1992 – 2005

Annual Peak Discharge

Colville River Monument 1

Estimate, Calculation, and Method Review

Prepared for

ConocoPhillips

By

Baker

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

March 2006

Table of Contents

Figures

Tables

1.0 Introduction

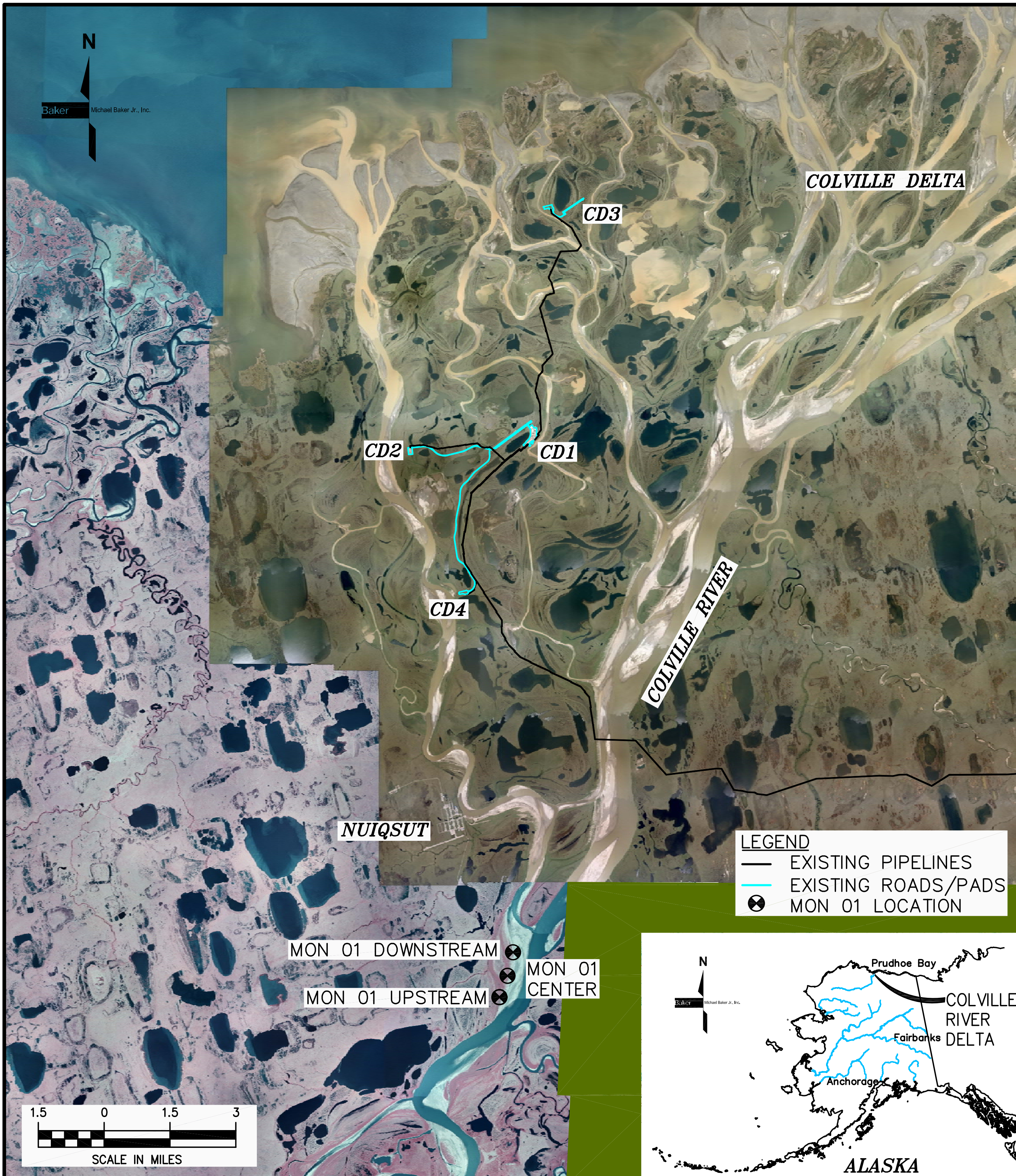
The 21,000 square mile Colville River Basin drains approximately 29% of the North Slope of Alaska (Walker 1983) and is comprised of the Colville River and its tributaries. The Alpine Development (Alpine) is located within the Colville River Delta. The estimation of the annual peak discharge of the Colville River is an important component of the annual hydrologic monitoring for Alpine. The location of the Monument 1 gage, at the head of the Colville River Delta, is the only reach of the Colville River where the flow from all primary contributors is confined in a single channel (see Figure 1).

Collecting peak annual Colville River discharge values allows ongoing validation of criteria established for Alpine and is also used to update the Colville River flood frequency analysis, the results of which could impact future facilities design criteria and design water surface elevations (WSE) in the Colville River Delta. In addition to resource development, hydrologic information for the Colville River is used for the protection of the ecosystem including caribou, various fish species, ducks, geese, and shorebirds (Brabets 1996). It is therefore important that the methods and results of the annual hydrologic investigations are accurate as well as conducted using the most applicable procedures and data.

In September 2004, the U.S. Department of the Interior Bureau of Land Management (BLM) finalized the Alpine Satellite Development Plan (ASDP) Final Environmental Impact Statement (FEIS). The FEIS was prepared to analyze potential environmental impacts of the ConocoPhillips Alaska, Inc. ASDP proposal to construct and operate five oil production pads and associated wells, roads, airstrips, pipelines, and power lines. ASDP is located in the northeast corner of the National Petroleum Reserve-Alaska and the Colville River Delta, North Slope Borough, Alaska (BLM 2004). BLM suggested in the FEIS that some of the annual peak discharge estimates for the Colville River may have been overestimated. In particular, BLM comments in the FEIS included the following:

- *This [discussion of indirect methods] suggests that at least some of the peak flows listed in Table 4A.2.2-7 [Colville River Breakup Peak Flow Record] are overestimated.* (BLM 2004, Section 4A pg 449).
- *… the 2003 peak flow of 350,000 cfs may be overestimated….* (BLM 2004, Section 4A pg 453).

During the summer of 2005, Michael Baker Jr., Inc. (Baker) conducted a direct discharge measurement near peak stage at Monument 1. This direct discharge measurement allowed Baker to prepare this technical paper by verifying the Monument 1 rating curve in order to address the BLM comments in the FEIS and to reevaluate annual peak discharge estimates and the calculation methods. This technical paper presents the results of this review of the annual peak discharge estimations of the Colville River at Monument 1 between 1992 and 2005.



ConocoPhillips
Alaska, Inc.

Baker

Michael Baker Jr., Inc.
A Unit of Michael Baker Corporation
1400 West Benson Blvd., Suite 200
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

DATE:	01/13/06	PROJECT:	105756
DRAWN:	WAP	FILE:	MON01_ASPN83Z4_FIG1.dwg
CHECKED:	MTA	SCALE:	1" = 3 MILES

MONUMENT 01
SITE
LOCATION

FIGURE 1

(SHEET 1 OF 1)

2.0 Colville River Peak Discharge Background

The annual peak discharge of the Colville River has been estimated at or near the Monument 1 gage location since 1962 using direct discharge measurements, indirect discharge methods, and the Monument 1 rating curve.

2.1 Monument 1 Rating Curve

Direct discharge measurements collected at Monument 1 between 1962 and 2005 were conducted during open water (ice free) conditions. In 1962 and 1977, the United States Geological Survey (USGS) conducted direct discharge measurements at various stages for the Colville River near Monument 1. Additional direct discharge measurements were collected in 1992, 1993, and 1995 employing standard USGS midsection techniques using a Price AA velocity meter. In 1996, a stage-discharge relationship was developed at Monument 1 (Shannon & Wilson 1996b). In 2005, a direct discharge measurement was conducted using an Acoustic Doppler Current Profiler (ADCP). Discharge results in 2005 plot within approximately 4% of the Monument 1 rating curve, suggesting that the rating curve has not shifted significantly over time. Since this discharge is within 5% of the rating curve, the 2005 measurement is considered a verification of the rating curve (Rantz 1982, pg 346). A graphical representation of the Monument 1 Stage-Discharge rating curve is presented in Figure 2.

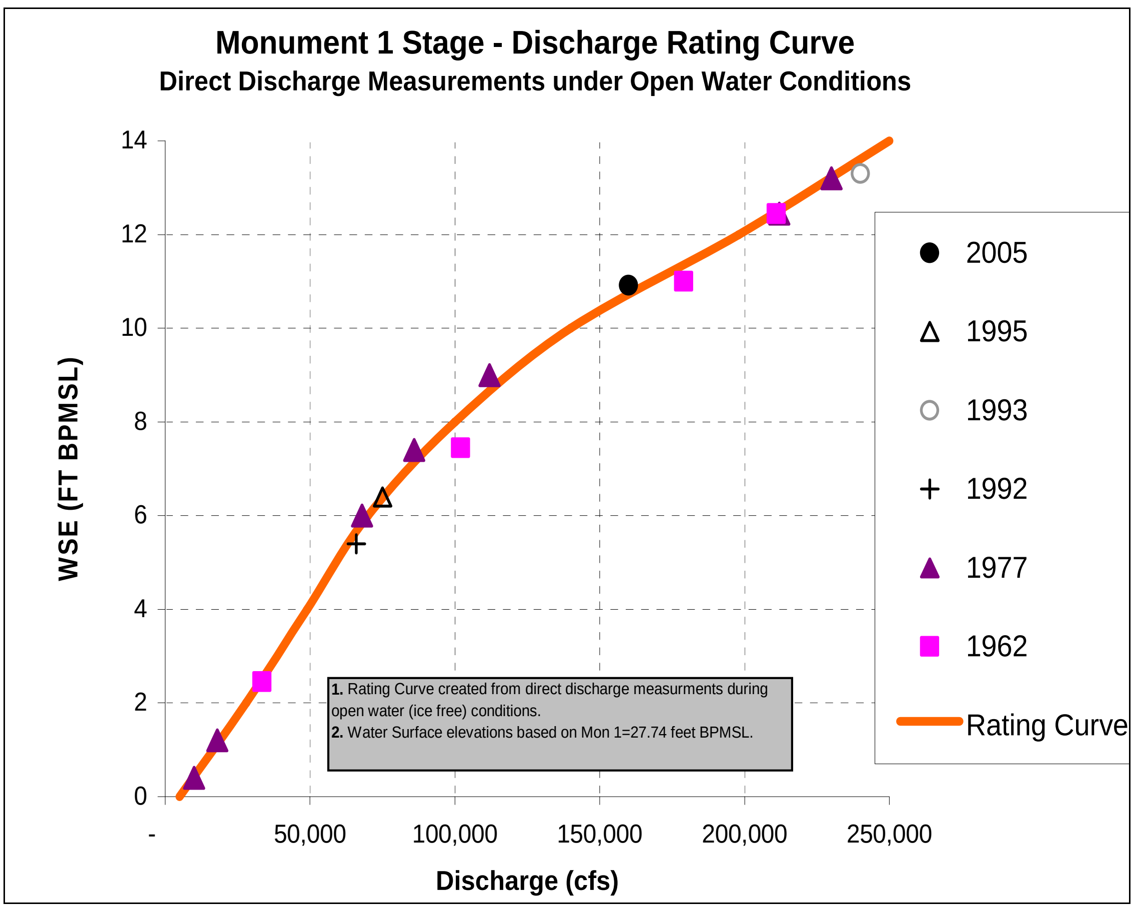


Figure 2 – Monument 1 Stage-Discharge Rating Curve

Once the Monument 1 rating curve was established in 1996, discharge of the Colville River could be estimated at various stages for open water conditions. The highest stage where a direct discharge measurement was conducted was on June 2, 1993, at a stage of approximately 13.4 feet British Petroleum Mean Sea Level (BPMSL). Consequently, the rating curves were established and verified to water surface elevations of less than approximately 14 feet BPMSL. Between 10 and 20 feet BPMSL, the width of the channel at Monument 1 is relatively uniform and therefore the slope of the rating curve (between 10 and 20 feet) is not expected to change considerably. At a water surface elevation greater than 20 feet BPMSL, the rating curve is expected to flatten as water will overtop the east bank of the channel. However, considering the uniform cross section and decreased effects of roughness, it is estimated that a reasonable extrapolation could be made up to approximately 18 feet BPMSL. For the purpose of this analysis, extrapolation was limited to the peak stage in 2001 of 14.2 feet BPMSL.

