0**	8.9**	1.0**	0.0	0.0
100+00	5,998,012	389,898	13.3	9.3*	-	9.3*	-	0.0	-
110+00	5,997,408	389,181	8.4	9.4	1.3**	9.3	1.3**	-0.1	0.0
120+00	5,996,562	388,766	10.1	9.5*	-	9.5*	-	0.0	-
130+00	5,995,678	388,392	7.7	9.9	1.5	9.7	1.4	-0.2	-0.1
140+00	5,994,810	387,949	8.0	9.8	1.2	9.6	1.0	-0.2	-0.2
Crossing	-	-	-	10.1	5.0	10.1	5.0	0.0	0.0
160+00	5,993,131	387,832	7.4	10.3**	0.7**	10.1**	0.8**	-0.2	0.1
170+00	5,992,216	387,612	8.8	10.3**	0.9**	10.1**	0.9**	-0.2	0.0
180+00	5,991,222	387,773	9.1	10.2	0.1	10.0	0.1	-0.2	0.0
190+00	5,990,326	387,980	9.5	10.2**	0.1**	10.0**	0.1**	-0.2	0.0
200+00	5,989,332	388,140	10.8	10.7*	-	10.7*	-	0.0	-
210+00	5,988,424	388,288	11.7	12.1**	1.0**	12.2**	0.8**	0.1	-0.2
220+00	5,987,468	388,496	12.6	12.5*	-	12.4*	-	-0.1	-
230+00	5,986,521	388,653	11.8	13.1**	0.9**	12.9**	0.8**	-0.2	-0.1
240+00	5,985,716	388,304	9.5	13.0	1.2	12.8	1.2	-0.2	0.0
250+00	5,985,068	387,631	4.6	13.0	2.0	12.7	1.9	-0.3	-0.1
Crossing	-	-	-	13.1	4.6	12.8	4.6	-0.3	0.0
270+00	5,983,229	387,096	10.1	13.2	1.1	12.9	1.0	-0.3	-0.1
280+00	5,982,304	387,112	10.0	13.3	0.8	13.1	0.9	-0.2	0.1
290+00	5,981,317	387,191	10.5	13.5	0.7	13.2	0.7	-0.3	0.0
300+00	5,980,348	387,206	11.6	13.6	0.6	13.4	0.5	-0.2	-0.1
310+00	5,979,417	387,222	11.3	13.7	0.8	13.5	0.8	-0.2	0.0
320+00	5,978,424	387,304	10.3	13.9	1.2	13.8	1.5	-0.1	0.3
330+00	5,977,493	387,317	9.6	14.2	2.0	14.0	1.9	-0.2	-0.1
340+00	5,976,600	387,008	10.5	14.5	1.5	14.2	1.2	-0.3	-0.3

Notes:
1. All elevations are reported in feet BPMSL. Horizontal coordinates are reported in Alaska State Plane, Zone 4, NAD27.
2. Ground elevations are based on the topographical base map used to define the finite element mesh.
3. Water surface elevations and velocities for model results without CD5 Facilities based on model output: 200_New_Facilities_i(1).flo.
4. Water surface elevations and velocities for model results with CD5 Facilities based on model output: 200_CD5_g(1).flo.
5. Water Surface Elevations with an asterisk (*) represent water surface elevations in the vicinity of the identified location and are lower than the ground elevation at this location.
6. Water surface elevations and velocities with a double asterisk (**) represent values in the vicinity of the identified location. The element at the specified location is considered turned off by the model, however the ground surface elvation is lower than the water surface elevation.
7. The difference in water surface elevation or velocity is positive when the 2005 value is higher than the 2002 value and negative when the more 2005 value is lower than the 2002 value.
8. Empty cells are areas where the model indicates dry ground.

Table A12: Water Surface Elevations and Water Velocities Along the CD4 Access Road During the 50-Year Flood

				2002 Existing Facilities (CD3 & CD4)				2005 Proposed Facilities (CD5)				Difference in Water Surface Elevation and Velocity (6)			
	State Plane Coordinates (1)			Along the Western Side of CD-South Access Road (3,5)		Along the Eastern Side of CD-South Access Road (3,5)		Along the Western Side of CD-South Access Road (4,5)		Along the Eastern Side of CD-South Access Road (4,5)		Along the Western Side of CD-South Access Road		Along the Eastern Side of CD-South Access Road	
Location	Northing	Easting	Approximate Ground Elevation (2)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)
10+00	5,974,702	381,090	8.3	11.4	0.5	13.0	0.5	11.8	0.6	10.7	0.0	0.4	0.1	-2.3	-0.5
20+00	5,973,749	381,094	11.9	11.6*	-	13.0	0.5	12.0	0.1	12.9*	-	0.4	-	-0.1	-
25+00	5,973,297	380,896	11.4	11.7	0.3	13.0	0.5	12.1	0.5	12.9	0.2	0.4	0.2	-0.1	-0.3
30+00	5,972,966	380,522	10.9	11.8	0.2	13.0	0.3	12.2	0.3	12.9	0.3	0.4	0.1	-0.1	0.0
40+00	5,972,333	379,742	8.8	11.8	0.3	13.0	0.4	12.2	0.4	12.9	0.3	0.4	0.1	-0.1	-0.1
50+00	5,971,637	379,025	9.6	11.8	0.2	13.0	0.3	12.2	0.2	12.9	0.2	0.4	0.0	-0.1	-0.1
60+00	5,970,858	378,392	8.8	11.8	0.1	13.0	0.3	12.2	0.1	12.9	0.2	0.4	0.0	-0.1	-0.1
70+00	5,970,133	377,741	10.0	11.8	0.1	13.0	0.1	12.2	0.0	12.9	0.1	0.4	-0.1	-0.1	0.0
75+00	5,969,650	377,622	14.6	12.0*	-	13.1*	-	12.2*	-	12.9*	-	0.2	-	-0.2	-
80+00	5,969,159	377,591	11.9	12.0	0.1	13.1	0.1	12.3	0.2	12.9	0.2	0.3	0.1	-0.2	0.1
85+00	5,968,662	377,546	16.0	12.0*	-	13.1*	-	12.4*	-	12.9*	-	0.4	-	-0.2	-
110+00	5,966,134	377,085	16.6	12.0*	-	13.1*	-	12.4*	-	12.9*	-	0.4	-	-0.2	-
115+00	5,965,687	377,122	12.3	12.0*	-	13.1	0.2	12.4	0.1	12.9	0.1	0.4	-	-0.2	-0.1
120+00	5,965,095	377,077	10.6	12.0	0.2	13.1	0.4	12.4	0.1	12.9	0.1	0.4	-0.1	-0.2	-0.3
130+00	5,964,205	376,897	14.9	12.0*	-	13.1*	-	12.4*	-	12.9*	-	0.4	-	-0.2	-
140+00	5,963,213	377,025	14.6	12.4*	-	13.1*	-	12.9*	-	13.1*	-	0.5	-	0.0	-
150+00	5,962,215	377,179	13.0	12.4*	-	13.2*	-	12.7*	0.7	12.9*	-	0.3	-	-0.3	-
155+00	5,961,723	377,256	12.7	12.4*	-	13.3	0.7	12.7	0.5	12.9	0.1	0.3	-	-0.4	-0.6
160+00	5,961,356	377,467	-	-	-	-	-	13.8	0.0	12.9	0.0	-	-	-	-
165+00	5,961,146	377,742	-	-	-	-	-	13.8	0.4	12.9	0.3	-	-	-	-
170+00	596,076	378,193	-	-	-	-	-	13.8	0.1	12.9	0.0	-	-	-	-
180+00	5,959,941	378,685	-	-	-	-	-	13.8	0.2	12.9	0.0	-	-	-	-
185+00	5,959,574	378,925	-	-	-	-	-	13.8	0.1	-	-	-	-	-	-
190+00	5,958,990	379,309	-	-	-	-	-	13.8	0.1	-	-	-	-	-	-
195+00	5,958,308	379,382	-	-	-	-	-	13.8	0.0	14.5	0.0	-	-	-	-
200+00	5,957,752	379,012	-	-	-	-	-	13.8	0.2	14.5	0.2	-	-	-	-
NW Corner Pad	5,957,564	377,387	10.1	13.8	0.2	-	-	14.0	0.1	-	-	0.2	-0.1	-	-
NE Corner Pad	5,957,816	378,483	15.0	-	-	14.0*	-	-	-	13.8*	-	-	-	-0.2	-
SW Corner Pad	5,957,231	377,467	10.1	13.8	0.7	-	-	13.9	0.6	-	-	0.1	-0.1	-	-
SE Corner Pad	5,957,400	378,591	13.2	-	-	14.2	0.3	-	-	14.3	0.1	-	-	0.1	-0.2

Notes:
1. All elevations are reported in BPMSL. Horizontal coordinates are reported in Alaska State Plane, Zone 4, NAD27.
2. Ground elevations are based on the topographical base map used to define the finite element mesh, which are based on photogrammetric contour date by Aeromap U.S. 6/30/99.
3. Water surface elevations and velocities for model results without CD5 Facilities based on model output: 50_New_Facilities_c(1).flo for stations 10+00 to 150+00. Water surface elevations and velocities from stations 160+00 to the CD-4 pad from the 2002 model do not match the existing CD-4 access road alignment and have been removed since they do not represent actual conditions.
4. Water surface elevations and velocities for model results with CD5 Facilities based on model output: 50_CD5_g(1).flo.
5. Water Surface Elevations with an asterisk (*) represent water surface elevations in the vicinity of the identified location and are lower than the ground elevation at this location.
6. Water surface elevations and velocities with a double asterisk (**) are non-representative. The modeled 2002 CD-4 access road alignment does not match the 2005 CD-4 road alignment within this region
7. The difference in water surface elevation or velocity is positive when the 2005 value is higher than the 2002 value and negative when the more 2005 value is lower than the 2002 value.
8. Empty cells are areas where the model indicates dry ground.

Table A13: Water Surface Elevations and Water Velocities Along the CD4 Access Road During the 200-Year Flood

				2002 Existing Facilities (CD3 & CD4)				2005 Proposed Facilities (CD5)				Difference in Water Surface Elevation and Velocity (6)			
	State Plane Coordinates (1)			Along the Western Side of CD-South Access Road (3,5)		Along the Eastern Side of CD-South Access Road (3,5)		Along the Western Side of CD-South Access Road (4,5)		Along the Eastern Side of CD-South Access Road (4,5)		Along the Western Side of CD-South Access Road		Along the Eastern Side of CD-South Access Road	
Location	Northing	Easting	Approximate Ground Elevation (2)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)
10+00	5,974,702	381,090	8.3	13.5	0.8	15.6	0.0	14.2	0.9	15.4	0.0	0.7	0.1	-0.2	0.0
20+00	5,973,749	381,094	11.9	13.7	0.7	15.6	0.2	14.4	0.8	15.4	0.3	0.7	0.1	-0.2	0.1
30+00	5,972,966	380,522	10.9	13.8	0.5	15.6	0.7	14.5	0.7	15.4	0.7	0.7	0.2	-0.2	0.0
40+00	5,972,333	379,742	8.8	13.9	0.5	15.6	0.6	14.5	0.6	15.4	0.6	0.6	0.1	-0.2	0.0
50+00	5,971,637	379,025	9.6	13.9	0.3	15.6	0.4	14.6	0.3	15.4	0.5	0.7	0.0	-0.2	0.1
60+00	5,970,858	378,392	8.8	13.9	0.2	15.6	0.3	14.6	0.2	15.5	0.4	0.7	0.0	-0.1	0.1
70+00	5,970,133	377,741	10.0	13.9	0.1	15.6	0.3	14.6	0.2	15.5	0.4	0.7	0.1	-0.1	0.1
75+00	5,969,650	377,622	14.6	14.0*	-	15.7	0.4	14.6*	-	15.5	0.4	0.6	-	-0.2	0.0
80+00	5,969,159	377,591	11.9	14.0	0.2	15.7	0.3	14.7	0.2	15.5	0.3	0.7	0.0	-0.2	0.0
85+00	5,968,662	377,546	16.0	14.0*	-	15.6*	-	14.7*	-	15.5*	-	0.7	-	-0.1	-
90+00	5,968,164	377,456	16.7	14.0*	-	15.7*	-	14.7*	-	15.5*	-	0.7	-	-0.2	-
110+00	5,966,807	377,206	16.6	14.0*	-	15.7*	-	14.7	0.5	15.5	0.1	0.7	-	-0.2	-
115+00	5,965,687	377,122	16.3	14.0	0.1	15.7	0.1	14.7	0.1	15.5	0.1	0.7	0.0	-0.2	0.0
120+00	5,965,095	377,077	10.6	14.0	0.1	15.7	0.5	14.7	0.1	15.5	0.1	0.7	0.0	-0.2	-0.4
125+00	5,964,720	377,037	15.2	14.0*	-	15.7	0.5	14.7*	-	15.5	0.1	0.7	-	-0.2	-0.4
130+00	5,964,205	376,897	14.9	14.0*	-	15.7	0.6	14.7*	-	15.5	0.1	0.7	-	-0.2	-0.5
140+00	5,963,213	377,025	14.6	14.9	0.2	15.7	0.9	15.5	0.1	15.5	0.2	0.6	-0.1	-0.2	-0.7
145+00	5,961,299	377,314	13.5	15.5	1.3	15.8	1.0	16.1	1.0	15.5	0.1	0.6	-0.3	-0.3	-0.9
150+00	5,962,215	377,179	13.0	15.2	0.8	15.7	1.1	15.8	1.0	15.5	0.2	0.6	0.2	-0.2	-0.9
155+00	5,961,723	377,256	12.7	15.4	0.9	15.8	1.1	15.9	1.2	15.5	0.2	0.5	0.3	-0.3	-0.9
160+00	5,961,356	377,467	-	-	-	-	-	16.1	1.0	15.5	0.1	-	-	-	-
165+00	5,961,146	377,742	-	-	-	-	1.3	16.1	0.4	15.5	0.2	-	-	-	-
170+00	5,960,761	378,193	-	-	-	-	0.4	16.1	0.5	15.5	0.7	-	-	-	-
180+00	5,959,941	378,685	-	-	-	-	-	16.1	0.4	15.7	1.2	-	-	-	-
185+00	5,959,574	378,925	-	-	-	-	0.8	16.1	0.3	15.9	1.8	-	-	-	-
190+00	5,958,990	379,309	-	-	-	-	0.8	16.1	0.2	16.4	1.8	-	-	-	-
195+00	5,958,308	379,382	-	-	-	-	0.4	16.1	0.1	16.7	0.7	-	-	-	-
200+00	5,957,752	379,012	-	-	-	-	0.1	16.1	0.1	16.7	0.1	-	-	-	-
NW Corner Pad	5,957,564	377,387	10.1	15.9	0.2	-	-	16.2	0.2	-	-	0.3	0.0	-	-
NE Corner Pad	5,957,816	378,483	15.0	-	-	16.2	0.4	-	-	16.1	0.1	-	-	-0.1	-0.3
SW Corner Pad	5,957,231	377,467	10.1	15.9	1.6	-	-	16.2	0.8	-	-	0.3	-0.8	-	-
SE Corner Pad	5,957,400	378,591	13.2	-	-	16.4	0.3	-	-	16.7	0.5	-	-	0.3	0.2

Notes:
1. All elevations are reported in BPMSL. Horizontal coordinates are reported in Alaska State Plane, Zone 4, NAD27.
2. Ground elevations are based on the topographical base map used to define the finite element mesh, which are based on photogrammetric contour date by Aeromap U.S. 6/30/99.
3. Water surface elevations and velocities for model results without CD5 Facilities based on model output: 200_New_Facilities_i(1).flo for stations 10+00 to 150+00. Water surface elevations and velocities from stations 160+00 to the CD-4 pad from the 2002 model do not match the existing CD-4 access road alignment and have been removed since they do not represent actual conditions.
4. Water surface elevations and velocities for model results with CD5 Facilities based on model output: 200_CD5_g(1).flo.
5. Water surface elevations with an asterisk (*) represent water surface elevations in the vicinity of the identified location and are lower than the ground elevation at this location.
6. Water surface elevations and velocities with a double asterisk (**) are non-representative. The modeled 2002 CD-4 access road alignment does not match the 2005 CD-4 road alignment within this region
7. The difference in water surface elevation or velocity is positive when the 2005 value is higher than the 2002 value and negative when the more 2005 value is lower than the 2002 value.