A variety of conditions possibly could cause fluctuations in the accuracy of the results of estimated discharge values using the Monument 1 rating curve. These parameters include the hydraulic conditions of the channel, changes in the cross-sectional area of the reach, obstructions in the channel and changes in vertical control from year to year. The most common cause of a shifting rating curve is scour or fill (Rantz 1982); however, for the open water Monument 1 rating curve the main influence is obstructions in the channel, primarily snow and ice. The presence of low water channel ice, snow, or floating ice will alter the hydraulic conditions of the reach resulting in an elevated water surface compared to open water conditions. Assuming steady state and open water conditions, the rating curve should provide a reliable approximation of discharge.

2.2 Colville River Annual Peak Indirect Discharge Background

Since 1992, hydrologic studies in support of Alpine have documented annual peak discharge estimates at Monument 1 during the spring. The spring breakup flooding is historically the largest annual flooding event for the Colville River. During these floods, it is frequently impractical to directly measure peak discharges due to the conditions of the river. The primary factors are the presence of ice in the channel and the dangers associated with operating a boat in the river during flood stage.

Historically, annual peak discharge has been estimated using the Monument 1 rating curve and using indirect discharge methods. Indirect methods of determining peak discharge are based on hydraulic equations which relate the discharge to the water surface profile and the geometry of the channel (Benson and Dalrymple 1967). Discharge estimates at Monument 1 were calculated using the slope area and slope conveyance methods.

The estimated peak discharge values and corresponding water surface elevations, between the years 1992 and 2005, are shown on Figure 3. Water surface elevations corresponding to the peak discharge were not available for 1997 and 2000 and therefore are not included.

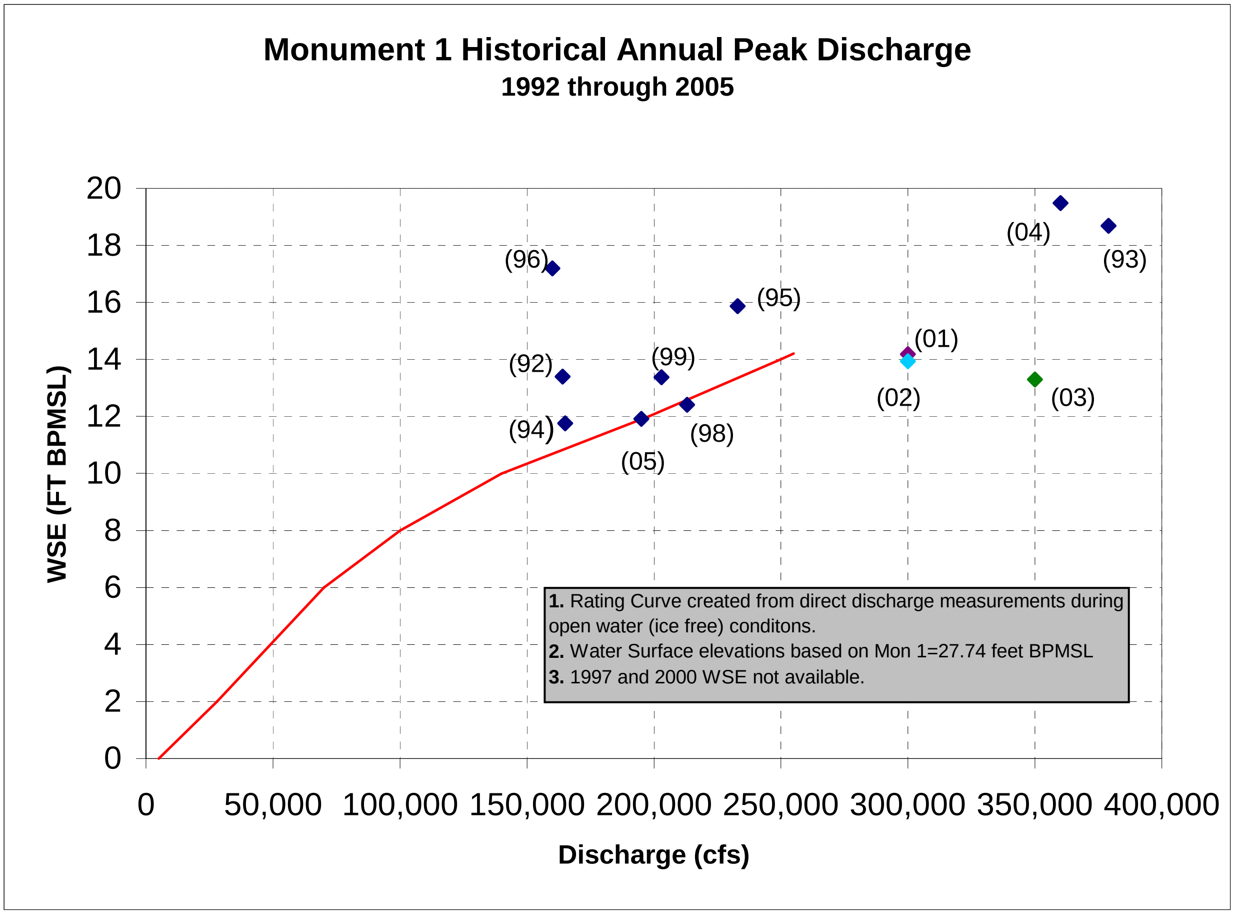


Figure 3 – Monument 1 Historical Annual Peak Discharge

2.3 Slope Area Method

The slope area method is the most commonly used form of indirect discharge measurement (Dalrymple and Benson 1967). The procedure solves the Bernoulli (energy) equation for one-dimensional, gradually-varied steady flow, and then uses a uniform-flow formula (Manning's equation) to solve for discharge. The equations used in the method are valid for non-uniform reaches that are invariably encountered in natural channels (Dalrymple and Benson 1967). The slope area method attempts to identify the energy slope of a flood using multiple cross sections, high-water profiles, and estimates of flow resistance (Manning's *n*).

Slope area calculations at Monument 1 consist of combining the conveyance, area, slope, and velocity head coefficient from three cross sections (upstream, center and downstream). The method also takes into account any affects from expanding or contracting reaches. The Monument 1 reach is located in a section of the river that is naturally contracting upstream of Monument 1 and expanding near the bifurcation with the Nigliq Channel. Placement of the downstream cross section is critical to avoid the expanding reach. The procedure and coefficient in the slope area method are questionable for expanding reaches and thus major expansions in the channel width should be avoided (Dalrymple and Benson 1967).

2.4 Slope Conveyance Method

The slope conveyance method relies on only a single cross section to estimate discharge. The concept of slope conveyance is a measure of the carrying capacity of the channel. The discharge in a uniform channel is the product of the conveyance and the square root of the slope. The procedure involves establishing the area, wetted perimeter, surface water slope, and channel roughness at a single cross section to estimate the discharge using Manning's equation.

Slope conveyance calculations at Monument 1 consist of computing the discharge across the center cross section. The cross section is perpendicular to the direction of flow under flood conditions and assumed to be a typical cross section for the reach. Similar to the slope area method, the water surface slope is determined from water surface elevation measurements taken at temporary staff gages located approximately 0.5 miles upstream and downstream of the center cross section. In general, the slope conveyance method only relies on one cross section. Unless the reach is uniform, it does not represent the actual conditions of the reach as well as the slope area method. Therefore, estimates from the slope conveyance method are (on average) less accurate than estimates from the slope area method.

3.0 Peak Discharge Values Rating Curve Verses Indirect Methods

Stage-discharge relationships are considered a reliable means of estimating discharge, but can be subject to minor random fluctuations resulting from the dynamic force of moving water. Because it is virtually impossible to sort out those minor fluctuations, a rating curve that averages the measured discharge within close limits is considered adequate. Furthermore, it is recognized that discharge measurements are not precise, and consequently an average curve drawn to fit a group of measurements is probably more accurate than any single measurement that is used to define the average curve (Rantz 1982, pg 345). Results from indirect discharge estimates using the slope area and slope conveyance methods have been found to differ from one another and also differ from the Monument 1 rating curve as shown in Figure 3. Studies by the USGS have shown that annual peak estimates from indirect methods are typically within 20% of a direct discharge reading. According to the USGS, it is generally believed that a “good” slope area measurement can replicate discharge with an error of 10% or less; a “fair” measurement would represent a 15% possible error; and a “poor” slope-area measurement would represent greater than 20% possible error (Benson and Dalrymple 1967).

Discrepancies between indirect methods and the rating curve can be attributed to a shifting rating curve or various hydraulic parameters. Discharge measurements that plot above or to the left of a stage discharge rating curve may be influenced by naturally occurring backwater conditions such as downstream ice jams and ice/snow present in the channel. Discharge measurements that plot below or to the right of the curve suggest a possible overestimation in the discharge value.

Since 1992, five indirect discharge estimates plot above the discharge rating curve. Spring breakup reports in 1994, 1995, 1996, and 1999 state that the peak discharge was affected by either intact channel ice or an ice jam located downstream of Monument 1. In 1992, the peak discharge was not observed in the field; therefore it is unknown whether the peak discharge was affected by backwater from ice.

Timing of the 1998 and 2005 peak discharges occurred during open water conditions. The 1998 indirect discharge estimate plots within approximately 2% of the Monument 1 rating curve. In 2005, the Monument 1 rating curve was used to estimate the peak discharge.

The peak discharge in 2001, 2002, and 2003 occurred each year during open water conditions. Open water conditions had existed in the reach from 1 to 5 days prior to the occurrence of peak discharge each year. Channel ice, intact and floating in the channel, was observed to have cleared from the Monument 1 reach before each estimated peak discharge occurred. Estimated discharge values in 2001, 2002, and 2003 plot significantly to the right of the Monument 1 rating curve.

Table 1 presents the published peak discharge values by Baker for 2001, 2002, and 2003 with the corresponding water surface elevation and percentage of variation from the Monument 1 rating curve. Figure 4 presents the results of calculated peak discharge at Monument 1 for 2001, 2002, and 2003 for both the slope area method and the slope conveyance method using cross sections based on the 2002 survey (see Section 5.1). From the figure, it appears that these indirect peak discharge estimates may have been overestimated. This figure graphically represents the discrepancies of the indirect discharge calculations at Monument 1 compared with the rating curve based on actual flow measurements (Figure 2), as suggested in the FEIS by the BLM.

Table 1 – Published Peak Discharge Values for 2001, 2002, and 2003

Year	WSE (Ft BPMSL)	Discharge (cfs)	Variation from Mon. 1 Rating Curve
2001	14.2	300,000	18%
2002	13.9	300,000	20%
2003	13.3	350,000	51%
(Baker 2001, Baker 2002, and Baker 2003)			

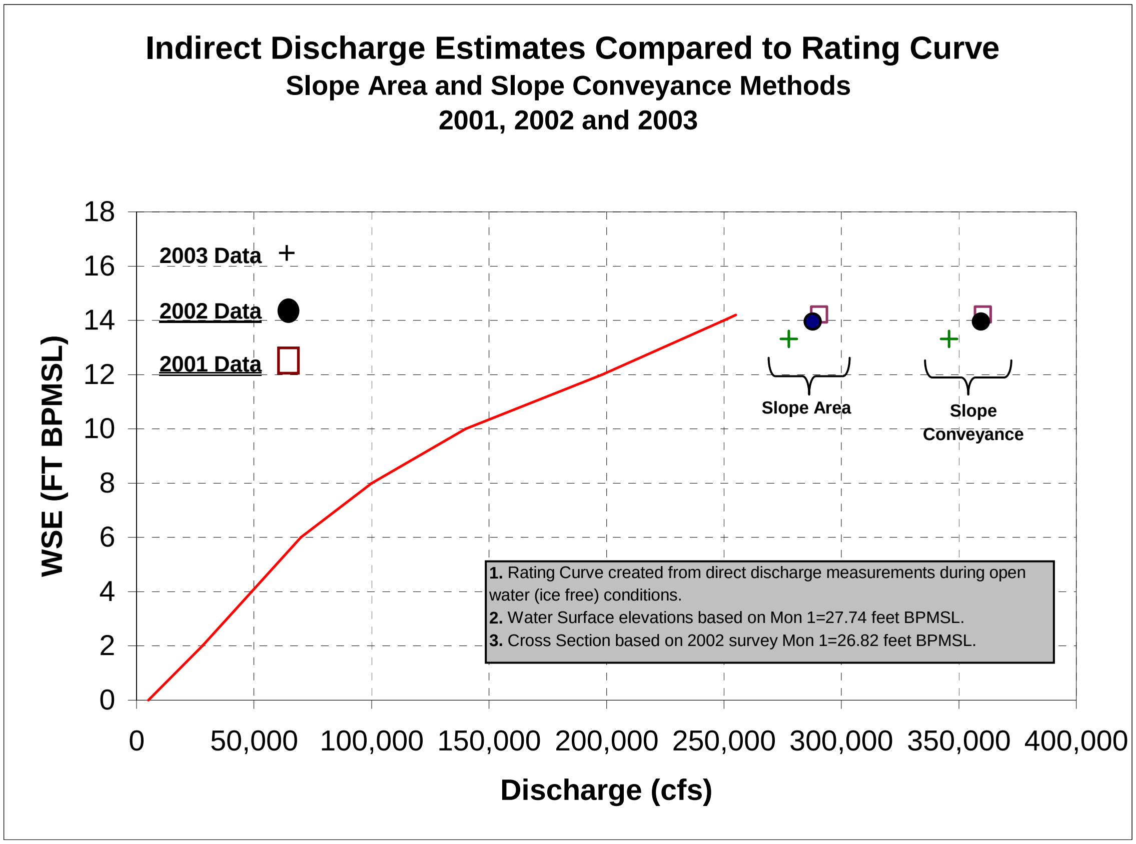


Figure 4 – Indirect Discharge Peak Estimates – 2001, 2002, and 2003

Water surface elevations at the time of peak discharge in 1993 and 2004 exceeded 14.2 feet BPMSL. Correlation between the rating curve and indirect discharge estimates for these two years was not undertaken for this analysis, as extrapolation of the Monument 1 rating curve was limited to 14.2 feet BPMSL. As previously noted, 1997 and 2000 water surface elevations corresponding to the peak discharge were not available.

4.0 Overview of 2001, 2002, and 2003

The peak indirect discharge estimates for the Colville River in 2001, 2002, and 2003 exceed the rating curve discharge estimates at corresponding water surface elevations. An overview of each year is presented below.

4.1 2001 Spring Breakup Overview

In 2001, the peak discharge at Monument 1 of 300,000 cubic feet per second (cfs) was estimated to have occurred on June 11 at a water surface elevation of 14.2 feet BPMSL. At the time of the peak discharge, the channel was clear of ice in the East Channel and upper Nigliq Channel and snow blocking flow into the Sakoonang and other channels in the lower Delta had cleared (Baker 2001).

Intact channel ice was observed at Monument 1 up through June 10. On June 11, the channel ice had cleared the reach and ice chunks were observed floating through the section until June 13, when hydrologic data collection stopped. Indirect discharge values were estimated between June 11 and June 13, with all three values plotting to the right of the Monument 1 rating curve.

4.2 2002 Spring Breakup Overview

In 2002, weather limited the data collection at Monument 1 near the time the estimated peak discharge occurred. The peak discharge of 300,000 cfs was estimated to have occurred on May 27 at a water surface elevation of 13.9 feet BPMSL. Intact channel ice had cleared the Monument 1 reach by May 24, three days prior to the peak discharge (Baker 2002).

Hydrologic data collection began at Monument 1 on May 23 when the channel was approximately 70% clear of ice. The intact ice, located along the east bank, had cleared through the reach on May 24. Seven indirect discharge values were estimated between May 24 and May 30, when hydrologic data collection ceased. Two of the seven values plot above the Monument 1 rating curve. These lower discharge estimates, both on May 24, were most likely influenced by the presence of ice remaining in the Delta downstream of Monument 1.

4.3 2003 Spring Breakup Overview

In 2003, a peak discharge of 350,000 cfs was estimated to have occurred on June 11 at a water surface elevation of 13.3 feet BPMSL. An initial ice-affected peak stage occurred on the evening of June 5 or morning of June 6 with an associated discharge estimation of 255,000 cfs. Following this initial peak stage, the channel at Monument 1 remained free of intact floating ribbon ice beyond June 6 (Baker 2003).

During 2003, hydrologic data was collected at Monument 1 between June 1 and June 13. Open water indirect discharge values were estimated using hydrologic data collected between June 6 and June 13. Only the single estimate compiled from hydrologic data collected on June 6 plots above the stage-discharge curve. The June 6 estimate is most likely influenced by the presence of ice remaining in the Delta downstream of Monument 1. The remaining seven estimates between June 7 through June 13 plot below the Monument 1 rating curve.

5.0 Rating Curve and Indirect Discharge Variables

A variety of hydraulic variables may influence the calculation of peak discharge at Monument 1. These parameters include vertical control, obstructions in the channel, cross-sectional area, channel roughness, and surface water slope.

5.1 Vertical Control at Monument 1

Prior to 1996, water surface elevations near Monument 1 were based on various survey monuments and assumed datums. In order to accurately monitor water surface elevations in the Colville River Delta, Lounsbury and Associates, Inc. installed 35 permanent surveying monuments throughout the Delta in 1996. The monuments are referenced to the BPMSL datum. Survey Monument 1 was installed at the head of the Colville Delta and tied to the Kuparuk Control Net by conventional third-order spirit-level traverse. All of the historical water surface elevation data collected at Monument 1 was converted to the BPMSL datum. Hydrologic data collected after 1996 has been referenced to an elevation of 27.74 feet BPMSL, established at survey Monument 1 (Shannon and Wilson, 1996a).

On June 11, 2002, Kuukpik-LCMF (LCMF) surveyed a new elevation of 26.82 feet BPMSL at survey Monument 1 using static GPS surveying techniques. In addition, cross-sectional surveys were completed at three locations along the Monument 1 reach. These cross sections were based on the 2002 surveyed elevation at Monument 1 of 26.82 feet BPMSL. Due to the variability associated with the survey methods used, LCMF stated that the elevation was accurate to within plus or minus approximately one foot. Because of this level of inaccuracy using static GPS techniques, the 1996 surveyed elevation of 27.74 feet BPMSL remained the basis of elevation for the collection of surface water data. However, the vertical control for the 2002 cross sections was based on 26.82 feet BPMSL.

In February of 2006, LCMF surveyed the elevation of Monument 1 using second-order three wire level techniques. LCMF determined the elevation to be 27.59 feet BPMSL, within 0.15 feet of the 1996 published elevation of Monument 1. Considering the results and methods of the 2006 survey, the 26.82 feet BPMSL basis of elevation used in 2002 for the cross sections was deemed inaccurate.

Therefore, the vertical datum of Monument 1 has been demonstrated to be relatively consistent between 1996 and 2006 and is not the cause of the disparity between the 2001, 2002, and 2003 peak discharge and the rating curve. However, the discrepancy in vertical control for the cross section survey used in 2002 did result in a significant overestimation of the cross-sectional area used for indirect calculations of peak discharge in 2002 and 2003.

5.2 Obstructions in the Channel at Monument 1

Obstructions in the channel at Monument 1 are predominantly related to the presence of ice and include floating intact channel ice and ice jams located either within the reach or downstream of Monument 1. Due to ice affects the discharge is typically lower relative to open water floods for a given stage. The formation of an ice cover or ice jam drastically increases the wetted perimeter. This added resistance to flow, especially if loose/jammed ice, along with the reduction in flow area caused by the ice, results in higher stages for comparable discharges than comparable open water conditions would produce (USACE 2002).

Direct discharge measurements conducted either using the USGS standard midsection technique or ADCP technologies are not feasible unless open water conditions exist due to safety and the inability to access the majority of flow. Since the stage-discharge rating curve at Monument 1 is based on open water conditions, indirect discharge methods must be used to estimate discharge values under circumstances where ice obstructs the channel. Historically, indirect methods have been used to estimate the annual peak discharge values when ice is present at Monument 1 including most recently in 2004. Due to the presence of such obstructions and the uncertainties associated with the effects of the ice, discharge estimates using an indirect method would be rated as poor (plus or minus 20%). This increased inaccuracy is primarily based on the continuously changing properties of the ice affecting the wetted perimeter, flow area, and roughness coefficient.

A sudden clearing of the channel ice or snow downstream of Monument 1 will result in a steeper slope and cause a discharge for a given water surface elevation greater than that estimated by the Monument 1 rating curve. This open water condition would plot a value to the right of the stage discharge rating curve as is the case in 2001, 2002, and 2003. The Alpine Facilities 2001 Spring Breakup Report states that the clearing of the channel ice likely caused an increase in discharge and a decrease in water surface elevation at Monument 1 (Baker 2001).

To evaluate this theory, indirect discharge estimates were compiled from multiple days during open water conditions in 2001, 2002, and 2003. Indirect methods were performed using both the slope area and slope conveyance techniques and were based on surveyed cross sections established using an elevation of 26.82 feet BPMSL at Monument 1. Analysis was conducted using cross sectional data surveyed in 2002. While some conditions plot above the rating curve, each specific instance occurred directly after ice cleared from the Monument 1 reach suggesting impacts due to ice and or snow in the channel. The results of this analysis indicate that all estimated values under open water conditions plot below the rating curve. Although sudden ice releases will contribute to increased discharge initially, the effect is expected to reach equilibrium at some point and not continue throughout breakup. Because all of the open water indirect calculated values consistently plot below the rating curve, this suggests that the indirect discharge values from 2001, 2002, and 2003 estimate higher discharge values when compared to the rating curve and while possible, it is less likely a result of a release in water. Estimated data from the slope area and slope conveyance methods are shown in relation to the stage discharge rating curve on Figure 5 and Figure 6, respectively.