Table A14: Water Surface Elevations and Water Velocities Along the CD4 Pipeline During the 200-Year Flood

Location	State Plan Coordinates (1)			2002 Existing Facilities CD3 & CD4 (3)		2005 Proposed Facilities CD 5 (4)		Difference in Water Surface Elevation and Velocity (7)	
	Northing	Easting	Ground Elevation (2)	Water Surface Elevation (5,6)	Water Velocity (ft/s) (6)	Water Surface Elevation (5,6)	Water Velocity (ft/s) (6)	Water Surface Elevation	Water Velocity (ft/s)
10+00	5,957,272	378,347	11.8	16.4	1.1	16.6	1.1	0.2	0.0
20+00	5,957,514	379,372	9.6	16.4	1.2	16.8	0.4	0.4	-0.8
30+00	5,957,989	380,128	11.7	16.3	0.6	16.7	0.2	0.4	-0.4
40+00	5,958,811	379,570	13.9	16.2	0.8	16.6	1.4	0.4	0.6
50+00	5,959,691	378,971	12.5	16.1	0.9	15.8	1.6	-0.3	0.7
60+00	5,960,436	378,535	11.6	15.9	1.1	15.6	1.0	-0.3	-0.1
70+00	5,960,987	378,166	10.8	15.8	0.8	15.5	0.5	-0.3	-0.3
80+00	5,962,260	378,017	12.0	15.7	0.6	15.5	0.1	-0.2	-0.5
90+00	5,963,309	377,848	10.7	15.7	0.6	15.5	0.1	-0.2	-0.5
100+00	5,964,256	377,993	11.7	15.7	0.3	15.5	0.1	-0.2	-0.2
110+00	5,965,156	378,189	8.5	15.7	0.3	15.5	0.1	-0.2	-0.2
120+00	5,966,192	378,348	3.2	15.7	0.2	15.5	0.1	-0.2	-0.1
130+00	5,967,156	378,504	4.3	15.7	0.2	15.5	0.1	-0.2	-0.1
140+00	5,968,083	378,707	8.0	15.7	0.2	15.5	0.2	-0.2	0.0
150+00	5,969,068	378,853	8.3	15.7	0.2	15.5	0.3	-0.2	0.1
160+00	5,969,934	379,340	10.1	15.7	0.4	15.5	0.4	-0.2	0.0
170+00	5,970,554	380,040	10.1	15.6	0.4	15.5	0.4	-0.1	0.0
180+00	5,971,251	380,734	10.8	15.6	0.3	15.4	0.3	-0.2	0.0
190+00	5,971,958	381,441	10.4	15.6	0.4	15.4	0.4	-0.2	0.0
200+00	5,972,584	382,145	10.3	15.6	0.5	15.4	0.5	-0.2	0.0
210+00	5,973,291	382,873	9.2	15.6	0.6	15.4	0.6	-0.2	0.0
220+00	5,973,924	383,631	5.7	15.5	0.7	15.4	1.0	-0.1	0.3
230+00	5,974,499	384,399	8.5	15.5	0.9	15.3	0.9	-0.2	0.0
240+00	5,974,858	385,123	10.0	15.4	1.4	15.2	1.4	-0.2	0.0

Notes:
1. All elevations are reported in feet BPMSL. Horizontal coordinates are reported in Alaska State Plane, Zone 4, NAD27.
2. Ground elevations are based on the topographical base map used to define the finite element mesh.
3. Water surface elevations and velocities for model results without CD5 Facilities based on model output: 200_New_Facilities_i(1).flo.
4. Water surface elevations and velocities for model results with CD5 Facilities based on model output: 200_CD5_g(1).flo.
5. The water depth is the difference between the predicted water surface elevation and the ground surface elevation at the specific location.

Table A15: Comparison of the 50-Year Flood Water Surface Elevations Along the CD5 Access Road

Location (1)	State Plane Coordinates (2)		2002 Existing Facilities CD3 & CD4 Water Surface Elevations (3)		2005 Proposed Facilities - CD 5 Water Surface Elevations (4)		Difference in Water Surface Elevation (5)	
	Northing	Easting	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities
111+00	5,974,547	364,206	11.1	11.1	11.8	10.0	0.7	-1.1
112+50	5,974,545	364,470	11.1	11.1	11.5	10.2	0.4	-0.9
115+00	5,974,548	364,730	11.1	11.0	11.8	10.0	0.7	-1.0
120+00	5,974,746	365,189	11.0	11.0	11.7	10.0	0.7	-1.0
130+00	5,975,327	365,974	10.9	10.8	11.6	10.0	0.7	-0.8
140+00	5,975,900	366,763	10.7	10.7	10.9	10.0	0.2	-0.7
150+00	5,976,729	367,267	10.4	10.4	10.7	9.9	0.3	-0.5
160+00	5,976,794	368,238	10.2	10.1	10.1	10.0	-0.1	-0.1
170+00	5,976,627	369,222	10.2	10.1	10.1	9.7	-0.1	-0.4
180+00	5,976,210	370,103	10.2	10.1	11.0	9.7	0.8	-0.4
190+00	5,975,252	370,309	10.6	10.6	11.2	9.7	0.6	-0.9
200+00	5,974,355	370,703	11.1	11.0	11.7	9.7	0.6	-1.3
210+00	5,973,963	371,590	11.7	11.6	12.2	-	0.5	-
220+00	5,974,494	372,407	11.9	11.9	12.3	-	0.4	-
230+00	5,975,089	373,148	11.9	9.9	12.3	9.7	0.4	-0.2

Notes:
1. 00+00 through 111+00 are located west of the floodplain and are not subjected to flood water. Stations 160+00 and 170+00 are located on the CD-5 Nigliq Bridge.
2. All elevations are reported in BPMSL, and coordinates are reported in Alaska State Plane, Zone 4, NAD27.
3. Existing CD3 & CD4 Facilities water surface elevations based on 2002 model output: 50_New_Facilities_c(1).flo.
4. Proposed CD5 Facilities water surface elevations based on model output: 50_CD5_g(1).flo.
5. The difference in water surface elevation is positive when the 2005 value is higher than the 2002 value and negative when the more 2005 value is lower than the 2002 value.
6. Station 230+00 is approximately the same position as station 25+00 on the CD2 access (Alpine Facilities) road

Table A16: Comparison of the 200-Year Flood Water Surface Elevations Along the CD5 Access Road

Location (1)	State Plane Coordinates (2)		2002 Existing Facilities CD3 & CD4 Water Surface Elevations (3)		2005 Proposed Facilities - CD 5 Water Surface Elevations (4)		Difference in Water Surface Elevation (5)	
	Northing	Easting	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities
111+00	5,974,547	364,206	13.0	13.0	14.2	11.5	1.2	-1.5
112+50	5,974,545	364,470	13.0	13.0	13.9	11.7	0.9	-1.3
115+00	5,974,548	364,730	13.0	13.0	14.2	11.5	1.2	-1.5
120+00	5,974,746	365,189	13.0	12.9	14.1	11.5	1.1	-1.4
130+00	5,975,327	365,974	12.8	12.8	14.0	11.5	1.2	-1.3
140+00	5,975,900	366,763	12.6	12.6	13.2	11.5	0.6	-1.1
150+00	5,976,729	367,267	12.3	12.3	12.8	11.4	0.5	-0.9
160+00	5,976,794	368,238	12.1	12.1	11.9	11.8	-0.2	-0.3
170+00	5,976,627	369,222	12.0	12.0	11.9	11.2	-0.1	-0.8
180+00	5,976,210	370,103	12.0	12.0	13.2	11.3	1.2	-0.7
190+00	5,975,252	370,309	12.4	12.4	13.4	11.3	1.0	-1.1
200+00	5,974,355	370,703	12.9	12.8	14.0	11.3	1.1	-1.5
210+00	5,973,963	371,590	13.6	13.5	14.5	-	0.9	-
220+00	5,974,494	372,407	13.9	13.9	14.6	-	0.7	-
230+00	5,975,089	373,148	13.9	11.7	14.6	11.3	0.7	-0.4

Notes:
1. 00+00 through 110+00 are located west of the floodplain and are not subjected to flood water. Stations 160+00 and 170+00 are located on the CD-5 Nigliq Bridge.
2. All elevations are reported in BPMSL, and coordinates are reported in Alaska State Plane, Zone 4, NAD27.
3. Existing CD3 & CD4 Facilities water surface elevations based on 2002 model output: 200_New_Facilities_i(1).flo.
4. Proposed CD5 Facilities water surface elevations based on model output: 200_CD5_g(1).flo.
5. The difference in water surface elevation is positive when the 2005 value is higher than the 2002 value and negative when the more 2005 value is lower than the 2002 value.
6. Station 230+00 is approximately the same position as station 25+00 on the CD2 access (Alpine Facilities) road

Table A17: Water Velocities Along the CD5 Access Road During the 50-Year and 200-Year Flood

Location (1)	State Plane Coordinates (2)		Q50 2005 Proposed Facilities CD5 Water Velocity (ft/s) (3)		Q200 2005 Proposed Facilities CD5 Water Velocity (ft/s) (4)	
	Northing	Easting	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities
111+00	5,974,547	364,206	0.2	0.1	0.2	0.1
112+50	5,974,545	364,470	2.2	4.6	3.4	5.5
115+00	5,974,548	364,730	0.5	0.1	0.8	0.6
120+00	5,974,746	365,189	0.8	0.2	1.2	0.4
130+00	5,975,327	365,974	1.2	0.2	1.7	0.3
140+00	5,975,900	366,763	1.6	0.2	2.4	0.3
150+00	5,976,729	367,267	1.1	0.3	2.0	0.4
160+00	5,976,794	368,238	9.7	9.9	11.8	12.1
170+00	5,976,627	369,222	2.1	1.3	3.7	1.5
180+00	5,976,210	370,103	1.1	0.1	1.7	0.4
190+00	5,975,252	370,309	1.5	0.0	2.1	0.1
200+00	5,974,355	370,703	1.5	0.0	2.1	0.1
210+00	5,973,963	371,590	1.2	0.0	1.6	0.0
220+00	5,974,494	372,407	0.2	0.0	0.4	0.0
230+00	5,975,089	373,148	0.1	0.0	0.2	0.3

Notes:
1. 00+00 through 110+00 are located west of the floodplain and are not subjected to flood water. Stations 160+00 and 170+00 are located on the CD-5 Nigliq Bridge.
2. All coordinates are reported in Alaska State Plane, Zone 4, NAD27.
3. Water velocities for Q50 model results with CD5 Facilities based on model output: 50_CD5_g(1).flo.
4. Water velocities for Q200 model results with CD5 Facilities based on model output: 200_CD5_g(1).flo.
5. Peak water velocities reported at proposed Paleo Bridge (112+50) and Nigliq Bridge (160+00).
6. Station 230+00 is approximately the same position as station 25+00 on the CD2 access (Alpine Facilities) road.

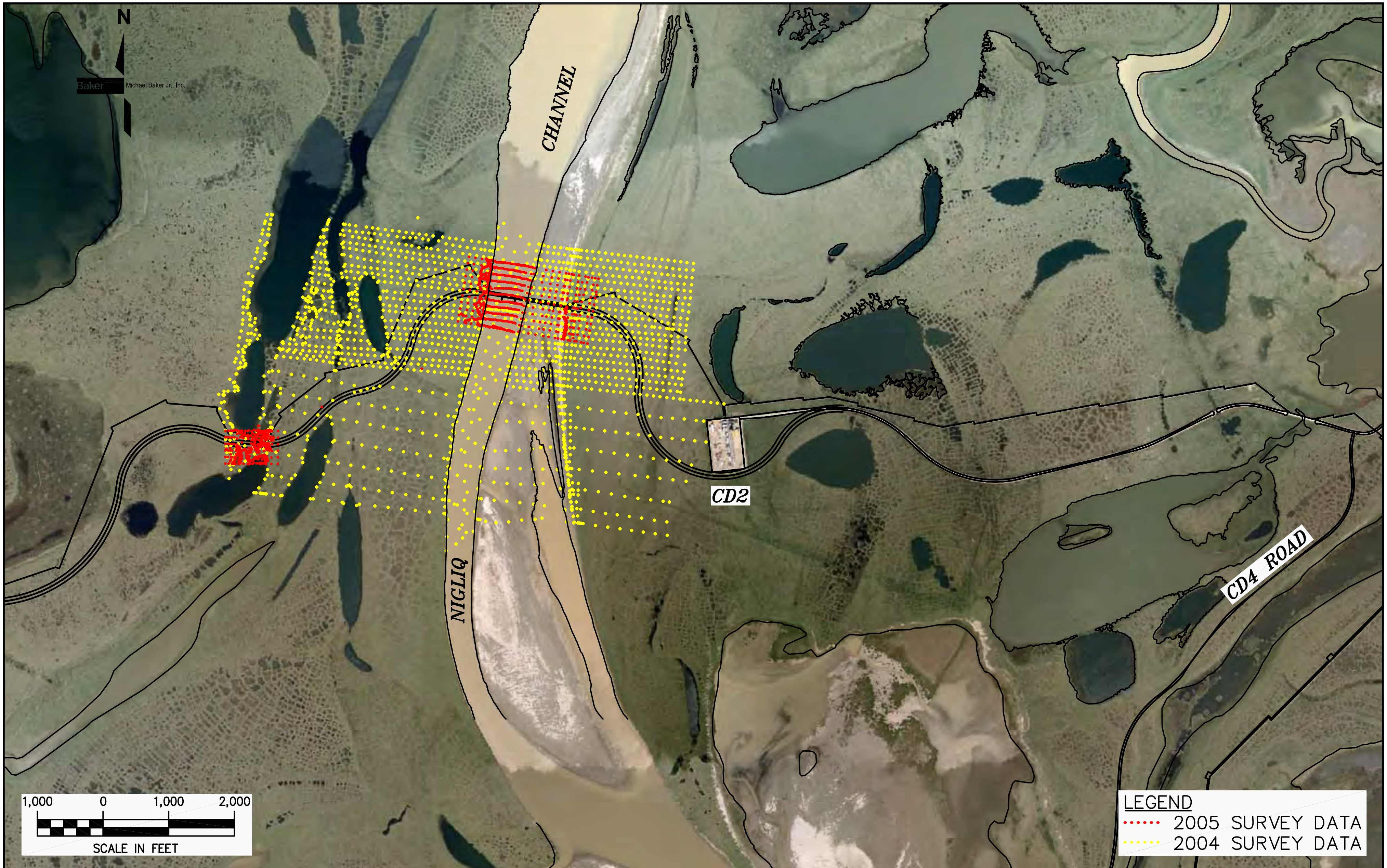
Table A18: Water Surface Elevations and Water Velocities Along the CD5 Pipeline During the 50-Year and 200-Year Flood