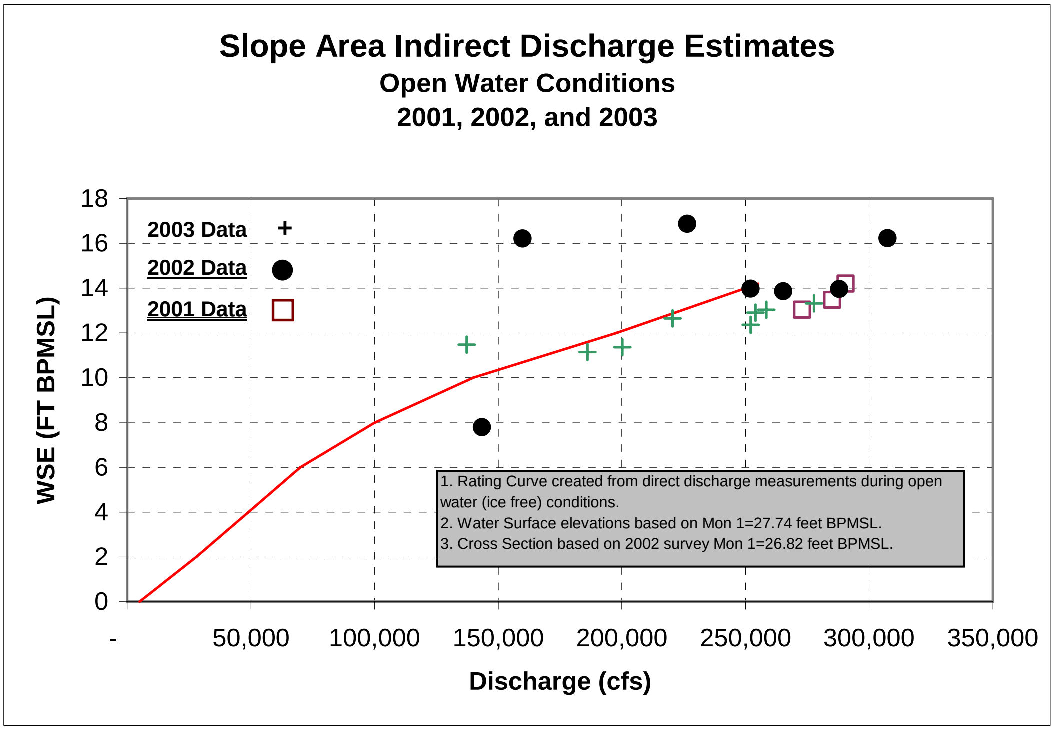


Figure 5 – Slope Area Indirect Discharge Estimates

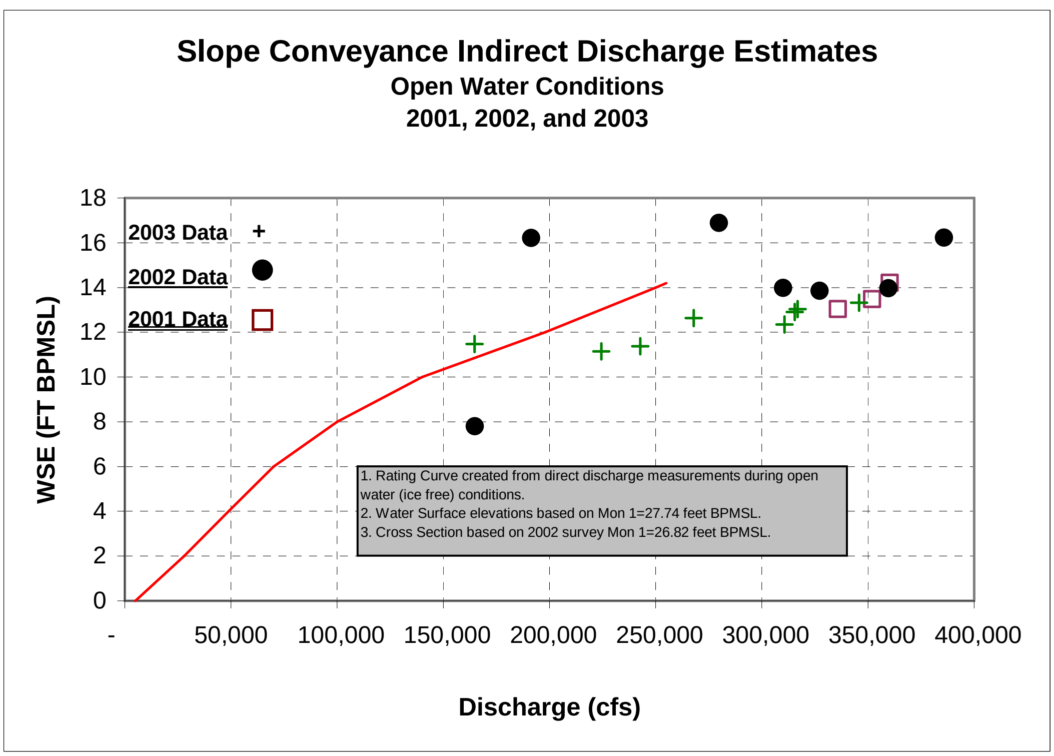


Figure 6 – Slope Conveyance Indirect Discharge Estimates

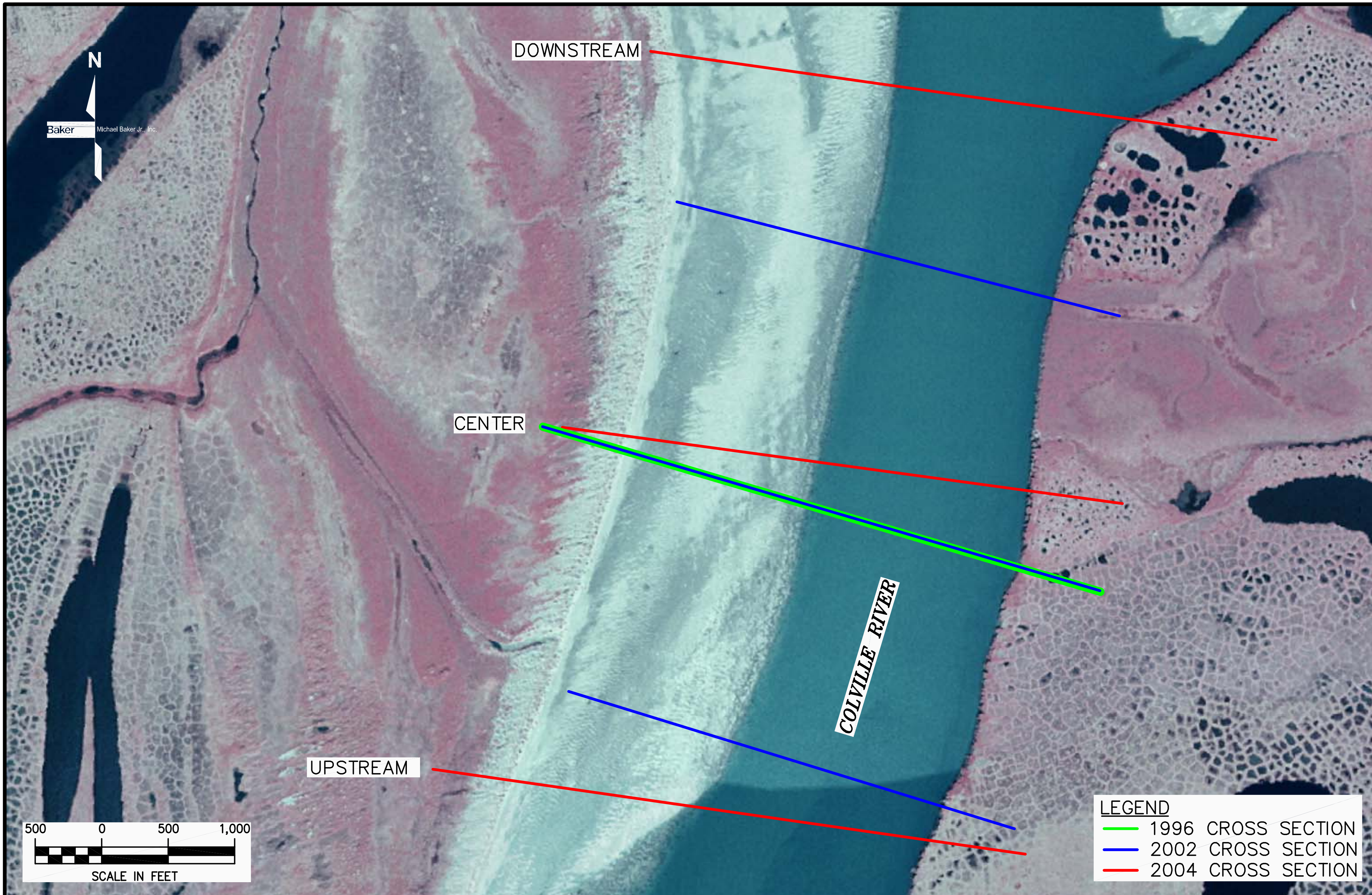
5.3 Changes in the Monument 1 Channel Cross Section

A stream forms its channel by erosion, practically all of which takes place during a few days or weeks in the year when the stream is in flood conditions. During high flows, lighter materials, such as silt, sand, or fine gravel are swept up by the turbulence and carried along in suspension in the flow. Heavier particles such as coarse gravel may roll and slide along the bottom. When the flood recedes, the heavier particles stop rolling and lighter ones drop out as the velocity decreases. The bed of the stream is changed during each flood (Barton and Cron 1979), but at the end of each flood the stream bed could be similar to initial conditions.

Natural events such as floods may cause channel change in a short period of time. The contours of the channel bottom most likely change continually due to natural processes of deposition and scour. For purposes of indirect discharge estimation, the stability of the bed and cross-sectional area at Monument 1 is assumed to remain constant during spring floods. Considering that the channel bottom along the shallow left bank is frozen during breakup, the potential change for the western half of the channel is expected not to be significant.

In an attempt to evaluate these changes, cross-sectional surveys were conducted at Monument 1 in 1996, 2002 and 2004 to monitor any sedimentation or depositional activities along the Monument 1 reach. Additional cross sections were surveyed in 2002 and 2004 approximately 3,000 feet upstream and downstream of Monument 1 so that indirect discharge estimates using the slope area method could be conducted. The locations and alignments of the 1996, 2002, and 2004 cross section surveys are shown in plan view on Figure 7. Profiles of each cross section are provided in Appendix A – Monument 1 Cross Sections.

Indirect discharge estimates in 2002 and 2003 were calculated using 2002 cross-sectional data based on an elevation of Monument 1 equal to 26.82 feet BPMSL. However, the elevation of the water surface was established based on an elevation of Monument 1 equal to 27.74 feet; therefore, a discrepancy was noted. In January of 2006, the cross-sectional data compiled in 2002 was adjusted to an elevation of 27.74 feet BPMSL at Monument 1. A comparison of this adjustment concluded that the cross-sectional area was overestimated in the 2002 and 2003 discharge calculations by approximately 2,800 square feet (5.5% of the actual area). Therefore, peak discharge values in 2002 and 2003 were incorrectly overestimated due to the overestimation of cross-sectional area. Indirect peak discharge estimates using data from both the original 2002 survey and the adjusted vertical control are shown on Figure 8.



ConocoPhillips
Alaska, Inc.

DATE:	01/30/06	PROJECT:	105756
DRAWN:	WAP	FILE:	FIGURE_7
CHECKED:	MDC	SCALE:	1" = 1,000'

Baker

Michael Baker Jr., Inc.
A Unit of Michael Baker Corporation
1400 West Benson Blvd., Suite 200
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

MONUMENT 01
SURVEYED CROSS SECTION LOCATIONS

FIGURE 7
(SHEET 1 OF 1)

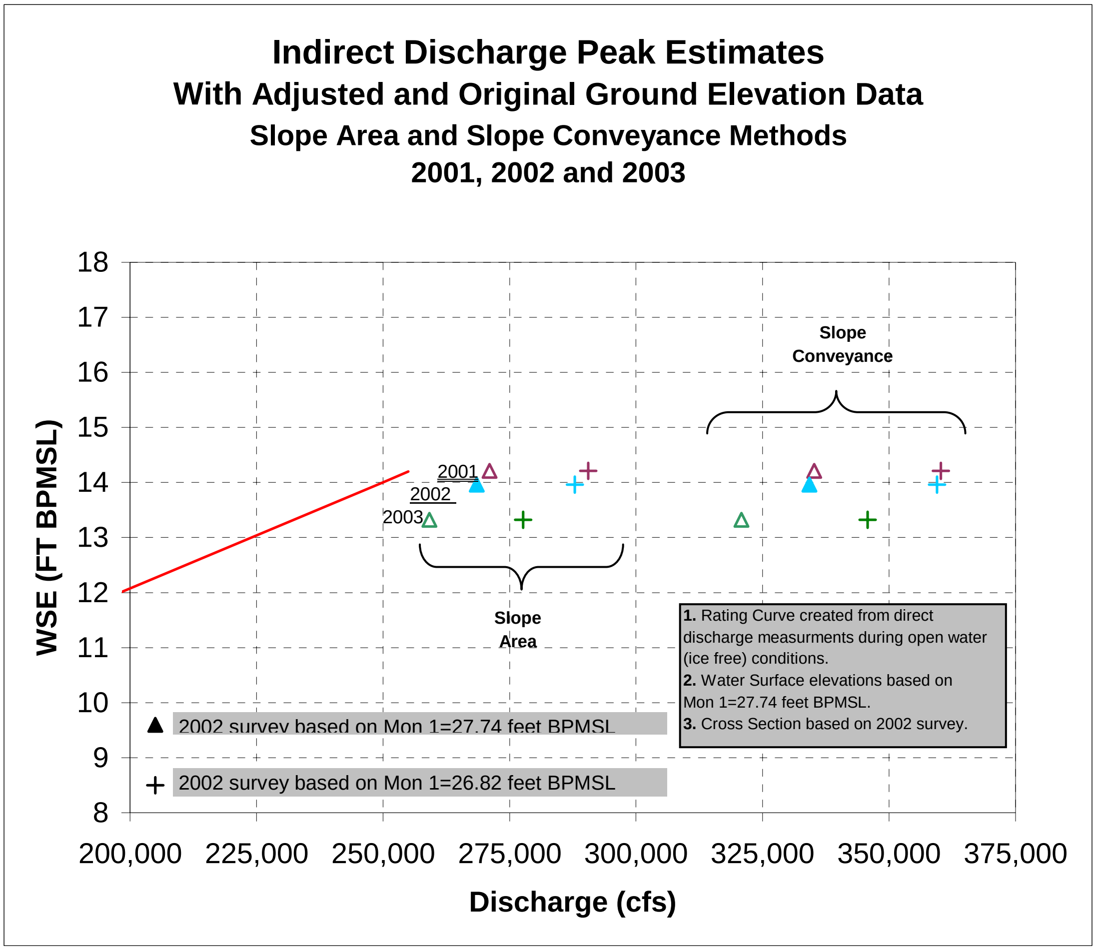
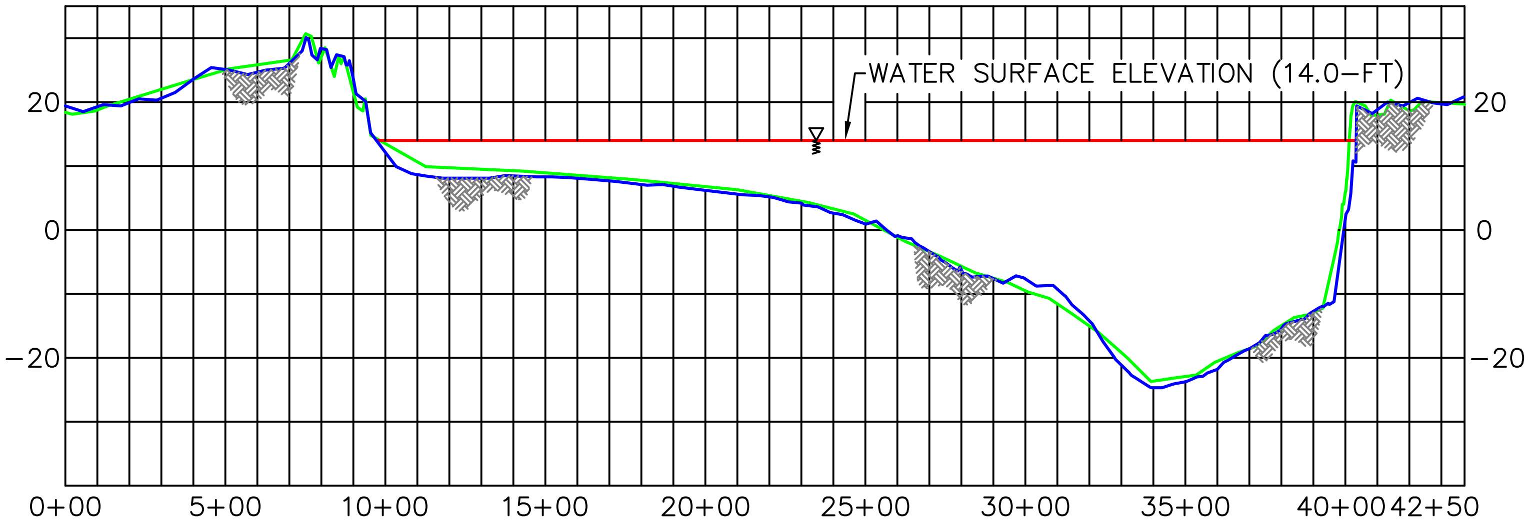


Figure 8 – Indirect Discharge Peak Estimates with Adjusted and Original Ground Elevation

Differences in the alignments and locations between the 2002 and 2004 cross section surveys make direct comparison of channel geometry inconclusive. However, comparison between the 1996 and adjusted 2002 cross-sectional surveys show a very minor cross-sectional area increase of 1,600 square feet (3.3%) between 1996 and 2002. This comparison is based on a water surface elevation of 14.0 feet BPMSL which was selected as a representative approximate peak water surface elevation for 2001, 2002, and 2003. On the west bank, the 1996 survey has relatively few data points compared to the 2002 survey and near the east bank, the 2002 centerline diverges by as much as 40 feet when compared with the 1996 survey. This comparison between 1996 and 2002 cross-sectional area could suggest that a shift in the Monument 1 rating curve may be expected. However, the 2005 direct discharge measurement verified the rating curve. Therefore, the probable increase in area between 1996 and 2002 would not be expected to be a significant contributor of discrepancies between indirect methods and the rating curve. Profile views of the 1996 and adjusted 2002 cross sections are compared graphically on Figure 9.

NOTES

1. 2002 CHANNEL PROFILE MEASUREMENTS COMPLETED BY KUUKPIK/LCMF INC. 1996 CHANNEL PROFILE MEASUREMENT COMPLETED BY LOUNSBURY AND ASSOCIATES.
2. ELEVATIONS SHOWN ARE REFERENCED TO BRITISH PETROLEUM MEAN SEA LEVEL DATUM.
3. AT A WSE EQUAL TO 14.0 FEET, THE CROSS SECTIONAL AREA OF THE 1996 MON 01 CENTER CROSS SECTION EQUALS 49,283sf. THE 2002 MON 01 CENTER CROSS SECTIONAL AREA EQUALS 50,900sf.
4. 1996 AND 2002 CROSS SECTION BASIS OF ELEVATION IS 27.74 FEET BPMSL AT MONUMENT 01.



1 MONUMENT 01 1996 AND 2002 CENTER CROSS SECTIONS

SCALE: HORZ. 1"= 600' / VERT. 1" = 30'

300 0 300 600

HORIZONTAL SCALE IN FEET

LEGEND

1996 CROSS SECTION

2002 CROSS SECTION

15 0 15 30

VERTICAL SCALE IN FEET

ConocoPhillips Alaska, Inc.

DATE:	01/30/06	PROJECT:	105756
DRAWN:	WAP	FILE:	FIGURE_9
CHECKED:	MDC	SCALE:	AS SHOWN

Baker

Michael Baker Jr., Inc.
A Unit of Michael Baker Corporation
1400 West Benson Blvd., Suite 200
Anchorage, Alaska 99503
Phone: (907) 273–1600
Fax: (907) 273–1699

MONUMENT 01

1996 & 2002 CENTER CROSS SECTIONS

FIGURE 9

(SHEET 1 OF 1)

Accurate representation of the channel cross section is critical in estimating the discharge using indirect methods. Figure 8 depicts how a discrepancy of 0.92 feet in vertical control can affect the calculated discharge estimates. Location of the cross sections is equally important in terms of placing the cross section perpendicular to flood flow conditions and in a reach that is contracting rather than expanding (Dalrymple and Benson 1967). The reach is expanding between the 2004 center and downstream cross sections thus introducing some uncertainty in the accuracy of the slope area estimate. For future indirect discharge estimations, using the adjusted 2002 cross sections survey data is recommended.

5.4 Channel Roughness

For purposes of estimating Manning's hydraulic roughness (*n*) values at Monument 1, the channel has historically been divided into two sections. These subsections were selected based on criteria presented by Davidian (1984). They included the west half of the channel inundated with water only during spring flooding events (left section of the river) and the east half conveying water throughout the summer (right section). The right section, which includes the thalweg, typically carries approximately 90% of the total discharge during spring flood events. The Manning's values used during 2001, 2002, and 2003 indirect discharge estimations for the left and right sections are $n = 0.023$ and $n = 0.021$, respectively. Establishment of the hydraulic roughness values were based on a 1993 direct discharge measurement (ABR and Shannon & Wilson 1994) and annual on-site investigations of the channel bottom using methods outlined by the USGS (Arcement and Schneider 1989). These values have been used for indirect discharge calculations at Monument 1 since 1996.

On June 10, 2005, a direct discharge measurement was conducted at Monument 1 using ADCP technology. Hydraulic roughness coefficients were back-calculated using both the slope area and slope conveyance methods with survey data from 1996, 2002, and 2004. Back-calculation with each set of cross section data was conducted based on Monument 1 to be 27.74 feet BPMSL. The Manning's value for the left section of the river was set 0.002 greater than the right section based on visual observations for the conditions of the reach and to maintain consistency with historical values. Table 2 shows the back-calculated *n* values.

Table 2 – Back-Calculated *n* Values from 2005 Direct Discharge Value

Method	Survey Data	Left Section (*n* value)	Right Section (*n* value)
Slope Area	2002	0.025	0.023
Slope Area	2004	0.029	0.027
Slope Conveyance	1996	0.029	0.027
Slope Conveyance	2002	0.029	0.027
Slope Conveyance	2004	0.028	0.026
Historically Used Values		*0.023*	*0.021*

Once the back-calculated hydraulic roughness coefficients from the 2005 discharge were developed, new *n* values were applied to historical indirect discharge calculations. Peak discharge estimates from 2001, 2002, and 2003 were re-calculated (1) using the roughness coefficients determined in back-calculation of the slope area method with 2002 adjusted cross-sectional data (0.025 and 0.023) and (2) using the roughness coefficients determined in back-calculation of the slope conveyance method with 2002 adjusted cross-sectional data (0.029 and 0.027). Calculated discharge values from both the slope area and slope conveyance method are shown on Figure 10. Original estimates from 2001, 2002, and 2003 were shown previously on Figure 4.

Data from this analysis suggests that the hydraulic roughness values at Monument 1 are greater than the values used in the original 2001, 2002, and 2003 calculations, thus possibly contributing to overestimation of discharge for these years.