Location (1)	State Plan Coordinates (2)			Q50 2005 Proposed Facilities CD5 (4)			Q200 2005 Proposed Facilities CD5 (5)		
	Northing	Easting	Ground Elevation (3)	Water Surface Elevation	Water Velocity (ft/s)	Water Depth	Water Surface Elevation	Water Velocity (ft/s)	Water Depth
PI 29	5,974,666	364,694	8.1	10.0	-	1.9	11.5	0.6	3.4
PI 30	5,974,724	364,700	7.5	10.0	0.4	2.5	11.5	0.6	4.0
PI 31	5,974,950	364,858	7.7	10.0	0.4	2.3	11.5	0.5	3.8
PI 32	5,974,996	364,820	7.7	10.0	0.4	2.3	11.5	0.6	3.8
PI 33	5,975,560	365,533	7.7	10.0	0.3	2.3	11.5	0.4	3.8
PI 34	5,975,615	365,518	8.4	10.0	0.3	1.6	11.5	0.4	3.1
PI 35	5,975,820	366,415	7.8	10.0	0.2	2.2	11.5	0.3	3.7
PI 36	5,975,875	366,403	7.8	10.0	0.2	2.2	11.5	0.3	3.7
PI 37	5,977,061	366,911	8.1	9.9	0.3	1.8	11.4	0.3	3.3
PI 38	5,977,035	366,964	8.2	9.9	0.3	1.7	11.4	0.4	3.2
PI 39	5,977,233	367,738	7.9	9.9	0.2	2.0	11.4	0.4	3.5
PI 40	5,976,912	367,820	-	-	-	-	-	-	-
PI 41	5,976,909	367,975	-	-	-	-	-	-	-
PI 42	5,976,868	368,001	-	-	-	-	-	-	-
PI 43	5,976,666	369,175	-	-	-	-	-	-	-
PI 44	5,976,696	369,187	-	-	-	-	-	-	-
PI 45	5,976,675	369,327	-	-	-	-	-	-	-
PI 46	5,976,877	370,037	7.5	9.7	0.3	2.2	11.3	0.3	3.8
PI 47	5,976,821	370,054	7.6	9.7	0.3	2.1	11.3	0.3	3.7
PI 48	5,976,027	370,785	7.2	9.7	0.1	2.5	11.3	0.2	4.1
PI 49	5,975,983	370,738	7.0	9.7	0.1	2.7	11.3	0.2	4.3
PI 50	5,975,124	371,527	7.6	9.7	0.1	2.1	11.3	0.1	3.7
PI 51	5,975,130	371,585	7.3	9.7	0.1	2.4	11.3	0.1	4.0

Notes:
1. PI 01 through PI 28 are located west of the floodplain and are not subjected to flood water. PI 40 to PI 45 is located on the CD-5 Nigliq Bridge and the pipeline is not affected by the flood water.
2. All elevations are reported in feet BPMSL. Horizontal coordinates are reported in Alaska State Plane, Zone 4, NAD27.
3. Ground elevations are based on the topographical base map used to define the finite element mesh (2005)
4. Water surface elevations and velocities for model results with CD5 Facilities based on model output: 50_CD5_g(1).flo.
5. Water surface elevations and velocities for model results with CD5 Facilities based on model output: 200_CD5_g(1).flo.

Appendix B Figures

Figure B1: Updated Topography Limits
Figure B2: Colville Delta Channels
Figure B3: Alpine Pipeline PIs
Figure B4: Permanent Staff Gage Locations
Figure B5: Stationing Along the Alpine Facilities Road
Figures B6 – B21: Model Output Figures
Figure B22: Stationing Along the CD3 Pipeline
Figure B23: Stationing Along the CD4 Access Road and CD4 Pipeline
Figure B24 Stationing Along the CD5 Access Road and CD5 Pipeline PIs



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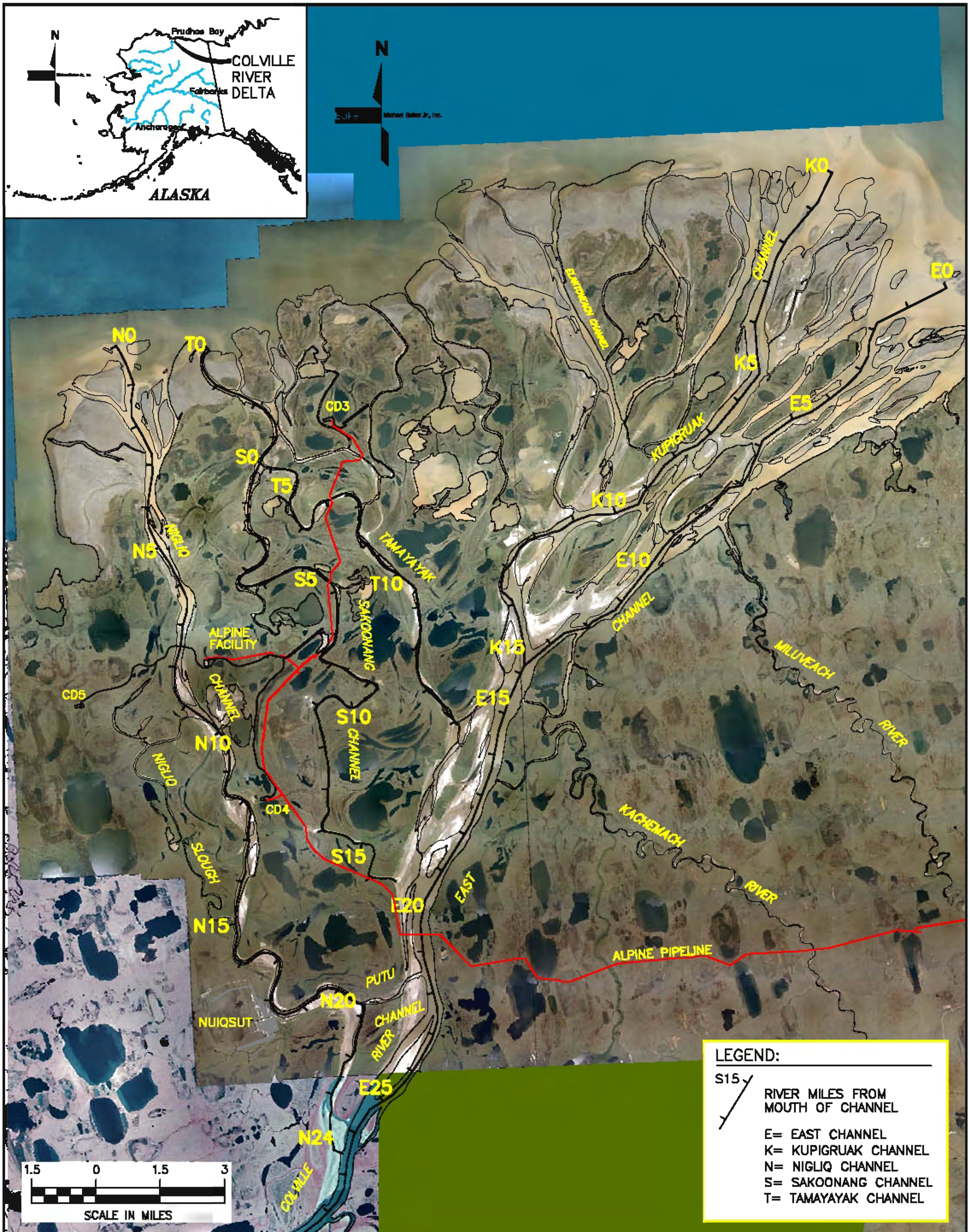
ConocoPhillips Alaska, Inc.	FILE NAME: 105755_02.dwg	SCALE: As Shown	Figure B1

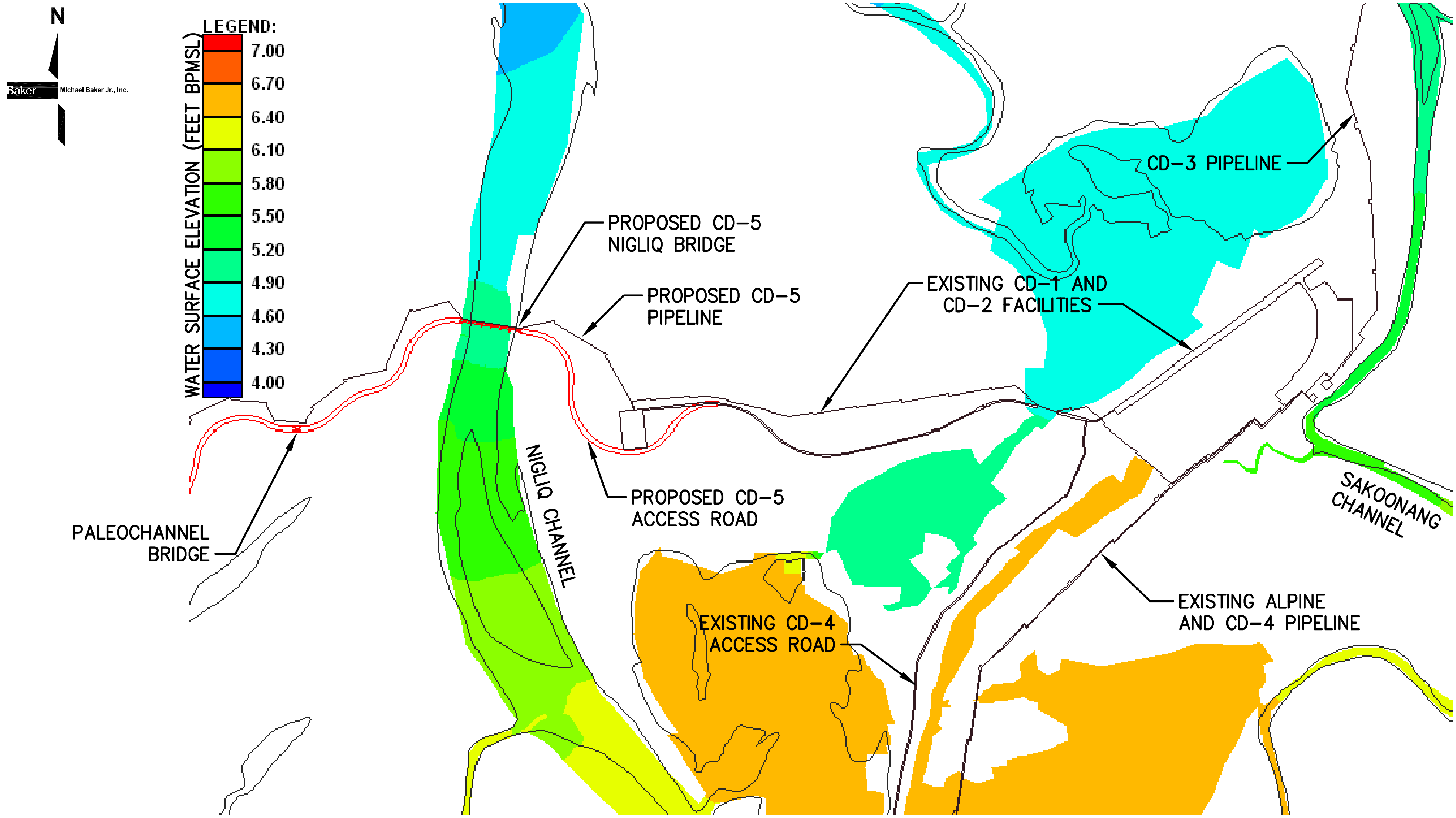


Baker Michael Baker Jr., Inc.	TITLE: COLVILLE DELTA CHANNELS		
ConocoPhillips Alaska, Inc.	FILE NAME: 105755 _10	SCALE: As Shown	Figure B2

Baker Michael Baker Jr., Inc.	TITLE: Location Of PI 01 – PI 15A Along The Alpine Pipeline	
ConocoPhillips Alaska, Inc.	FILE NAME: 105755 _04	SCALE: As Shown	Figure B3

Baker Michael Baker Jr., Inc.	TITLE: Permanent Staff Gage Locations		
ConocoPhillips Alaska, Inc.	FILE NAME: 105755 _03.dwg	SCALE: As Shown	Figure B4

Baker Michael Baker Jr., Inc.	TITLE: Stationing Along The Alpine Facilities/Road		
ConocoPhillips Alaska, Inc.	FILE NAME: 105755 _05.dwg	SCALE: As Shown	Figure B5



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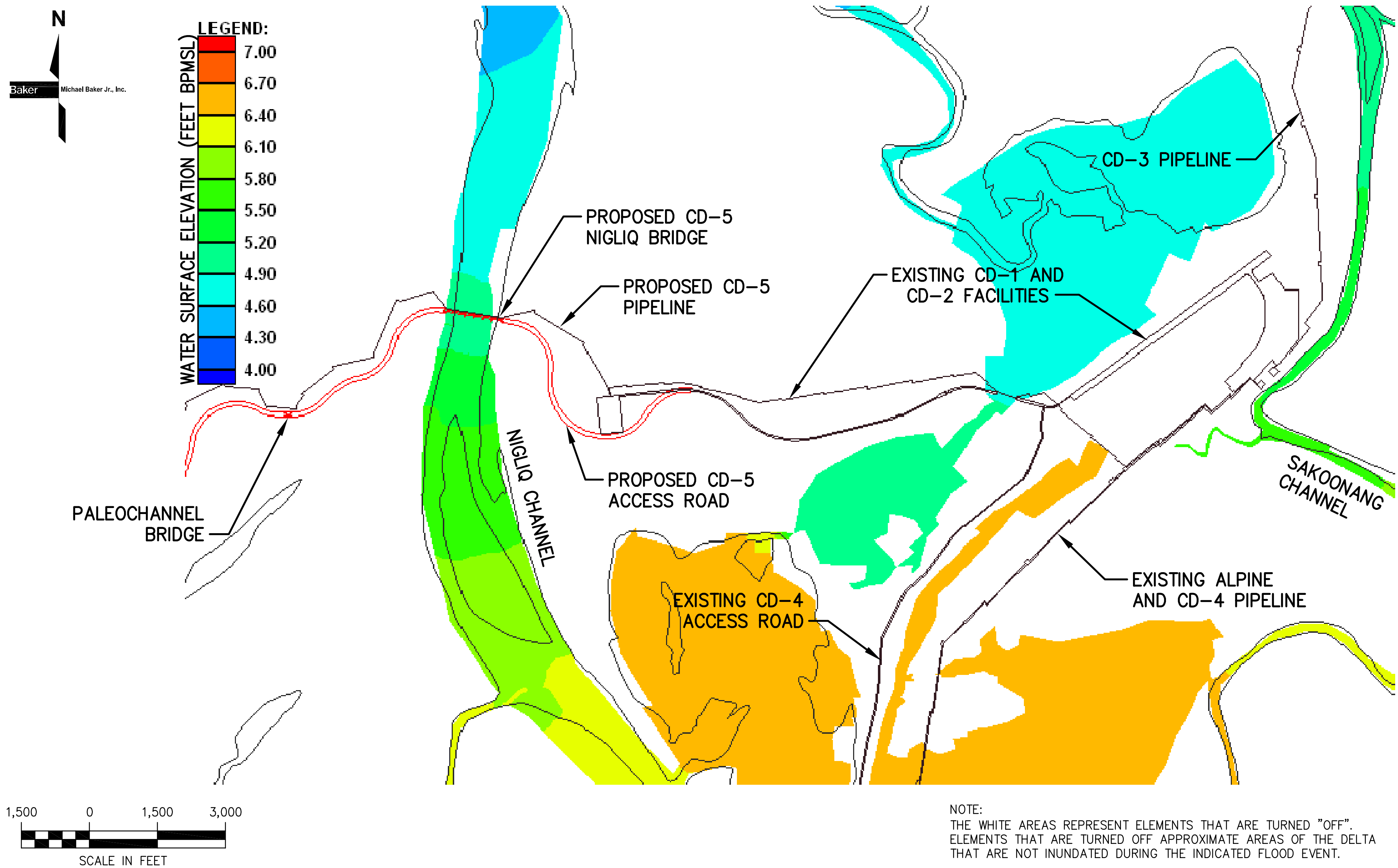
SCALE IN FEET

NOTE:
THE WHITE AREAS REPRESENT ELEMENTS THAT ARE TURNED "OFF". ELEMENTS THAT ARE TURNED OFF APPROXIMATE AREAS OF THE DELTA THAT ARE NOT INUNDATED DURING THE INDICATED FLOOD EVENT.