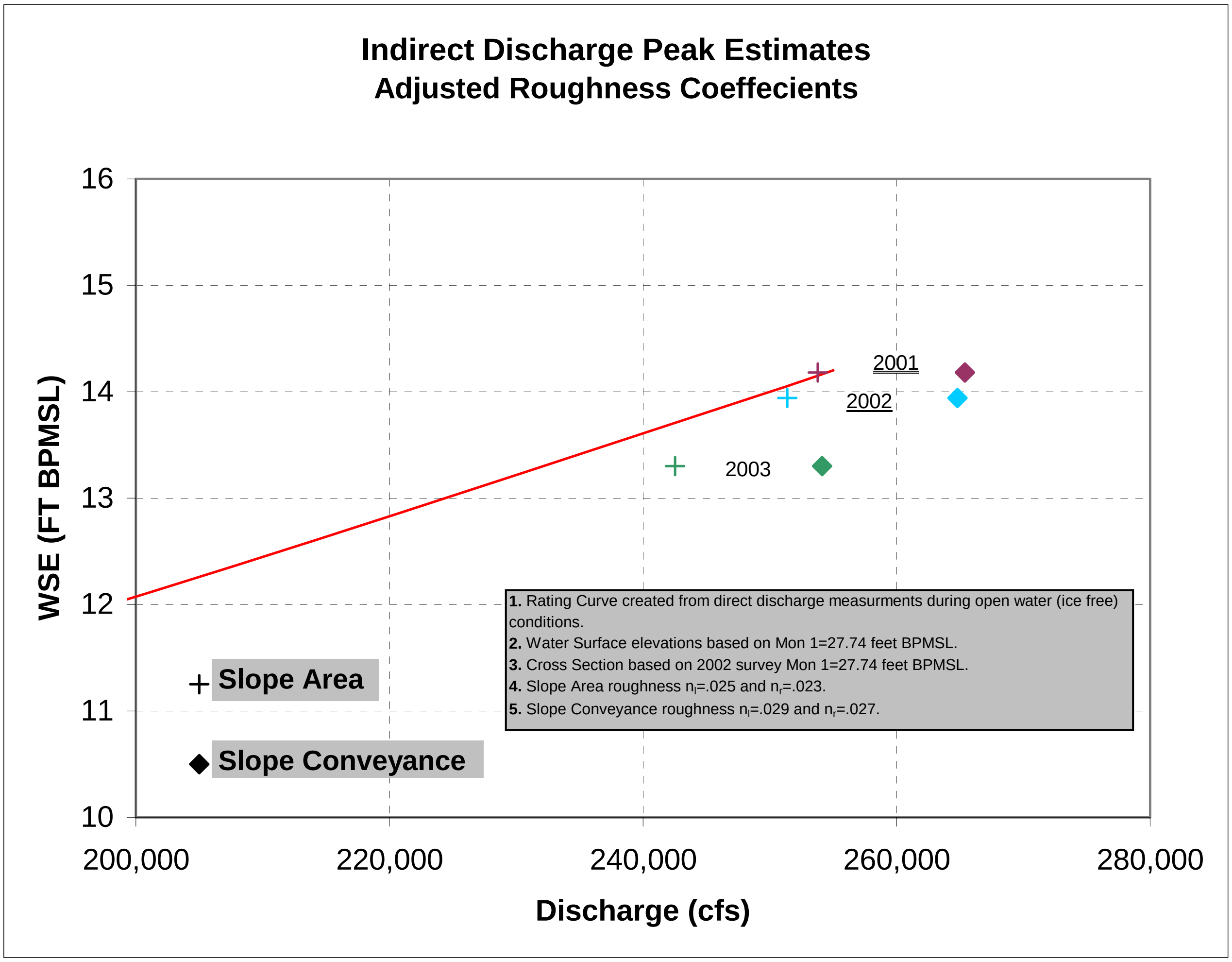


Figure 10 – Indirect Discharge Peak Estimates using Adjusted Roughness Coefficients

5.5 Surface Water Slope

The surface water differential has historically been determined by measuring the difference in water surface elevation upstream and downstream of Monument 1. Due to safety concerns on the east bank, water surface elevations have been recorded along the west bank of the river using temporary staff gages. The slope was then calculated by dividing the vertical differential between the upstream and downstream water surface elevation by the distance over the thalweg between the two gage locations. The horizontal distance between the monitoring gages was calculated based on coordinates collected using differential RTKGPS survey techniques.

The USGS recommends computing the slope of the reach by averaging the water surface elevations on both banks at each cross section location. However, attempts to accurately document water surface elevations along the east bank have historically proved unsuccessful. The topography of the east bank in conjunction with drifted snow is such that installation of temporary staff gages is difficult and dangerous. In addition, gages have consistently been destroyed by ice flowing immediately adjacent to the eastern bank. Collection of water surface elevations using traditional surveying techniques on the east bank poses a safety concern due to the presence of saturated snow drifts and the depth of water. Drift lines along the east bank left by cresting stage has been found to be unreliable due the natural recession of the snow during spring breakup.

The width of the Colville River at Monument 1 is approximately 3,180 feet at a water surface elevation of 14 feet BPMSL. The thalweg and majority of the cross-sectional area is found along the east bank. Current practices assume that the surface water slope measured along the western bank is constant across the entire channel. Although it is possible for the slope to vary between the east and west bank, little can be done safely to resolve this issue. The water surface slope parameter potentially accounts for a portion of the inaccuracies in indirect discharge accuracies but considering the at flood stage the river is wide and deep, the discrepancy is considered to be minor. Additionally, the west bank gages were used to measure the slope for the back-calculation of the roughness coefficients and to calculate indirect discharge. For this reason, inconsistencies between the surface water slope on the east and west bank are not believed to be a significant source of inaccuracy.

6.0 Fluctuations in Results from Indirect Discharge Methods

Direct discharge measurements during flood periods at Monument 1 are frequently unsafe or impractical to measure. It is therefore important that the methods used in indirect discharge calculations be based on the proper data and make use of the best procedures known in order that the highest possible accuracy is obtained (Benson and Dalrymple 1967).

Discharge estimates plotted on Figures 5 and 6 indicate that historical estimates using indirect methods exceed the Monument 1 rating curve under open water conditions. Figure 8 presents the difference between the indirect peak discharge values in 2001, 2002, and 2003 using the 2002 cross section data for both bases of elevation.

The percentage fluctuation between the rating curve and indirect estimates were calculated for various conditions. Table 3 and Table 4 present the percentage of fluctuation associated with the 2002 cross section based on Monument 1 equal to 26.82 and 27.74 feet BPMSL respectively, and the results presented in each table are based on the 1993 roughness coefficients. The percentage of fluctuation between the 2002 cross section based on Monument 1 equal to 27.74 feet BPMSL and the roughness coefficients back-calculated from the 2005 direct discharge are presented in Table 5.

Table 3 – Comparison of Rating Curve and Indirect Methods : Monument 1 = 26.82 ft BPMSL and 1993 Roughness Values

Method	Year	Discharge (cfs)		Variation from Mon. 1 Rating Curve
		Calculated	Rating Curve	
Slope Area	2001	291,000	255,000	14.1%
	2002	288,000	249,000	15.7%
	2003	278,000	233,000	19.3%
			Average	*16.4%*
Slope Conveyance	2001	360,000	255,000	41.2%
	2002	360,000	249,000	44.6%
	2003	346,000	233,000	48.5%
			Average	*44.8%*
Notes: Data represents original 2002 cross-sectional data with Mon 1=26.82 and 1993 roughness coefficients				

Table 4 – Comparison of Rating Curve and Indirect Methods : Monument 1 = 27.74 ft BPMSL and 1993 Roughness Values

Method	Year	Discharge (cfs)		Variation from Mon. 1 Rating Curve
		Calculated	Rating Curve	
Slope Area	2001	271,000	255,000	6.3%
	2002	269,000	249,000	8.0%
	2003	259,000	233,000	11.2%
			Average	*8.5%*
Slope Conveyance	2001	335,000	255,000	31.4%
	2002	334,000	249,000	34.1%
	2003	321,000	233,000	37.8%
			Average	*34.4%*
Notes: Data represents adjusted 2002 cross-sectional data with Mon 1=27.74 and 1993 roughness coefficients				

Table 5 – Comparison of Rating Curve and Indirect Methods : Monument 1 = 27.74 ft BPMSL and 2005 Roughness Values

Method	Year	Discharge (cfs)		Variation from Mon. 1 Rating Curve
		Calculated	Rating Curve	
Slope Area	2001	254,000	255,000	0.4%
	2002	251,000	249,000	0.8%
	2003	243,000	233,000	4.3%
			Average	*1.6%*
Slope Conveyance	2001	265,000	255,000	3.9%
	2002	265,000	249,000	6.4%
	2003	254,000	233,000	9.0%
			Average	*6.5%*
Notes: Data represents adjusted 2002 cross-sectional data with Mon 1=27.74 and 2005 roughness coefficients				

The results of this analysis suggests that indirect discharge values estimated using the slope area method more closely represent discharge values corresponding to the Monument 1 rating curve when compared to data estimated using the slope conveyance method. Excluding the calculations based on 2002 cross-sectional survey data when Monument 1 was 26.82 feet, slope area estimates would be considered “good” measurements (error less than 10%) and values estimated from the slope conveyance method (error greater than 15%) would be considered “poor” measurements (Benson and Dalrymple 1967). Considering the methods and logistics associated with data collection at Monument 1 and the conditions of the reach during spring flooding, a “good” estimation of discharge is acceptable and the best estimation feasible.

Although both indirect methods use the same survey data for the center cross section, the slope area method applies an upstream and downstream cross section that more closely matches actual conditions thus increasing the accuracy of the indirect method. Hydraulic parameters such as water surface slope and roughness coefficients are constant between the methods. As discussed above, the surface water slope assumption, hydraulic roughness values, cross-sectional survey data, and the assumption that the bed stability remains constant throughout breakup are each potentially adding to minor inconsistencies between a direct measurement and an indirect discharge estimate.

7.0 Conclusions

Historically, peak discharge for the Colville River has been estimated using both indirect methods and using the Monument 1 rating curve. In 2001, 2002, and 2003, peak discharge values were published based on various indirect discharge calculation methods and records indicate that the peak discharge passed through the Monument 1 reach during open water conditions. In 2005, the Monument 1 rating curve was verified, and in 2006 the datum of Monument 1 was also verified. Consequently, peak discharge values can be determined for open water conditions using the Monument 1 rating curve rather than calculated using indirect methods. Figure 11 presents the peak discharge values for 2001, 2002, and 2003 associated with the open water stage-discharge rating curve. Table 6 presents a tabulation of the 2001, 2002, and 2003 peak discharge values based on the Monument 1 rating curve. Based on this review, it is recommended that the peak discharge values for 2001, 2002, and 2003 be changed to represent the discharge as estimated using the Monument 1 rating curve.