Baker Michael Baker Jr., Inc.	TITLE: 2 – Year Flood, Water Surface Elevations Without CD5 Facilities (Existing Conditions)		
COLVILLE RIVER DELTA TWO-DIMENSIONAL SURFACE WATER MODEL CD-5 PROJECT UPDATE – FEBRUARY 2006	FILE NAME: 105755_12.dwg	SCALE: As Shown	Figure B6



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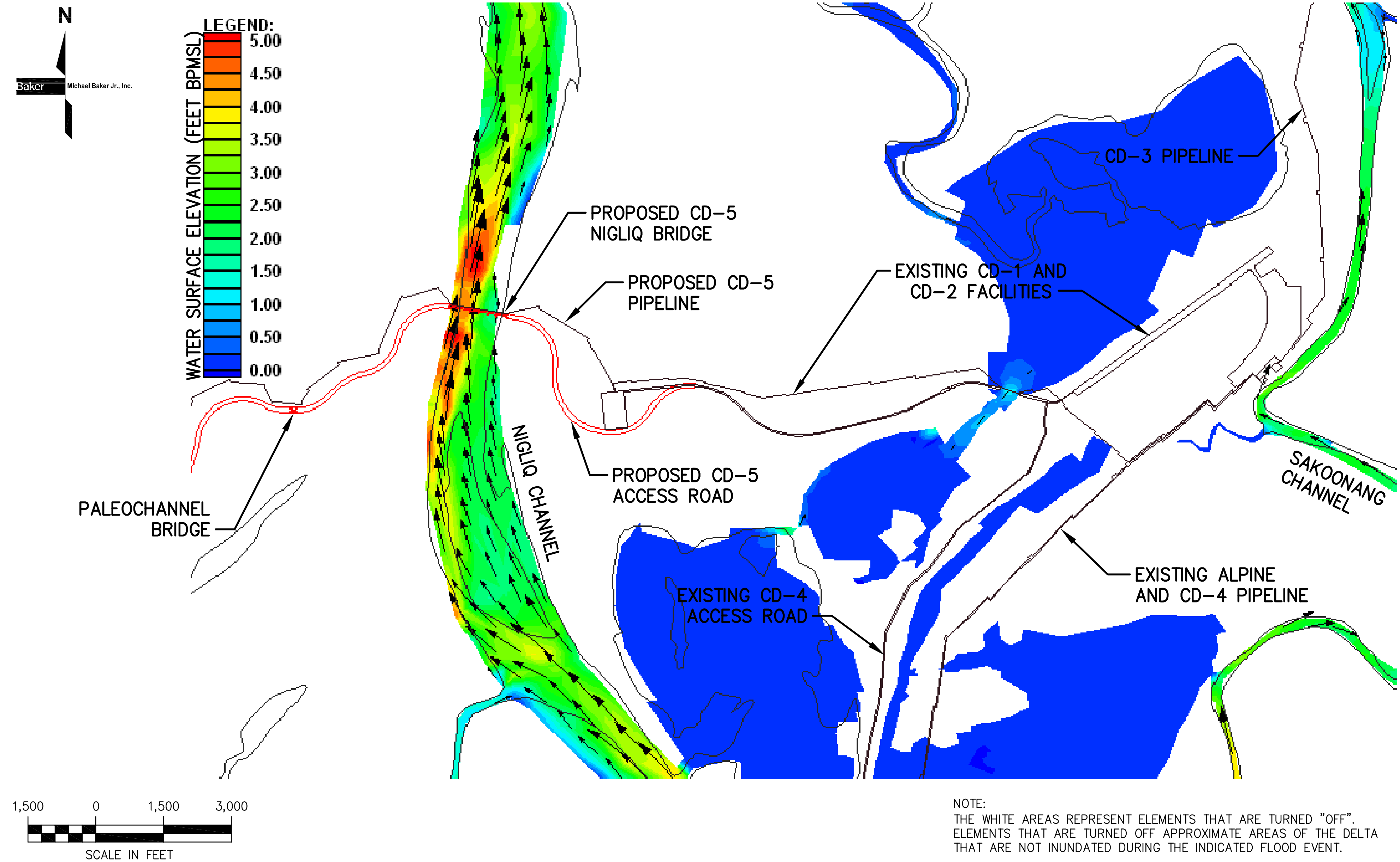
Baker Michael Baker Jr., Inc.	TITLE: 2 – Year Flood, Water Surface Elevations With CD5 Facilities	
COLVILLE RIVER DELTA TWO-DIMENSIONAL SURFACE WATER MODEL CD-5 PROJECT UPDATE – FEBRUARY 2006	FILE NAME: 105755_12.dwg	SCALE: As Shown — Figure B7



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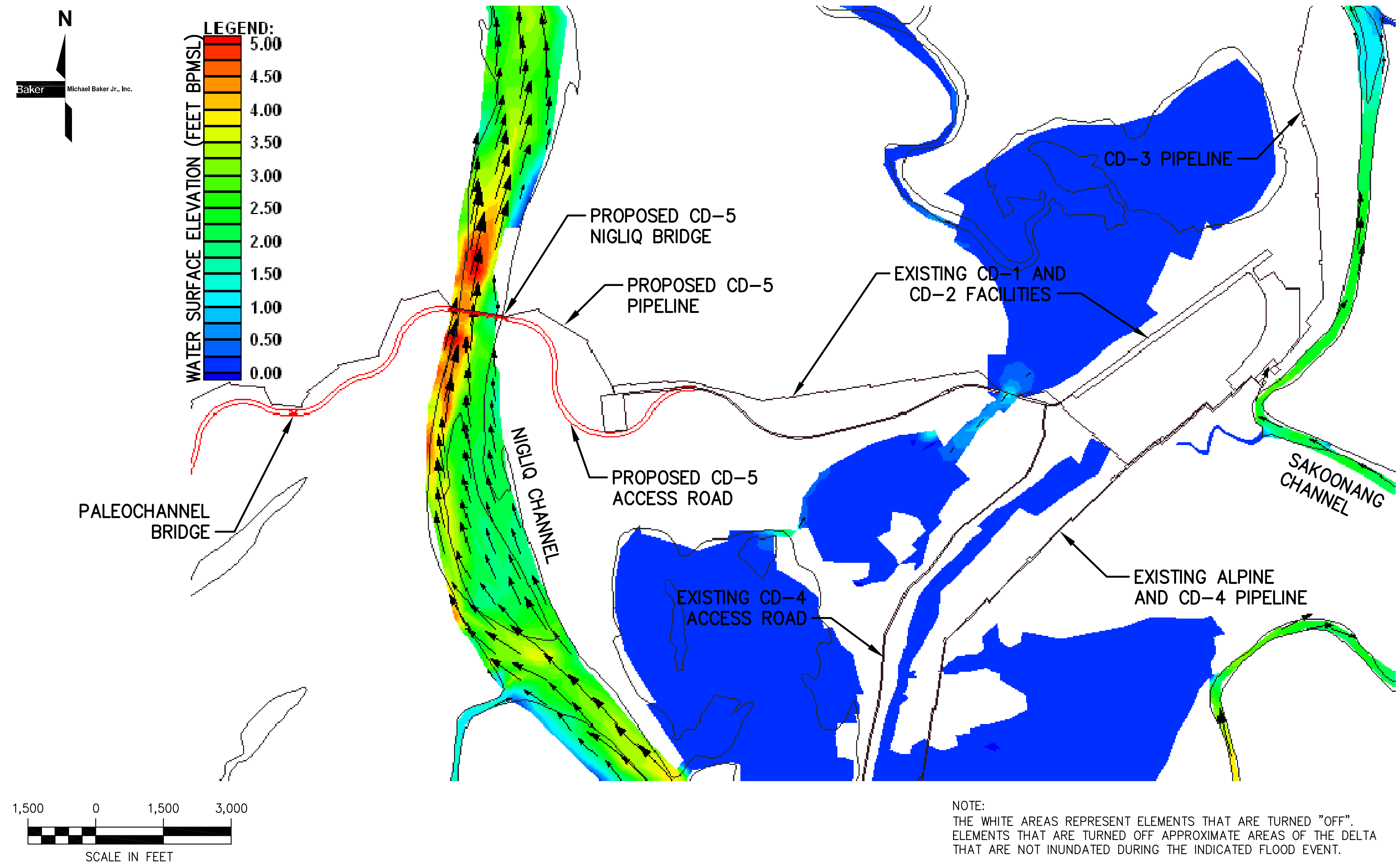
Baker **Michael Baker Jr., Inc.**	TITLE: 2 – Year Flood, Depth Averaged Velocity Without CD5 Facilities (Existing Conditions)		
COLVILLE RIVER DELTA TWO-DIMENSIONAL SURFACE WATER MODEL CD-5 PROJECT UPDATE – FEBRUARY 2006	FILE NAME: 105755_12.dwg	SCALE: As Shown	Figure B8



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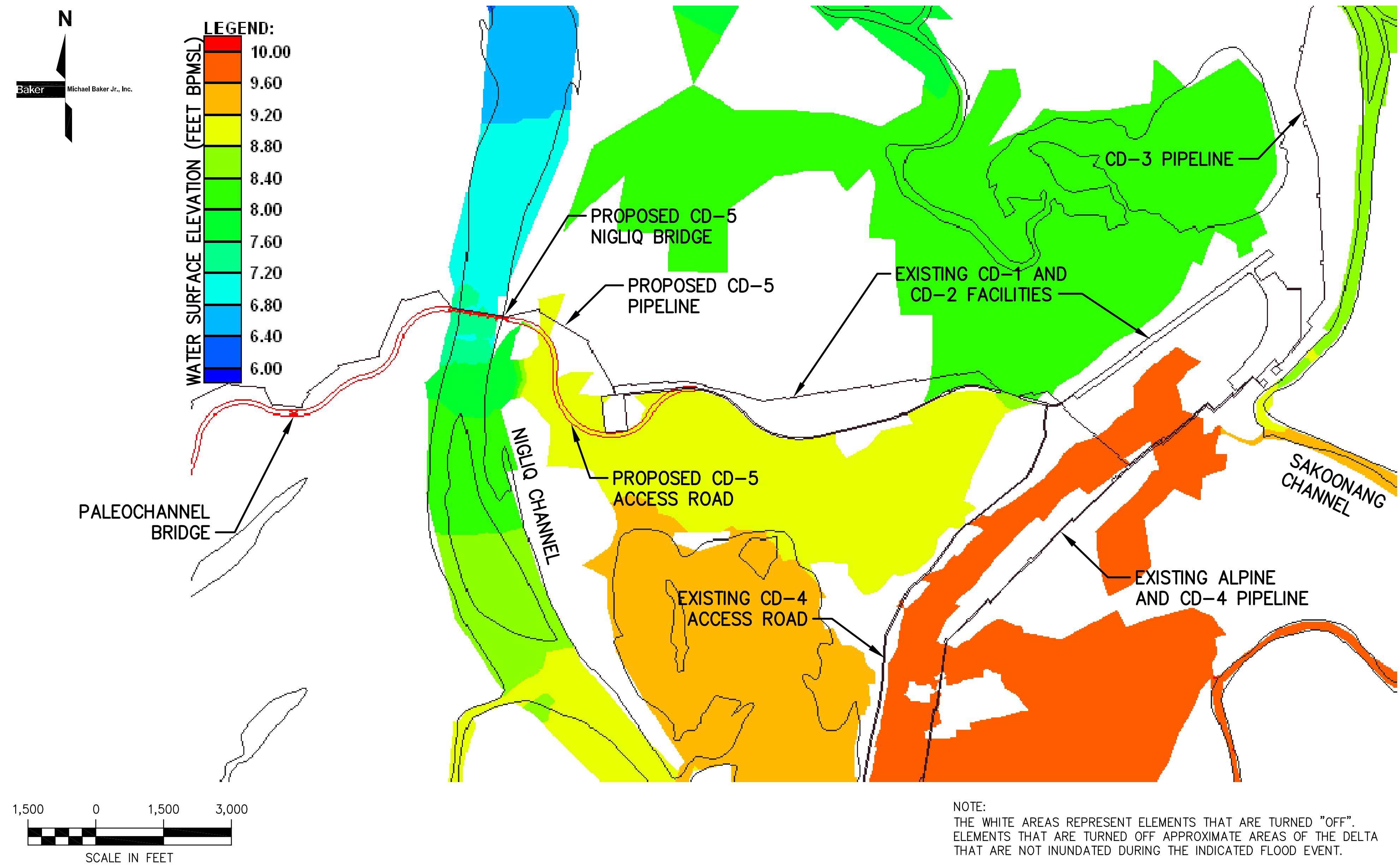
Baker Michael Baker Jr., Inc.	TITLE: 2 – Year Flood, Depth Averaged Velocity With CD5 Facilities		
COLVILLE RIVER DELTA TWO-DIMENSIONAL SURFACE WATER MODEL CD-5 PROJECT UPDATE – FEBRUARY 2006	FILE NAME: 105755_12.dwg	SCALE: As Shown	Figure B9