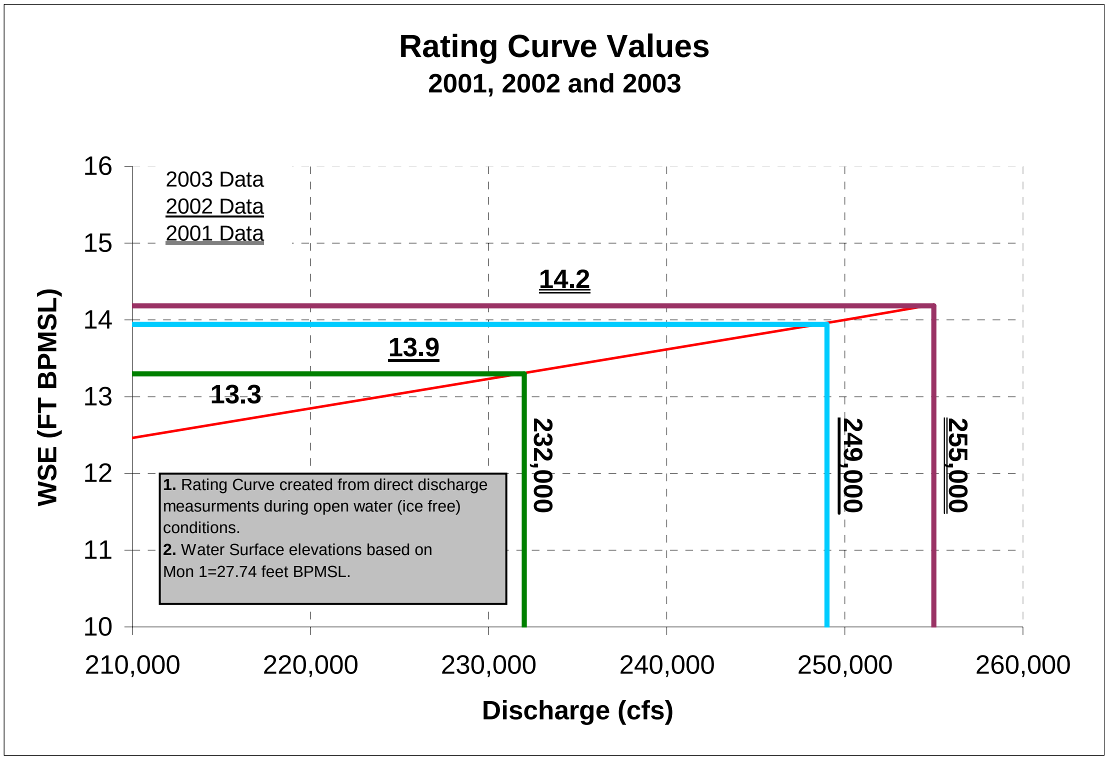


Figure 11 – Rating Curve Values for 2001, 2002, and 2003

Table 6 – Recommended Peak Discharge Values using the Monument 1 Rating Curve for 2001, 2002 and 2003

Year	WSE (Ft BPMSL)	Discharge (cfs)
2001	14.2	255,000
2002	13.9	249,000
2003	13.3	232,000

This review of the practices and procedures used historically in estimating discharge at Monument 1 between 1992 and 2005 suggests the following:

- Collection of sufficient hydrologic and hydraulic data should continue to allow for estimation of annual peak discharge of the Colville River. This should continue to include documentation of daily and peak water levels, water surface slopes and conditions of the reach during breakup.
- Due to the variety of conditions during breakup, multiple methods for determining peak discharge should continue to be employed to assure the most accurate estimation of peak discharge.
- The Monument 1 rating curve should be verified periodically by directly measuring discharge at Monument 1.
- Peak discharge values during open water conditions should be estimated using the Monument 1 rating curve.
- Indirect discharge estimates should continue especially when obstructions are present in the channel during the time of peak discharge or when slopes of the water surface change. The slope area method is the preferred indirect method. The 2002 cross section based on Monument 1 elevation equal to 27.74 feet and updated roughness values should be used for future indirect discharge estimation.

8.0 References

Alaska Biological Research (ABR) and Shannon & Wilson. June 1994. *Geomorphology and Hydrology of the Colville River Delta, Alaska,*. Prepared for ARCO Alaska, Inc.

Arcement and Schneider. 1989. *Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Floodplains.* U.S. Geological Survey Water Supply, Paper 2339. U.S. Government Printing Office, Denver, CO.

Benson, M. A. and Tate Dalrymple. 1967. General Field and Office Procedures for Indirect Discharge Measurements. In *Techniques of Water-Resources Investigations of the United States Geological Survey.* Book 3, Chapter A1. United States Government Printing Office, Washington, DC.

Barton, James R. and Frederick W. Cron, 1979. *Restoration of Fish Habitat in Relocated Streams.*

BLM 2004. *Alpine Satellite Development Plan Final Environmental Impact Statement.* U.S. Department of the Interior Bureau of Land Management. September 2004.

Brabets, T. 1996. *Evaluation of the Streamflow Gaging Network of Alaska in Providing Regional Streamflow Information.* Water Resource Investigations Report 96-4001.

Dalrymple, Tate and M.A Benson. 1967. Measurement of Peak Discharge by the Slope Area Method. In *Techniques of Water-Resources Investigations of the United States Geological Survey,* Book 3, Chapter A2. United States Government Printing Office, Washington, DC.

Davidian, J. 1984. Computation of Water Surface Profiles in Open Channels. In *Techniques of Water Resources Investigations of the United States Geological Survey,* Book 3, Chapter A15. United States Government Printing Office, Washington, DC. Pgs 20-26.

Michael Baker Jr., Inc. (Baker). 2001. *Alpine Facilities 2001 Spring Breakup and Hydrologic Assessment.* August 2001. Prepared for Phillips Alaska, Inc.

Michael Baker Jr., Inc. (Baker). 2002. *Alpine Facilities 2002 Spring Breakup and Hydrologic Assessment.* October 2002. Prepared for ConocoPhillips Alaska, Inc.

Michael Baker Jr., Inc. (Baker). 2003. *Alpine Facilities 2003 Spring Breakup and Hydrologic Assessment.* September 2003. Prepared for ConocoPhillips Alaska, Inc.

Rantz, S.E. and others. 1982. Measurement and Computation of Streamflow. Volume 2. Computation of Discharge. USGS Water-Supply Paper 2175. United States Government Printing Office, Washington, D.C.

Shannon & Wilson, Inc. 1996a. *1996 Colville River Delta Channel Assessment, Colville River Delta, North Slope, Alaska*.

Shannon & Wilson, Inc. 1996b. *1996 Spring Breakup and Hydrologic Assessment, Colville River Delta, North Slope, Alaska*. Prepared for Michael Baker Jr., Inc. November, 1996.

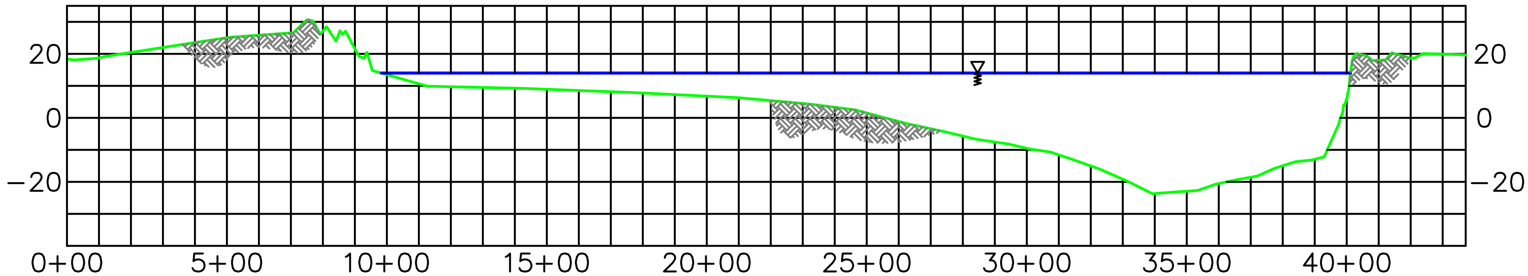
USACE. 2002. U.S. Army Corps of Engineers Ice Engineering Manual EM 1110-2-1612. Washington D.C. 30 October 2002.

Walker, H.J. 1983. *Guidebook to Permafrost and Related Features of the Colville River Delta, Alaska*. State of Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, Fairbanks, Alaska.

Appendix A – Monument 1 Cross Sections

NOTES

1. CHANNEL PROFILE MEASUREMENTS COMPLETED BY LOUNSBURY AND ASSOCIATES.
2. ELEVATIONS SHOWN ARE REFERENCED TO BRITISH PETROLEUM MEAN SEA LEVEL DATUM.
3. AT A WSE EQUAL TO 14.0 FEET THE CROSS SECTIONAL AREA EQUALS 49,283sf.
4 CROSS SECTION BASIS OF ELEVATION IS 27.74 FEET BPMSL AT MONUMENT 01.



1 MONUMENT 01 1996 CENTER CROSS SECTION

SCALE: HORZ. 1"= 600' / VERT. 1" = 60'

HORIZONTAL SCALE IN FEET

VERTICAL SCALE IN FEET

ConocoPhillips Alaska, Inc.

DATE:	01/30/06	PROJECT:	105756
DRAWN:	WAP	FILE:	APPENDIX A 1 OF 7
CHECKED:	MDC	SCALE:	AS SHOWN

Baker

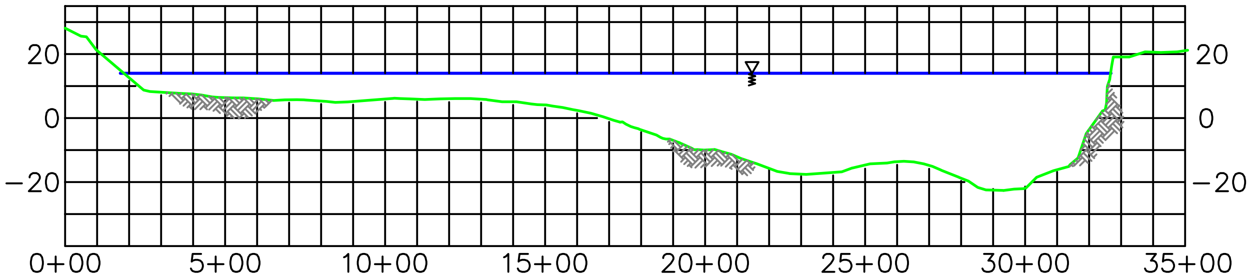
Michael Baker Jr., Inc.
A Unit of Michael Baker Corporation
1400 West Benson Blvd., Suite 200
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

MONUMENT 01
1996 CENTER
CROSS SECTION

APPENDIX A
(SHEET 1 OF 7)

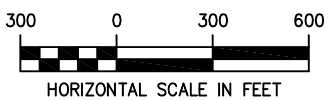
NOTES

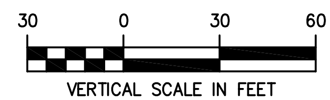
1. CHANNEL PROFILE MEASUREMENTS COMPLETED BY KUUKPIK/LCMF INC.
2. ELEVATIONS SHOWN ARE REFERENCED TO BRITISH PETROLEUM MEAN SEA LEVEL DATUM.
3. AT A WSE EQUAL TO 14.0 FEET THE CROSS SECTIONAL AREA EQUALS 55,255sf.
4 CROSS SECTION BASIS OF ELEVATION IS 27.74 FEET BPMSL AT MONUMENT 01.



1 MONUMENT 01 2002 UPSTREAM CROSS SECTION

SCALE: HORZ. 1"= 600' / VERT. 1" = 60'





ConocoPhillips Alaska, Inc.

DATE: 01/30/06	PROJECT: 105756
DRAWN: WAP	FILE: APPENDIX A 2 OF 7
CHECKED: MDC	SCALE: AS SHOWN

Baker

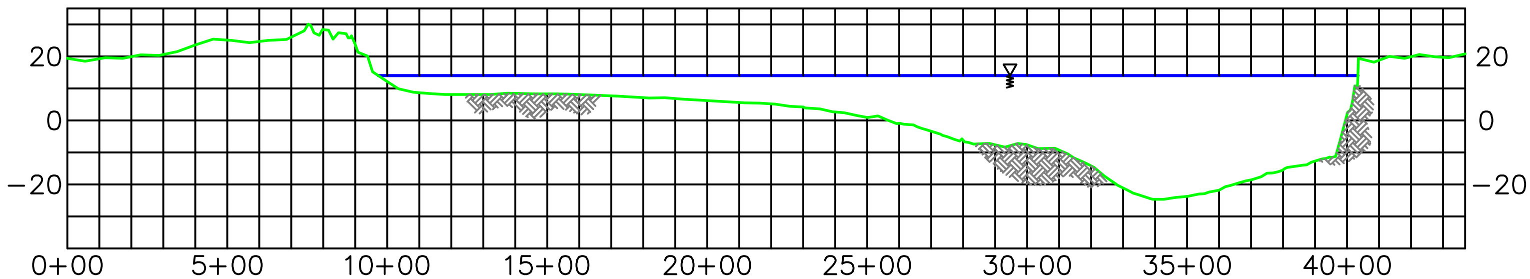
Michael Baker Jr., Inc.
A Unit of Michael Baker Corporation
1400 West Benson Blvd., Suite 200
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

MONUMENT 01
2002 UPSTREAM
CROSS SECTION

APPENDIX A
(SHEET 2 OF 7)

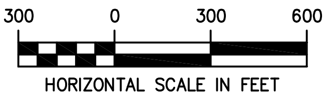
NOTES

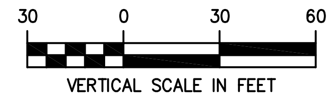
1. CHANNEL PROFILE MEASUREMENTS COMPLETED BY KUUKPIK/LCMF INC.
2. ELEVATIONS SHOWN ARE REFERENCED TO BRITISH PETROLEUM MEAN SEA LEVEL DATUM.
3. AT A WSE EQUAL TO 14.0 FEET THE CROSS SECTIONAL AREA EQUALS 50,900sf.
4 CROSS SECTION BASIS OF ELEVATION IS 27.74 FEET BPMSL AT MONUMENT 01.