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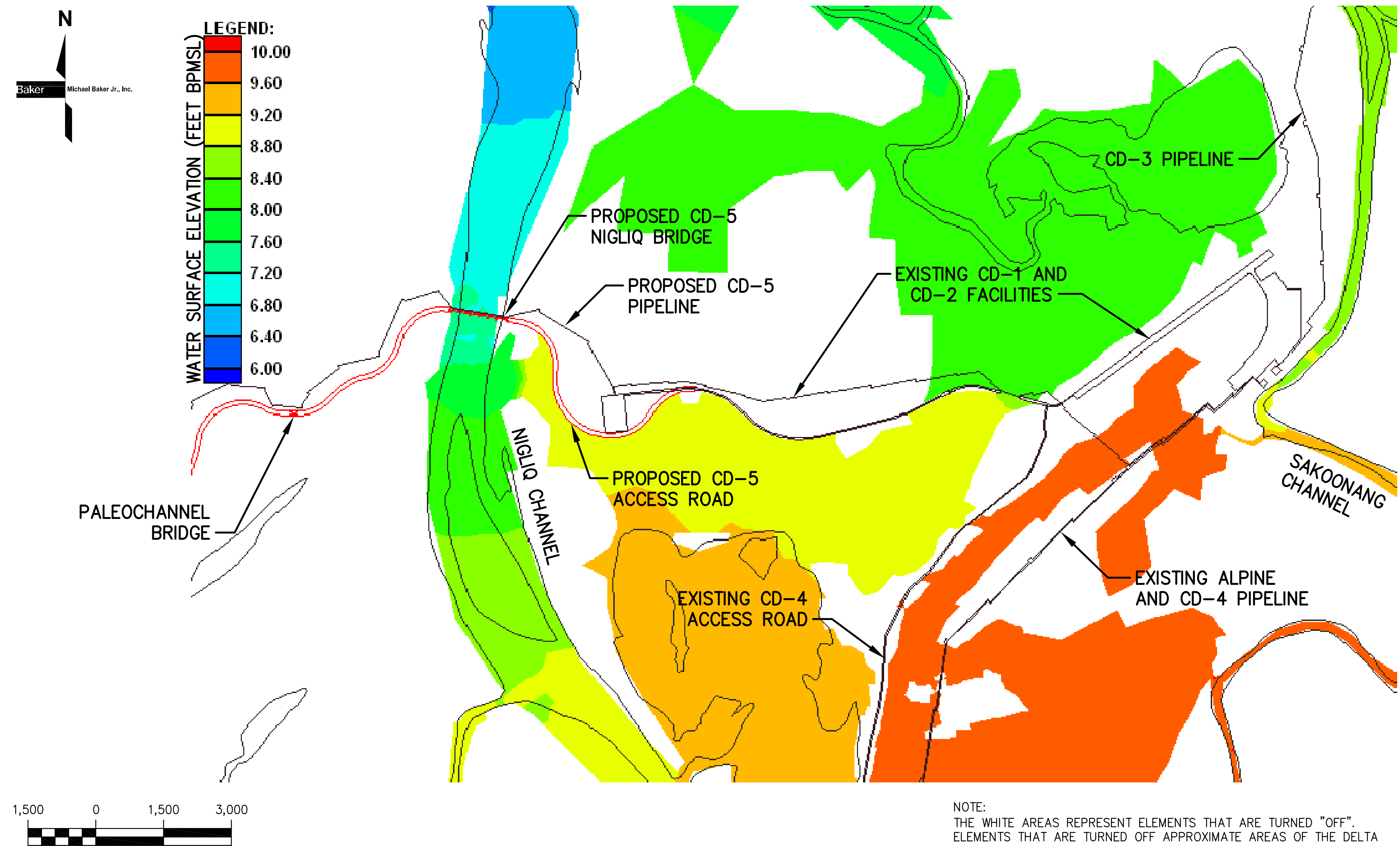
Baker **Michael Baker Jr., Inc.**	TITLE: 10 – Year Flood, Water Surface Elevations Without CD5 Facilities (Existing Conditions)	
COLVILLE RIVER DELTA TWO-DIMENSIONAL SURFACE WATER MODEL CD-5 PROJECT UPDATE – FEBRUARY 2006	FILE NAME: 105755_12.dwg	SCALE: As Shown	Figure B10



NOTE:
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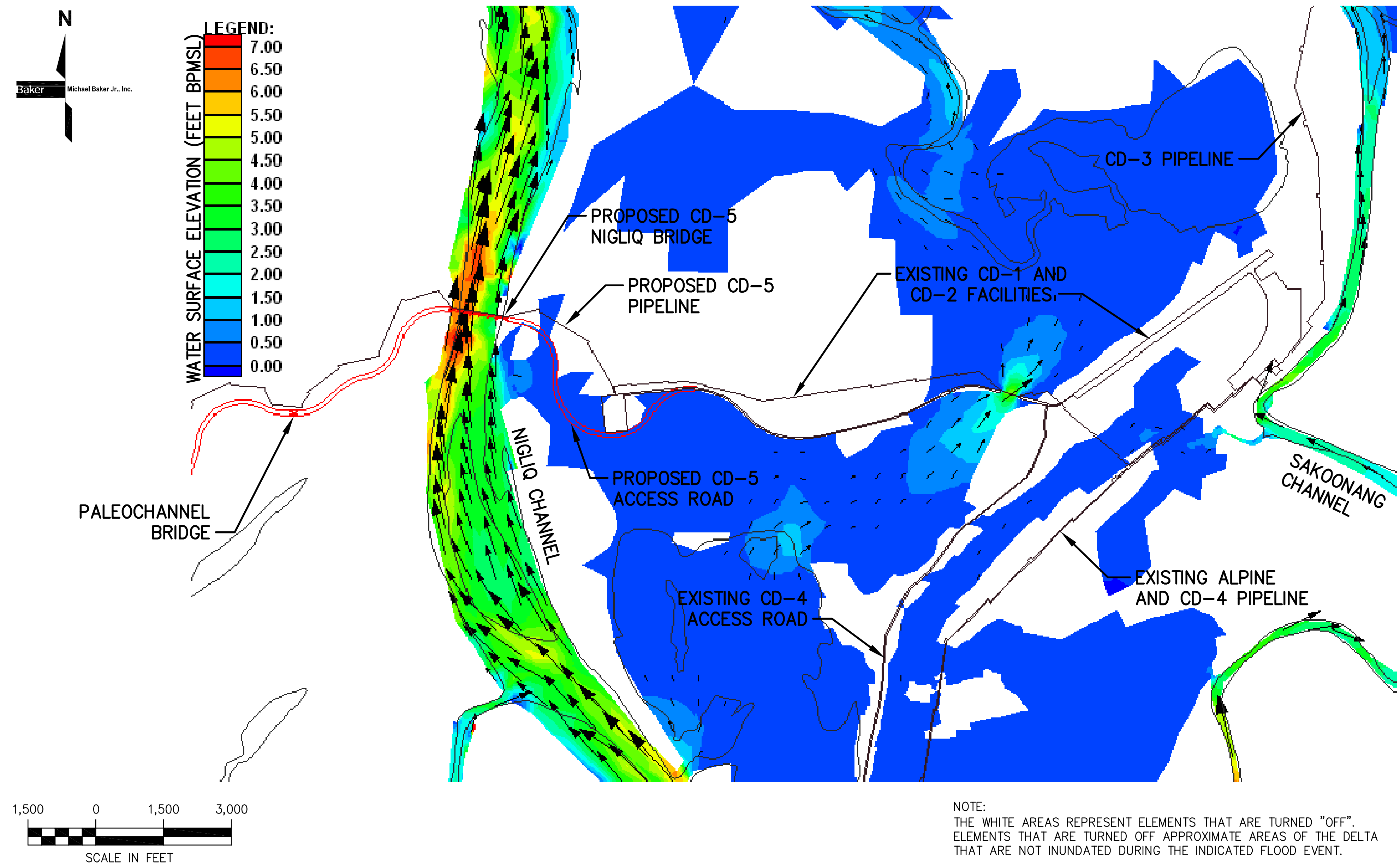
Baker Michael Baker Jr., Inc.	TITLE: 10 – Year Flood, Water Surface Elevations With CD5 Facilities
COLVILLE RIVER DELTA TWO-DIMENSIONAL SURFACE WATER MODEL CD-5 PROJECT UPDATE – FEBRUARY 2006	FILE NAME: 105755_12.dwg | SCALE: As Shown | Figure B11



NOTE:
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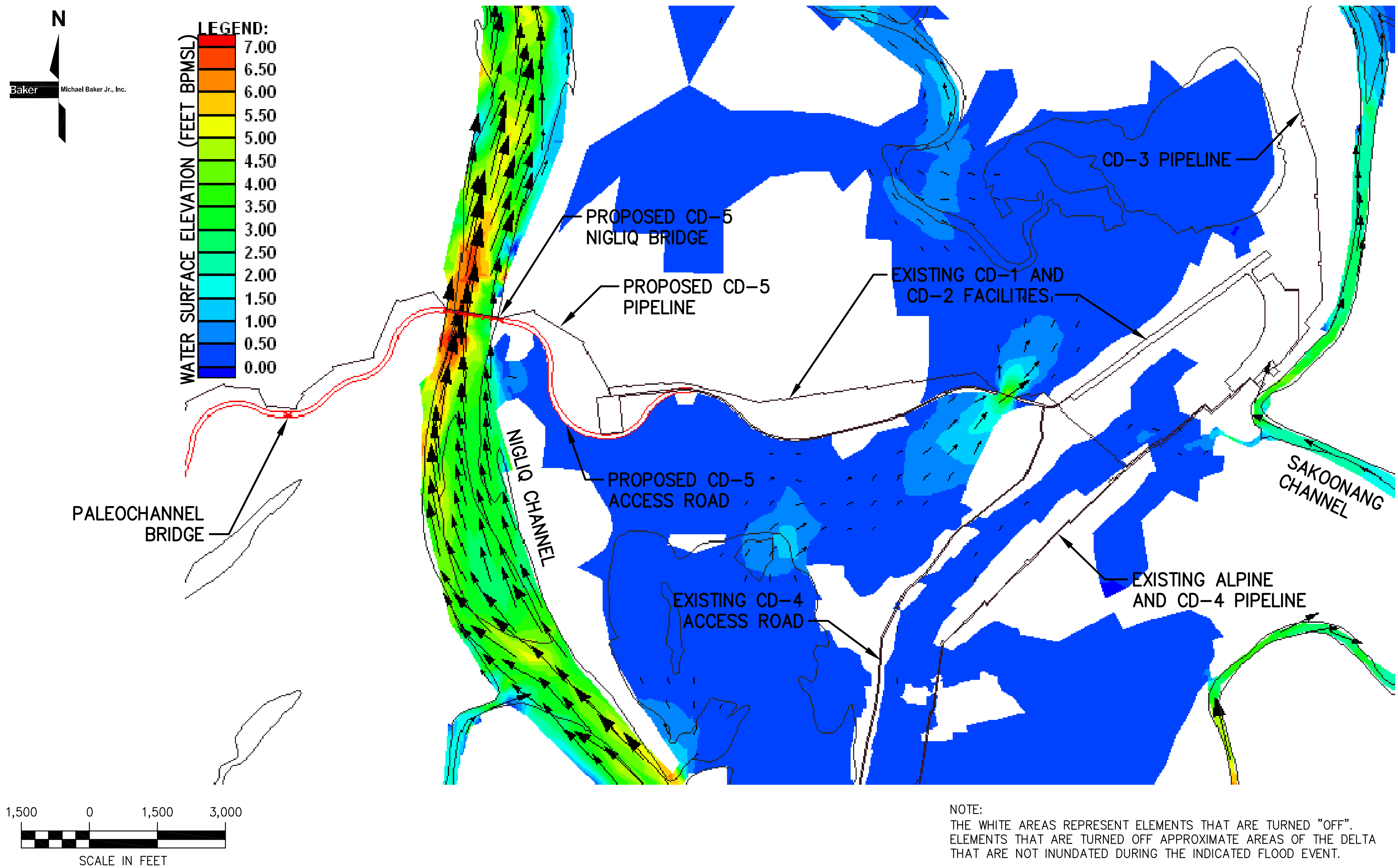
Baker Michael Baker Jr., Inc.	TITLE: 10 – Year Flood, Depth Averaged Velocity Without CD5 Facilities (Existing Conditions)		
COLVILLE RIVER DELTA TWO-DIMENSIONAL SURFACE WATER MODEL CD-5 PROJECT UPDATE – FEBRUARY 2006	FILE NAME: 105755_12.dwg	SCALE: As Shown	Figure B12



NOTE:
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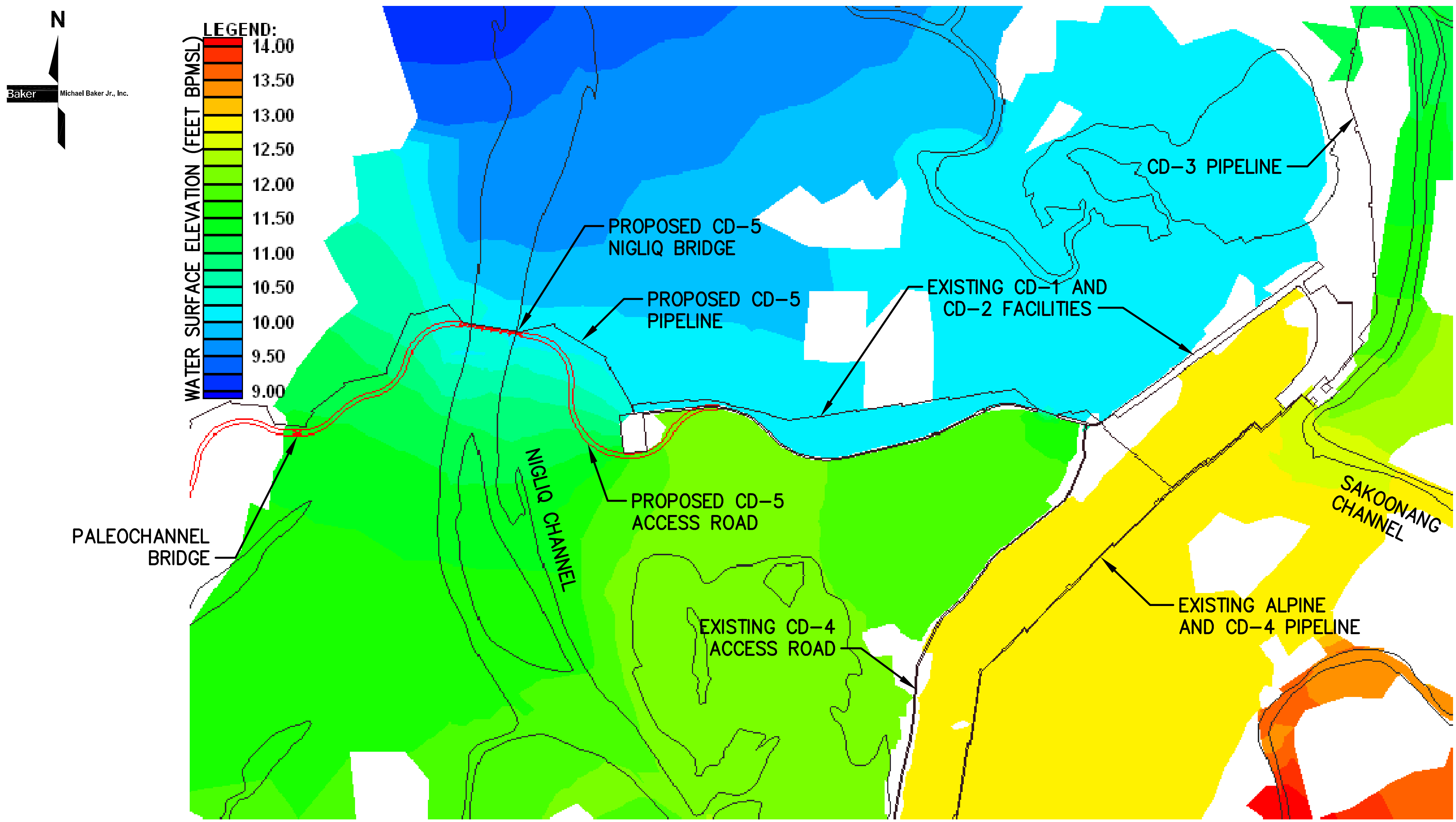
Baker **Michael Baker Jr., Inc.**	TITLE: 10 – Year Flood, Depth Averaged Velocity With CD5 Facilities		
COLVILLE RIVER DELTA TWO-DIMENSIONAL SURFACE WATER MODEL CD-5 PROJECT UPDATE – FEBRUARY 2006	FILE NAME: 105755_12.dwg	SCALE: As Shown	Figure B13



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SCALE IN FEET

NOTE:
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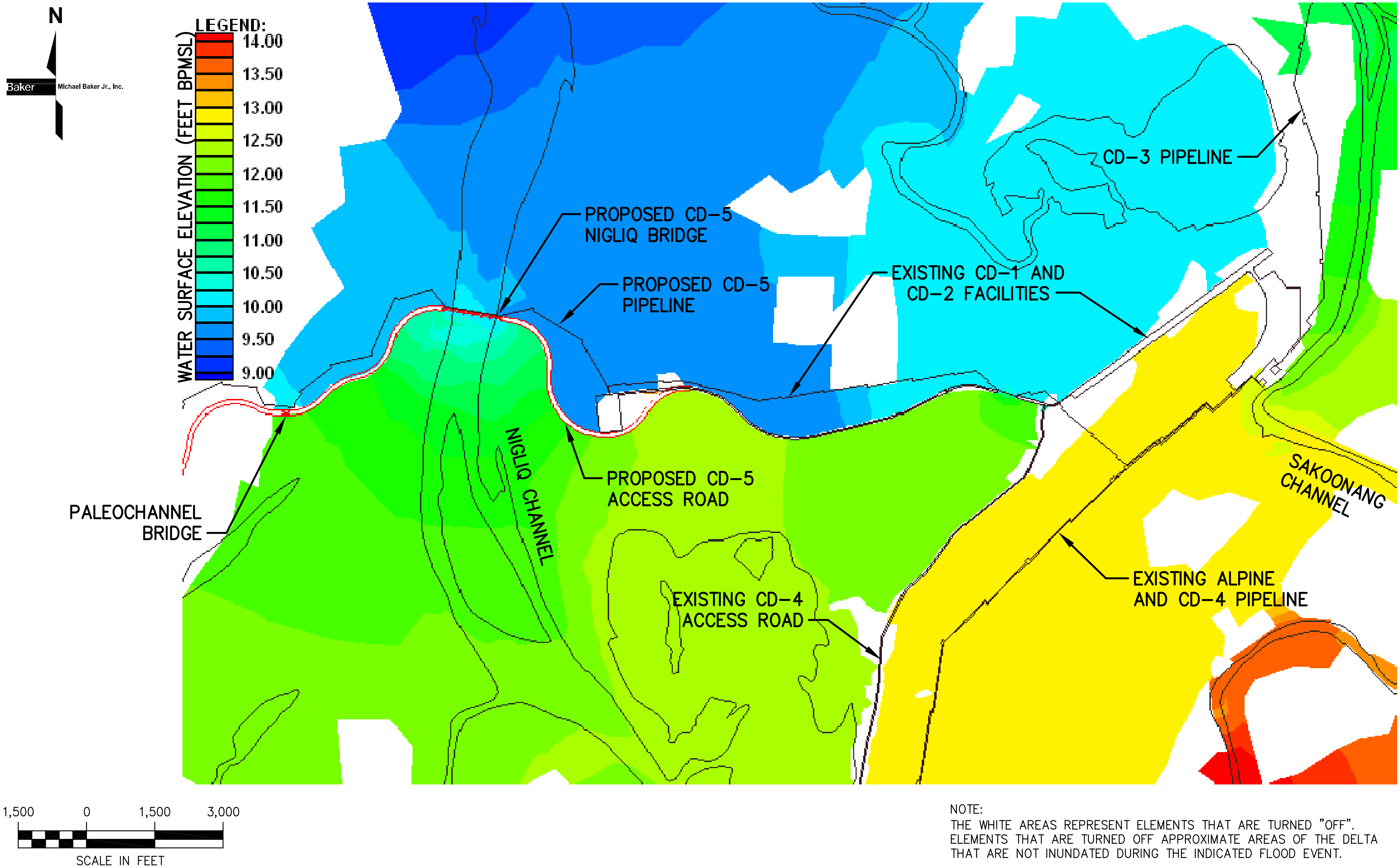
Baker **Michael Baker Jr., Inc.**	TITLE: 50 – Year Flood, Water Surface Elevations Without CD5 Facilities (Existing Conditions)		
COLVILLE RIVER DELTA TWO-DIMENSIONAL SURFACE WATER MODEL CD-5 PROJECT UPDATE – FEBRUARY 2006	FILE NAME: 105755_12.dwg	SCALE: As Shown	Figure B14



NOTE:
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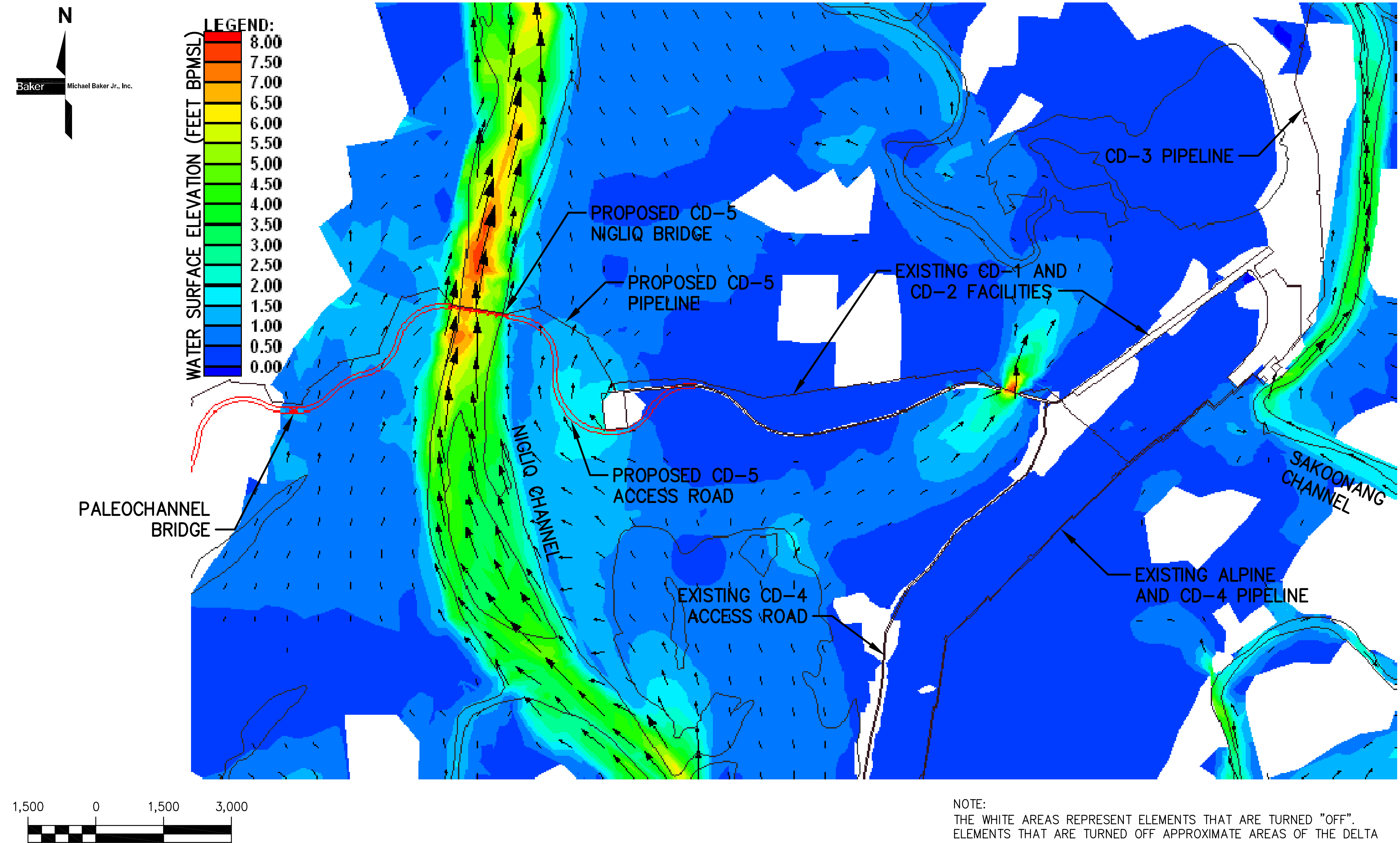
Baker — Michael Baker Jr., Inc.	TITLE: 50 – Year Flood, Water Surface Elevations With CD5 Facilities		
COLVILLE RIVER DELTA TWO-DIMENSIONAL SURFACE WATER MODEL CD-5 PROJECT UPDATE – FEBRUARY 2006	FILE NAME: 105755_12.dwg	SCALE: As Shown	Figure B15



NOTE:
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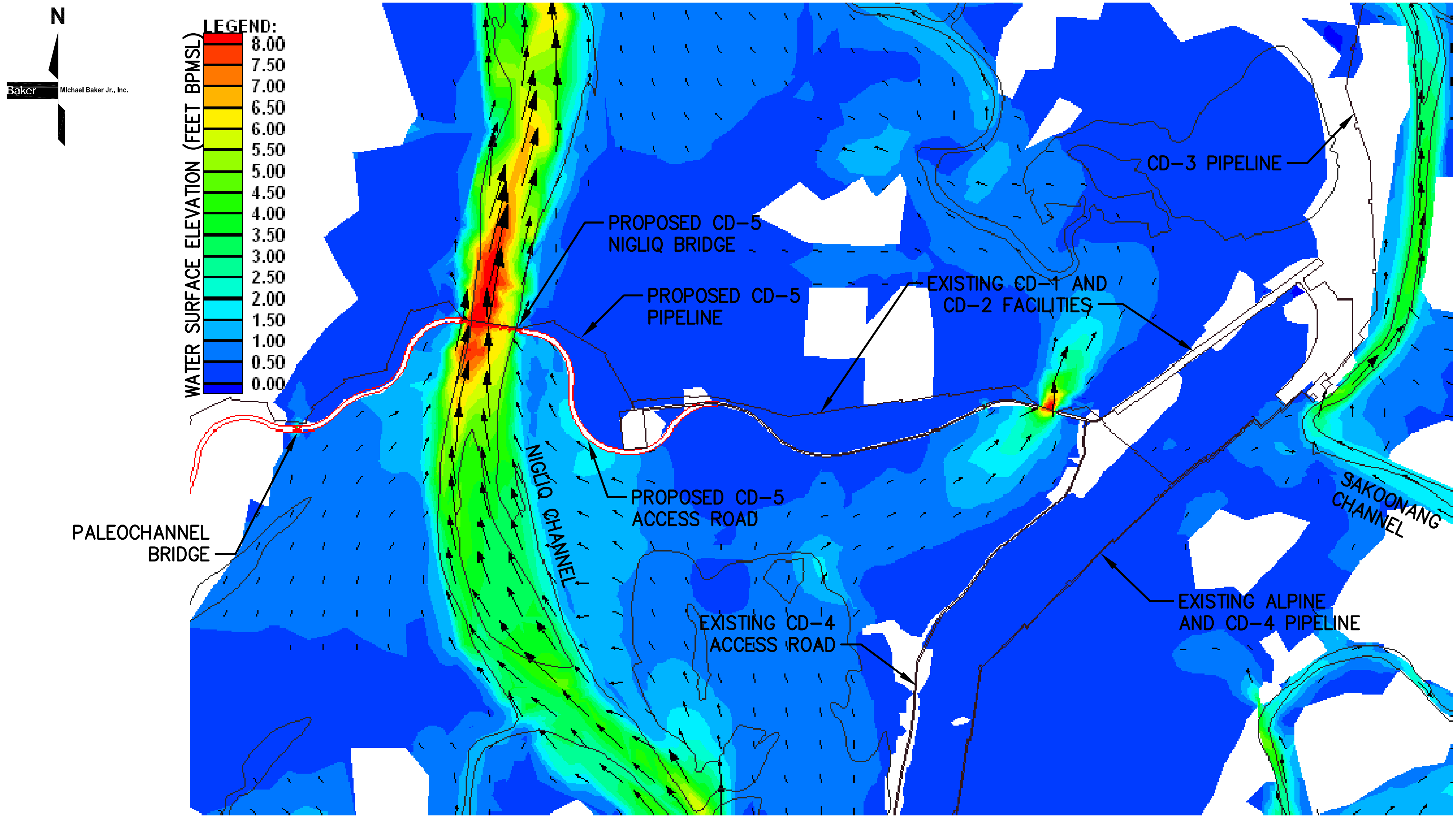
Baker Michael Baker Jr., Inc.	TITLE: 50 – Year Flood, Depth Averaged Velocity Without CD5 Facilities (Existing Conditions)		
COLVILLE RIVER DELTA TWO-DIMENSIONAL SURFACE WATER MODEL CD-5 PROJECT UPDATE – FEBRUARY 2006	FILE NAME: 105755_12.dwg	SCALE: As Shown	Figure B16



1,500 0 1,500 3,000

SCALE IN FEET

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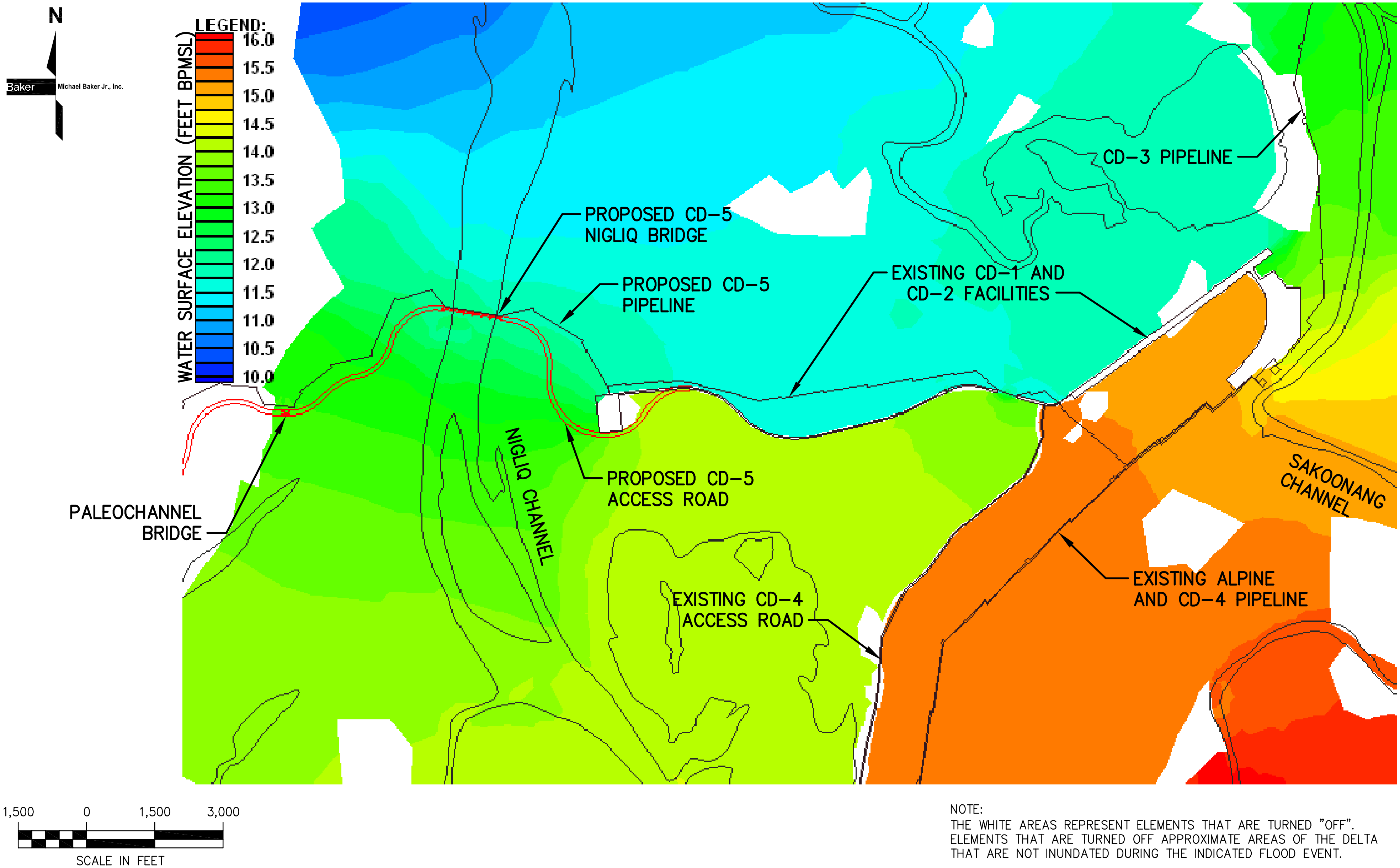
Baker **Michael Baker Jr., Inc.**	TITLE: 50 – Year Flood, Depth Averaged Velocity With CD5 Facilities		
COLVILLE RIVER DELTA TWO-DIMENSIONAL SURFACE WATER MODEL CD-5 PROJECT UPDATE – FEBRUARY 2006	FILE NAME: 105755_12.dwg	SCALE: As Shown	Figure B17