1 MONUMENT 01 2002 CENTER CROSS SECTION

SCALE: HORZ. 1"= 600' / VERT. 1" = 60'





ConocoPhillips Alaska, Inc.

DATE:	01/30/06	PROJECT:	105756
DRAWN:	WAP	FILE:	APPENDIX A 3 OF 7
CHECKED:	MDC	SCALE:	AS SHOWN

Baker

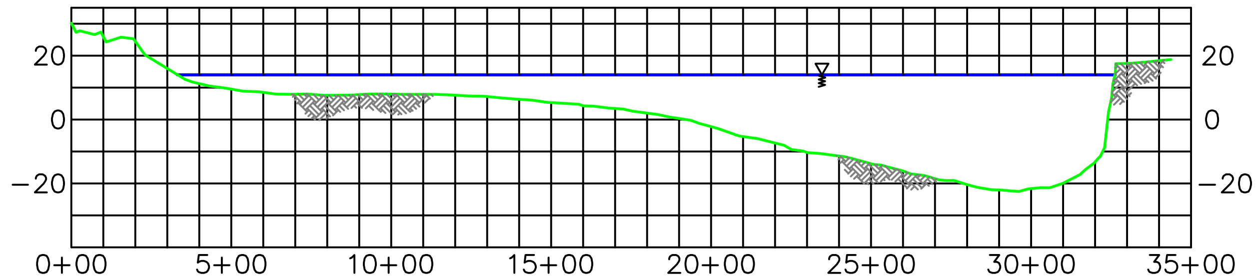
Michael Baker Jr., Inc.
A Unit of Michael Baker Corporation
1400 West Benson Blvd., Suite 200
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

MONUMENT 01
2002 CENTER
CROSS SECTION

APPENDIX A
(SHEET 3 OF 7)

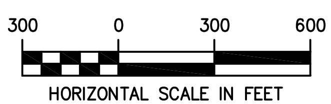
NOTES

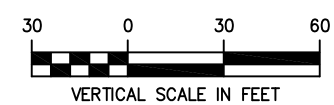
1. CHANNEL PROFILE MEASUREMENTS COMPLETED BY KUUKPIK/LCMF INC.
2. ELEVATIONS SHOWN ARE REFERENCED TO BRITISH PETROLEUM MEAN SEA LEVEL DATUM.
3. AT A WSE EQUAL TO 14.0 FEET THE CROSS SECTIONAL AREA EQUALS 48,090sf.
4 CROSS SECTION BASIS OF ELEVATION IS 27.74 FEET BPMSL AT MONUMENT 01.



1 MONUMENT 01 2002 DOWNSTREAM CROSS SECTION

SCALE: HORZ. 1"= 600' / VERT. 1" = 60'





ConocoPhillips
Alaska, Inc.

DATE:	01/30/06	PROJECT:	105756
DRAWN:	WAP	FILE:	APPENDIX A 4 OF 7
CHECKED:	MDC	SCALE:	AS SHOWN

Baker

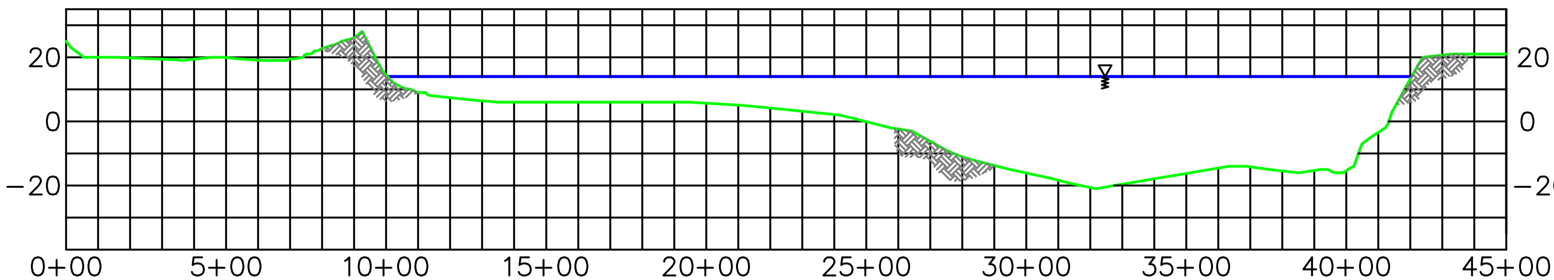
Michael Baker Jr., Inc.
A Unit of Michael Baker Corporation
1400 West Benson Blvd., Suite 200
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

MONUMENT 01
2002 DOWNSTREAM
CROSS SECTION

APPENDIX A
(SHEET 4 OF 7)

NOTES

1. CHANNEL PROFILE MEASUREMENTS COMPLETED BY KUUKPIK/LCMF INC.
2. ELEVATIONS SHOWN ARE REFERENCED TO BRITISH PETROLEUM MEAN SEA LEVEL DATUM.
3. AT A WSE EQUAL TO 14.0 FEET THE CROSS SECTIONAL AREA EQUALS 57,703sf.
4 CROSS SECTION BASIS OF ELEVATION IS 27.74 FEET BPMSL AT MONUMENT 01.



1 MONUMENT 01 2004 UPSTREAM CROSS SECTION

SCALE: HORZ. 1"= 600' / VERT. 1" = 60'

HORIZONTAL SCALE IN FEET

VERTICAL SCALE IN FEET

ConocoPhillips
Alaska, Inc.

DATE:	01/30/06	PROJECT:	105756
DRAWN:	WAP	FILE:	APPENDIX A 5 OF 7
CHECKED:	MDC	SCALE:	AS SHOWN

Baker

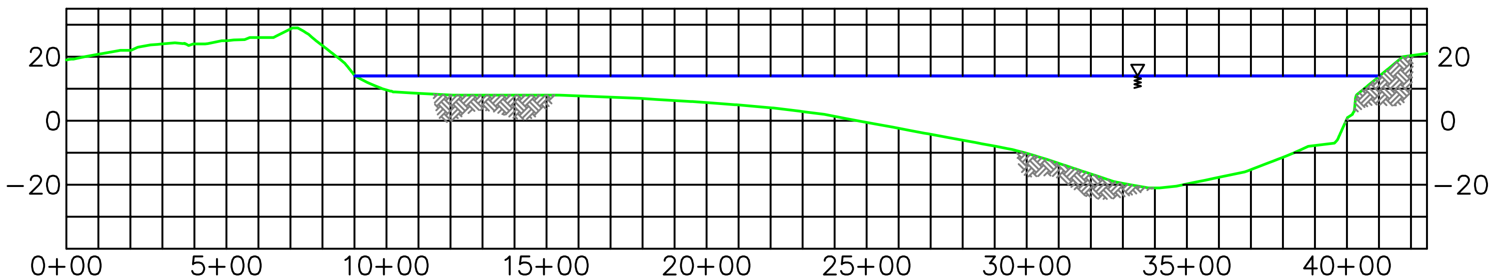
Michael Baker Jr., Inc.
A Unit of Michael Baker Corporation
1400 West Benson Blvd., Suite 200
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

MONUMENT 01
2004 UPSTREAM
CROSS SECTION

APPENDIX A
(SHEET 5 OF 7)

NOTES

1. CHANNEL PROFILE MEASUREMENTS COMPLETED BY KUUKPIK/LCMF INC.
2. ELEVATIONS SHOWN ARE REFERENCED TO BRITISH PETROLEUM MEAN SEA LEVEL DATUM.
3. AT A WSE EQUAL TO 14.0 FEET THE CROSS SECTIONAL AREA EQUALS 51,129sf.
4 CROSS SECTION BASIS OF ELEVATION IS 27.74 FEET BPMSL AT MONUMENT 01.



1 MONUMENT 01 2004 CENTER CROSS SECTION

SCALE: HORZ. 1"= 600' / VERT. 1" = 60'

HORIZONTAL SCALE IN FEET

VERTICAL SCALE IN FEET

ConocoPhillips Alaska, Inc.

DATE:	01/30/06	PROJECT:	105756
DRAWN:	WAP	FILE:	APPENDIX A 6 OF 7
CHECKED:	MDC	SCALE:	AS SHOWN

Baker

Michael Baker Jr., Inc.
A Unit of Michael Baker Corporation
1400 West Benson Blvd., Suite 200
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

MONUMENT 01

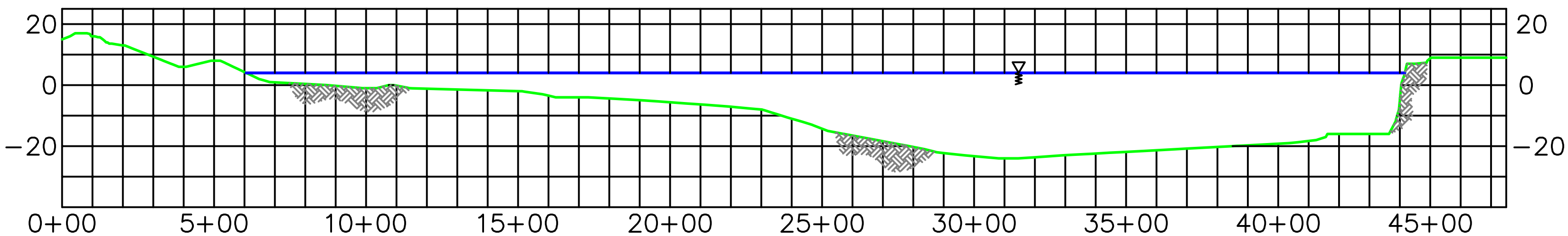
2004 CENTER

CROSS SECTION

APPENDIX A

(SHEET 6 OF 7)

NOTES
1. CHANNEL PROFILE MEASUREMENTS COMPLETED BY KUUKPIK/LCMF INC.
2. ELEVATIONS SHOWN ARE REFERENCED TO BRITISH PETROLEUM MEAN SEA LEVEL DATUM.
3. AT A WSE EQUAL TO 14.0 FEET THE CROSS SECTIONAL AREA EQUALS 60,064sf.
4 CROSS SECTION BASIS OF ELEVATION IS 27.74 FEET BPMSL AT MONUMENT 01.



1 MONUMENT 01 2004 DOWNSTREAM CROSS SECTION
SCALE: HORZ. 1"= 600' / VERT. 1" = 60'

300 0 300 600
HORIZONTAL SCALE IN FEET

30 0 30 60
VERTICAL SCALE IN FEET

ConocoPhillips Alaska, Inc.

DATE:	01/30/06	PROJECT:	105756
DRAWN:	WAP	FILE:	APPENDIX A 7 OF 7
CHECKED:	MDC	SCALE:	AS SHOWN

Baker

Michael Baker Jr., Inc.
A Unit of Michael Baker Corporation
1400 West Benson Blvd., Suite 200
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

MONUMENT 01
2004 DOWNSTREAM
CROSS SECTION

APPENDIX A
(SHEET 7 OF 7)