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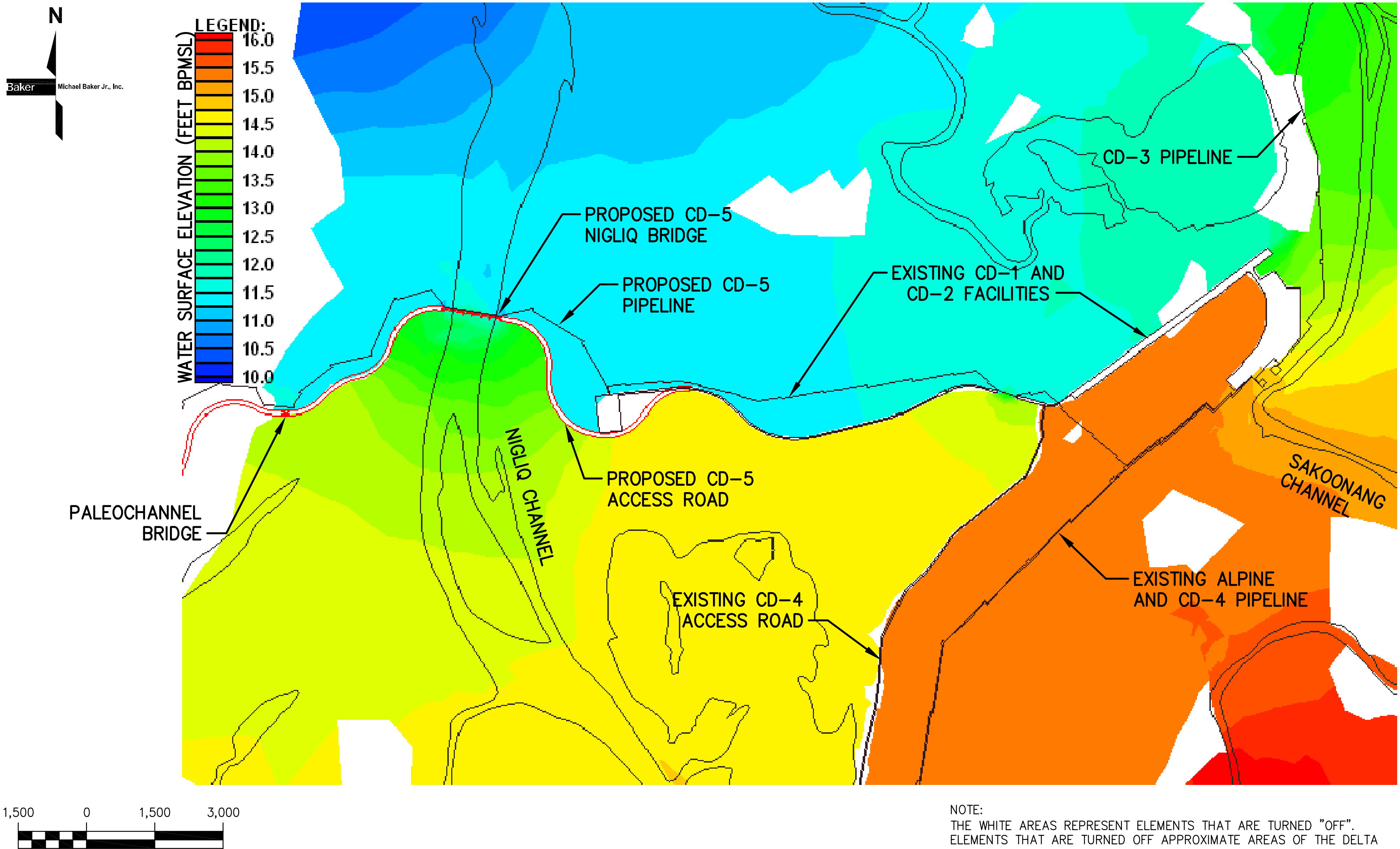
Baker **Michael Baker Jr., Inc.**	TITLE: 200 – Year Flood, Water Surface Elevations Without CD5 Facilities (Existing Conditions)		
COLVILLE RIVER DELTA TWO-DIMENSIONAL SURFACE WATER MODEL CD-5 PROJECT UPDATE – FEBRUARY 2006	FILE NAME: 105755_12.dwg	SCALE: As Shown	Figure B18



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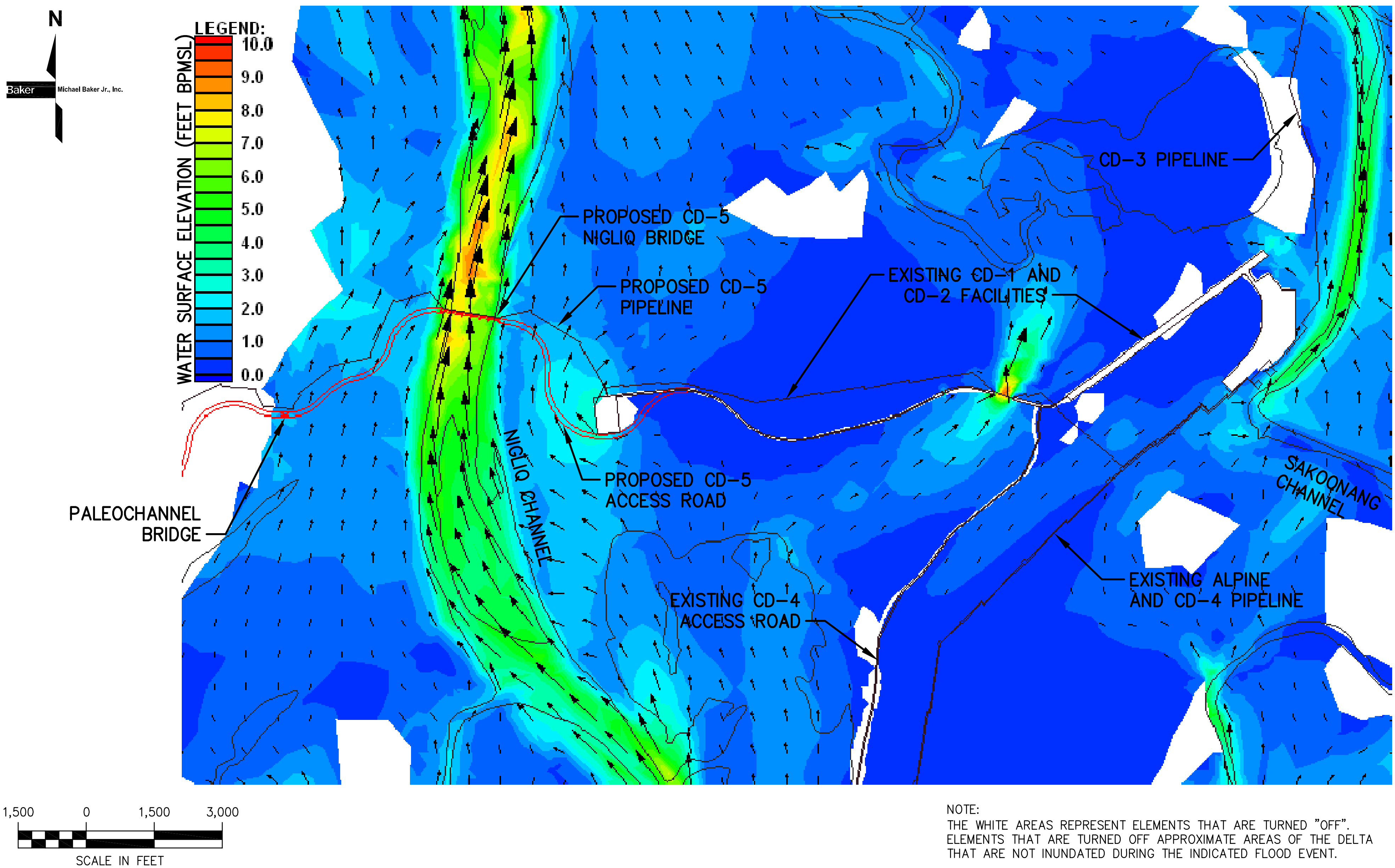
THAT ARE NOT INUNDATED DURING THE INDICATED FLOOD EVENT.

Baker Michael Baker Jr., Inc.	TITLE: 200 – Year Flood, Water Surface Elevations With CD5 Facilities		
COLVILLE RIVER DELTA TWO-DIMENSIONAL SURFACE WATER MODEL CD-5 PROJECT UPDATE – FEBRUARY 2006	FILE NAME: 105755_12.dwg	SCALE: As Shown	Figure B19



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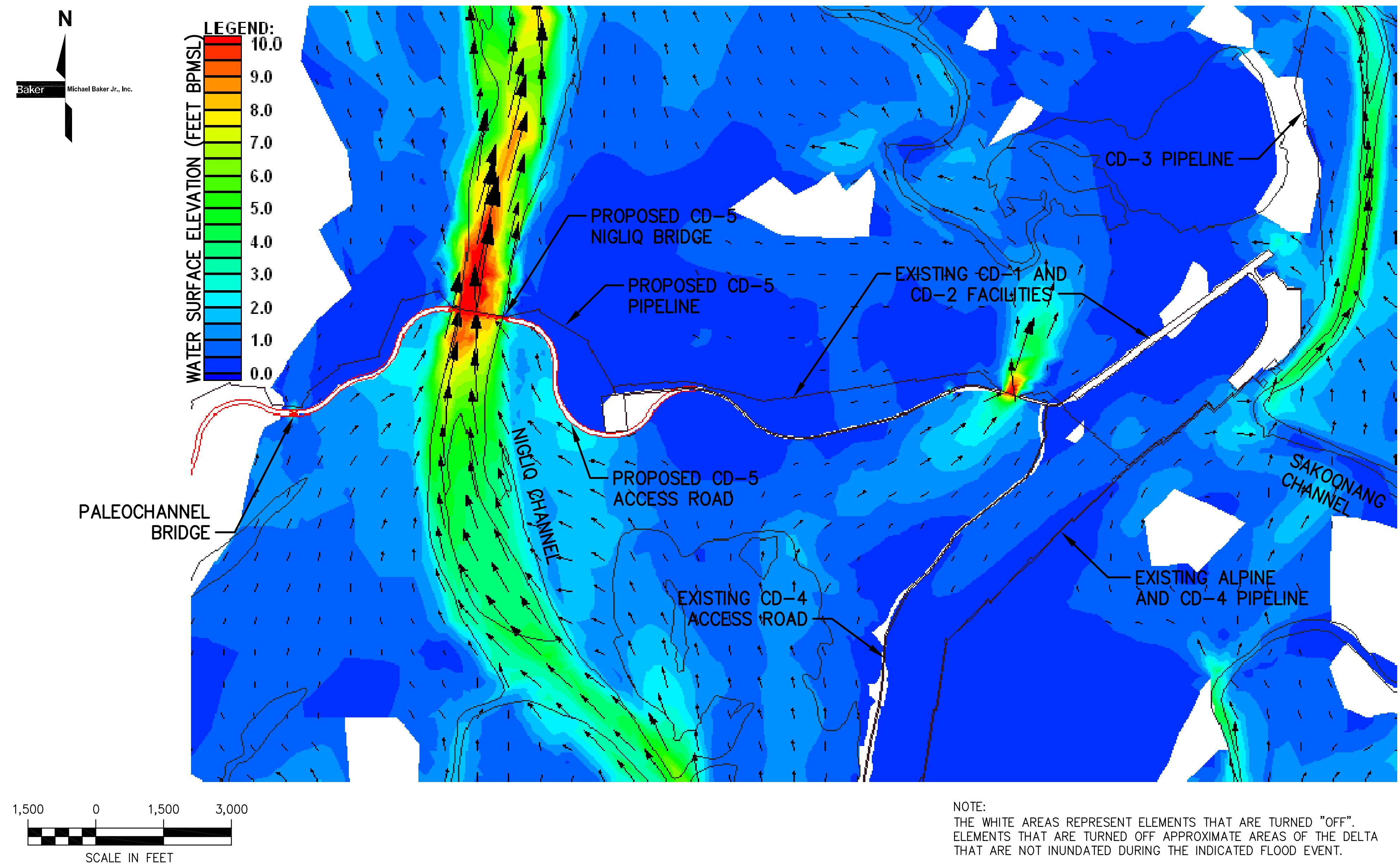
Baker Michael Baker Jr., Inc.	TITLE: 200 – Year Flood, Depth Averaged Velocity Without CD5 Facilities (Existing Conditions)	
COLVILLE RIVER DELTA TWO-DIMENSIONAL SURFACE WATER MODEL CD-5 PROJECT UPDATE – FEBRUARY 2006	FILE NAME: 105755_12.dwg	SCALE: As Shown	Figure B20



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Baker — Michael Baker Jr., Inc.	TITLE: 200 – Year Flood, Depth Averaged Velocity With CD5 Facilities		
COLVILLE RIVER DELTA TWO-DIMENSIONAL SURFACE WATER MODEL CD-5 PROJECT UPDATE – FEBRUARY 2006	FILE NAME: 105755_12.dwg	SCALE: As Shown	Figure B21

Baker Michael Baker Jr., Inc.	TITLE: Stationing Along The CD3 Pipeline
ConocoPhillips Alaska, Inc.	FILE NAME: 105755 _06 | SCALE: As Shown | Figure B22

Baker Michael Baker Jr., Inc.	TITLE: Stationing Along The CD4 Access Road and CD4 Pipeline
ConocoPhillips Alaska, Inc.	FILE NAME: 105755 _07 | SCALE: As Shown | Figure B23

Baker Michael Baker Jr., Inc.	TITLE: Stationing Along The CD5 Access Road and CD5 Pipeline PI'S	
ConocoPhillips Alaska, Inc.	FILE NAME: 105755 _11.dwg	SCALE: As Shown

Figure B24

Appendix C CD5 Bridge Scour Project Note February 16, 2006

Project Note

To: Sally Rothwell, ConocoPhillips	Date: February 16, 2006
From: Jeff Baker. P.E.	Project: CD5 Satellite Development
Subject: CD5 Bridge Scour	

This project note revises the CD5 Bridge Scour Project Note dated February 8, 2006. The change is in Section 1.0, second sentence, where the setback distance of the abutment was incorrectly stated. The setback distance has been changed to "40 feet from the edge of low water (elevation zero)", instead of "50-foot setback from the edge of bank". The net result is an increase in the recommended design scour depth at the west abutment of the Nigliq Bridge from -44 to -46 feet.

Bridge scour estimates were made for both the CD5 Nigliq Channel Bridge (Nigliq Bridge) and the Paleo-Channel Bridge (Paleo Bridge) to determine design scour elevations for the bridge foundation members. All scour recommendations are based on the 200-year design flood conditions. Contraction scour estimates of lower magnitude floods in the Nigliq channel are also provided to show the effect of the bridge with respect to the natural contraction scour at the proposed crossing location.

All elevations are presented in the datum feet BPMSL.

1.0. CD5 Nigliq Channel Bridge Scour

The proposed Nigliq Bridge is 1,250 feet wide. The east abutment is located at the top of the bank while the west abutment has a 40-feet from the edge of low water (elevation zero). The bridge crosses the channel at the narrowest point of a natural channel constriction, see Figure 1. Bridge abutments will be vertical pipe piles surrounded by gravel contained within vertical open cell sheet piles. Five sets of in-stream piers will be installed to support the deck superstructure. The bridge geometry was based on the 35% civil/structural bridge drawings developed by PND Incorporated (PND, 2005a).

Hydraulic data for the scour computations were obtained from both the existing 2-dimensional surface water model (Michael Baker Jr., Inc. 2006) and a 1-dimensional HEC-RAS model of the

Nigliq Channel in the vicinity of the CD5 bridge crossing. The HEC-RAS model was specifically developed to provide localized hydraulic data for the scour computations.

1.1. HEC-RAS Model Development

Cross section data were obtained by extracting ground surface and channel geometry from the topography of the 2-dimensional model. This included the new topography added for the CD5 2-dimensional model update (Michael Baker Jr., Inc, 2006). All cross section data were based on the existing conditions, i.e. without the CD5 road and bridge. Manning's roughness values were also taken from the 2-dimensional model. Minor adjustments to Manning's values were made during calibration of the HEC-RAS model. Once the initial cross sections were input, additional cross sections were interpolated to improve the HEC-RAS computations. Bridge geometry and the CD5 road alignment were incorporated into the cross sections to represent the post CD5 conditions.

Discharge in the Nigliq Channel through the proposed CD5 Bridge was calculated from the 2-dimensional model runs by using the predicted water velocity and depth data through the bridge. A flow string with a minimum of 20 points was created and discharge was estimated based on the velocities and depths through the bridge. Calculation methods were similar to USGS discharge measurement technique calculations.

Estimated discharge through Nigliq Channel Bridge for specific return periods are shown below:

Table 1.1: Estimated Discharge through Nigliq Channel Bridge

Return Period	Discharge (cfs)
200	186,000
50	132,000
10	81,000

Discharge upstream of the bridge was assumed equal to the discharge through the bridge. An additional 10% of discharge was added downstream of the bridge to account for the cross flow and varied flow conditions observed in the 2-dimensional model. This provided a close approximation in the water surface elevation predictions between the HEC-RAS and 2-dimensional models at the CD5 Bridge. Downstream boundary conditions for the HEC-RAS model were represented based on known water surface elevations, which were estimated from the 2-dimensional model at the specified return periods.

1.2. Sediment/Bed Material

Determination of the D50 (diameters for which 50% of the soil particles are finer as determined from sieve analysis) was compiled from Duane Miller & Associates geotechnical investigations conducted along the Nigliq Crossing (Nigliq Channel) and Nigliq Overflow (Nigliq Paleo Channel) in 2004 and 2005. The primary intent of these geotechnical investigations were to examine the deeper soils for bridge pier design purposes and limited D50 laboratory analysis was performed on samples collected near the ground surface. However, the available data provides a conservative estimate of particle sizes and was considered adequate for the analysis.

Only two of the geotechnical borings at the Nigliq Bridge crossing collected soil samples in the upper layer of material at 5.5 feet and 7.0 feet below ground surface (bgs). D50 values were 0.19 mm at both the 5.5 and 7 feet bgs samples. Between 42 feet and 102 feet, the D50 values ranged from 3.47 mm (42 feet bgs) to 10.40 mm (102 feet bgs). A D50 of 0.19 mm was used for all scour computations.

1.3. Contraction Scour

Contraction scour occurs when the flow area of a channel is reduced, either by a natural channel constriction or by the reduction in flow areas from road embankments. At the Nigliq Bridge location, both scenarios for contraction scour are present. Contraction scour was estimated using the methods in HEC-18, *Evaluating Scour at Bridges Fourth Edition*, developed by the U.S. Federal Highway Administration (FHWA, 2001), the Blench Regime Method, and with the ABSCOUR program (MSHA, 2006) developed by the Maryland State Highway Administration, Office of Bridge Development, Structure Hydrology and Hydraulics Unit (recommended as an alternate method in HEC-18).

All HEC-18 contraction scour estimates are based on the Laursen Live-Bed due to the sediment load and fine grained material found on the channel bottom.

An estimate of the bedload transport rate is required to predict scour using the Blench Method. No bedload measurements have been made in the vicinity of the Nigliq Bridge and a bedload transport rate of 1 ppm has been assumed for the calculations. This is a conservative value essentially representing a clear-water scour condition and the upper limit of the regime depth. Since the bridge spans the entire main channel, the regime depth was considered a valid approximation of contraction scour and was used as a check to the HEC-18 predictions.

The ABSCOUR program is an expanded application of Laursen's Live-Bed contraction scour equation as presented in the FHWA HEC-18 Manual, with certain modifications developed to account for the distribution of flow under the bridge, the bridge geometry and the computation of velocity at the bridge abutments (MSHA, 2004). ABSCOUR was used to predict scour in the post CD5 condition only as a third method to corroborate the initial HEC-18 predictions. Version 7, Build 1.04 of the ABSCOUR program was used.

Design scour elevations are based on 200-year discharges. Scour estimates for the 10 and 50-year discharges are provided to illustrate the effect the Nigliq Bridge has on the natural scour of the channel. Since the bridge is over a natural channel constriction, channel scour at this location occurs without the Nigliq Bridge in place. The proposed bridge spans the entire main channel limiting additional contraction scour to flood events where overbank flows occur. Contraction scour estimates are presented in Tables 1.2, 1.3, and 1.4.

Table 1.2: Contraction Scour based on 10-Year Design Discharge (feet)

	HEC-18	Blench Regime	ABSCOUR
Natural Channel Contraction Scour	1.6	0.0	-
Contraction Scour with CD5 Bridge	1.7	0.0	0.5
Additional Scour due to CD5 Bridge	0.1	0.0	-

Note: Q10 WSE = 7.2 feet

Table 1.3: Contraction Scour based on 50-Year Design Discharge (feet)

	HEC-18	Blench Regime	ABSCOUR
Natural Channel Contraction Scour	2.8	1.0	-
Contraction Scour with CD5 Bridge	7.9	4.1	5.0
Additional Scour due to CD5 Bridge	5.1	3.1	-

Note: Q50 WSE = 10.0 feet

Table 1.4: Contraction Scour based on 200-Year Design Discharge (feet)

	HEC-18	Blench Regime	ABSCOUR
Natural Channel Contraction Scour	3.9	3.8	-
Contraction Scour with CD5 Bridge	11.6	10.5	9.1
Additional Scour due to CD5 Bridge	7.7	8.0	-

Note: Q200 WSE = 12.0 feet

1.4. Pier Scour

Pier scour was estimated based on the CSU equation as presented in the methods of HEC-18. The maximum pier scour was estimated assuming a pier in the deepest channel section and maximum expected water velocity acting on the pier. This provides the most conservative estimate and should be applied to all piers for design to account for any shifting of the channel thalweg. A depth of 46 feet (a 12-foot water surface elevation minus the thalweg elevation of -22 feet, minus the contraction scour of 12 feet) and a maximum velocity of 12 feet per second (estimated from the 2-dimensional model) were used to estimate pier scour. A maximum pier scour depth of 9.6 feet is estimated for the 48-inch diameter piers based on equation 6.2 in HEC-18. Note this is a slightly lower value than that presented in the project note dated December 21, 2005 (Michael Baker Jr., Inc., 2005). Equation 6.2 predicts the maximum pier scour for round nose piers aligned with the flow, which is the case for the Nigliq Bridge piers.

1.5. Abutment Scour

Abutment scour was estimated using the methods presented in HEC-18 and ABSCOUR. Abutment scour calculations assumed vertical wall sheet piles with wing walls. The configuration of the multiple cell open sheet piles was considered more representative of a wing wall configuration than a straight vertical wall. Hydraulic input data were estimated from both the 2-dimensional model and the HEC-RAS model developed for the bridge reach. HEC-18 equations provided the maximum abutment scour for both the left and right abutments. Abutment scour values are presented in Table 1.5.

Table 1.5: Abutment Scour based on 200-Year Design Discharge (feet)

	HEC-18	**ABSCOUR**
West (Left) Abutment	24.0	22.0
East (Right) Abutment	23.7	9.1

1.6. Total Scour

The results of the 200-year flood scour analysis are presented below. All channel sediment was considered non-frozen fine-grained silt. These scour analyses do not take into account any scour protection countermeasures and do not consider layering of coarser gravels that may be encountered at deeper depths.

Table 1.6: Predicted Scour Depths (feet) based on a 200-Year Return Event

	Contraction Scour	Abutment Scour	Pier Scour	Total Scour
General	11.6	-	-	12
Piers	11.6	-	9.6	21
East Abutment	11.6	23.7	-	36
West Abutment	11.6	24.0	-	36

1.7. Recommended CD-5 Nigliq Bridge Design Scour Elevations

The design scour elevation for all piers is recommended at -43 feet. The design elevation assumes a total scour of 21 feet below the channel thalweg, which is at an elevation of -22 feet. Applying this design elevation to all piers considers potential movement of the thalweg and is a conservative approach, especially for the piers on the shallow eastern part of the channel. However, the bridge piers are vital structural components for the bridge and some additional conservatism is reasonable.

Design elevations for the abutments must take into account the potential for lateral migration of the channel banks. A bank migration study of the Nigliq Bridge reach was conducted in a previous study by Michael Baker Jr., Inc. (Michael Baker Jr., Inc., 2004). The study concluded that the east bank is stable, neither aggregating nor eroding based on a comparison of aerial photographs taken over a 51-year period. Therefore, no bank erosion is expected. The recommended design scour elevation for the east abutment is the total scour subtracted from the existing ground elevation. Based on a review of the existing topography the existing ground is at an elevation of 8 feet and the recommended design scour elevation for the east abutment is -28 feet.

The same bank migration study predicts an average bank erosion rate of 2.2 feet per year along the west bank. Considering a design life of 50 years, 110 feet of erosion can be expected. To account for uncertainties in the predicted erosion rate, a safety factor of 2 is recommended and 220 feet of erosion has been assumed. Based on the existing channel geometry and assuming the geometry will not change, the elevation at the toe of the abutment is -8 feet with 220 feet of lateral channel migration to the west. Thus, the recommended design scour elevation for the west abutment is -46 feet.

Table 1.7: Recommended Design Scour Elevation for the CD5 Nigliq Bridge

	Design Scour Elevation (Feet BPMSL)
All Piers	-43
East Abutment	-28
West Abutment	-46

2.0. Paleo-Channel Bridge Scour

The 80-foot (65-foot opening) bridge spanning the Paleo-Channel is located west of the Nigliq Channel in an area comprised primarily of low-lying tundra and shallow lakes. The bridge spans a shallow lake, which is part of a low-lying channel that only has active flow during large flood events. Contraction scour and abutment scour computations were completed using the applicable methods outlined in HEC-18 and the Transportation Association of Canada, *Guide to Bridge Hydraulics, Second Edition*. (TAC 2001).

2.1. Bed Material

D50 laboratory analysis was performed on soil samples collected at the proposed Paleo Bridge between 54 feet bgs (0.88 mm) and 85 feet bgs (1.70 mm). Due to the absence of analysis near the ground surface, a D50 value of 0.19 mm was used for scour computations. This assumption considers that the Paleo-Channel Bridge spans a body of water containing sediment/bed material that most likely represents the organic silt found in the Nigliq Channel.

2.2. Contraction Scour

Discharge through the proposed Paleo Bridge was calculated from the 2-dimensional model runs by using the predicted water velocity and depth data through the bridge. A flow string with a minimum of 20 points was created and discharge was estimated based on the velocities and depths, similar to USGS discharge measurement techniques. Discharge through the Paleo-Channel Bridge during the 200-year design event is estimated as 3,600 cfs.

Ground geometry was based on survey data provided by LCMF (LCMF 2005), and bridge geometry data provided was by PND Incorporated (PND 2005b). All scour estimates for the Paleo Bridge assume clear water conditions as there is little moving bedload in the low velocity overbank flows. The Paleo Bridge was modeled as a flood relief bridge spanning a shallow wide floodplain. The bridge is over a small pond, however, it is not over an established channel and there is no established channel with independent flows approaching the bridge during design flood conditions. A 1-dimensional HEC-RAS model would not accurately represent the flow conditions at this location. Therefore, all hydraulic variables used in the scour computations were taken from the 2-dimensional model output (Michael Baker Jr., Inc., 2006).

Contraction scour was estimated using two methods, HEC-18 clear water scour, and the Competent-Velocity Method. The estimated water surface elevation at the bridge during the 200-year flood is 11.7 feet (Michael Baker Jr., Inc., 2006) and the ground elevation under the bridge is 4.5 feet (LCMF, 2005).

The competent-velocity method assumes that general scour will proceed until the mean velocity through the bridge opening is reduced to a value just capable of eroding bed material exposed during the scour process. The average general scour is then estimated by making the mean velocity through the bridge opening equal to the competent mean velocity that will erode the bed material. The competent velocity methods assumes a constant discharge, however, the discharge through the Paleo Bridge is not constant and will increase as scour occurs. Therefore, the competent velocity method was not considered appropriate to estimate scour for the Paleo Bridge.

Table 2.1: Paleo-Channel Bridge Contraction Scour based on 200-Year Design Discharge (feet)

	HEC-18
Contraction Scour	22.2
Contraction Scour Elevation	-17.7

2.3. Abutment Scour

Abutment scour was estimated using the procedures defined in HEC-18. Based on Froehlich's equation abutment scour was estimated as 14.5 feet for both the left and right abutments. Based on the HIRE equation, abutment scour was estimated 21 feet for both the left and right abutments. Again, all input data for the scour computations was determined from the 2-dimensional model output.

Table 2.2: Paleo-Channel Bridge Abutment Scour based on 200-Year Design Discharge (feet)

	Froehlich's Equation	HIRE Equation
Abutment Scour	14.5	21.0
Abutment Scour Elevation	-10.0	-16.5

2.4. Recommended Design Scour Elevation

The Paleo Bridge is located on a shallow, wide floodplain and acts as a relief bridge during high magnitude flood events. Floodwaters do not reach this location during mean annual flood events. Approach velocities are low and there is no active channel where flows are being diverted. Combining both the contraction and abutment estimates for a total scour would be overly conservative. Therefore, the recommended scour is the greater of the contraction or abutment scour estimates. The highest contraction scour estimate is 22 feet and the highest abutment scour estimate is 21 feet. Therefore, the recommended design scour elevation for the Paleo-Channel Bridge is 22 feet below the thalweg and or-18 feet.

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