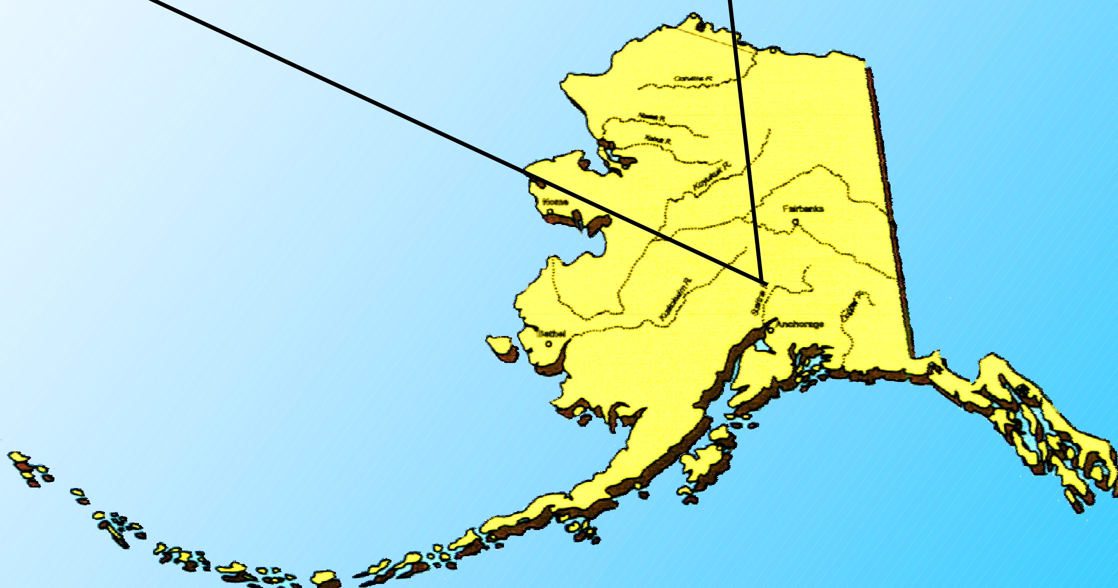
Talkeetna Airport, Phase II

Hydrologic/ Hydraulic Assessment

Final Report

March 2004



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TALKEETNA AIRPORT, PHASE II
HYDROLOGIC/HYDRAULIC ASSESSMENT

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1.0 INTRODUCTION

The Alaska Department of Transportation and Public Facilities (ADOT & PF) wishes to make improvements at the Talkeetna Airport (Figure 1.0.1). However, past studies indicate that some of the airport property may lie within the 100-year floodplain of the Talkeetna River (USACE 1972, and Legare 1996, 1997, 1999). This is a problem for three reasons.

(1) The Federal Aviation Administration is reluctant to fund improvements that are at risk of being flooded by the 100-year flood (Cinelli 1999a).

(2) Title 17.29.180 of the Matanuska-Susitna Borough Code of Ordinances, requires that no improvements be made within a floodway[1] that will result in any increase in the water surface elevation of the base flood[2] (Hudson 2003). Although a floodway has not been defined for the Talkeetna River, it is the practice` of the Matanuska-Susitna Borough to enforce Title 17.29.180 for all permitted new construction within the floodplain of the base flood (Hudson 2003).

(3) Title 17.29.170 of the Matanuska-Susitna Borough Code of Ordinances requires that the lowest floor of a structure[3], built within a flood-hazard area, be located at or above[4] the base flood elevation, or be flood-proofed (Hudson 2002, Lee 2002).

This report summarizes the results of a hydrologic and hydraulic assessment of the Talkeetna and Susitna Rivers near the community of Talkeetna. The objectives of this analysis are as follows.

(1) Obtain background data that can be used to make the assessment (see Section 2.0).

(2) Estimate the magnitude of the 100-year flood-peak discharge on the Susitna River immediately above and below the Talkeetna River (see Section 3.0).

(3) Estimate the magnitude of the 100-year flood-peak discharge at the mouth of the Talkeetna River (see Section 3.0).

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[1] "Floodway" means the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than 1 foot.

[2] "Base flood" is a term used by the Federal Emergency Management Agency (FEMA) and is defined as a flood having a 1 percent chance of being equaled or exceeded in any given year. Thus, "base flood" and "100-year flood" refer to the same event, and the terms are used interchangeably in this report.

[3] The "lowest floor" is defined as the lowest floor of the lowest enclosed area, including a basement. An unfinished or flood-resistant enclosure, usable solely for parking of vehicles, building access or storage in any area other than a basement area, is not considered a building's lowest floor, provided that such enclosure is not built so as to render the building in violation of the applicable non-elevation design requirements of Matanuska-Susitna Borough 17.29.170(A)(2).

(4) Develop a relationship to predict the discharge in the Susitna River based on a known discharge in the Talkeetna River and use it to estimate the discharge in the Susitna River at the time of a 100-year flood-peak discharge in the Talkeetna River (see Section 4.0).

(5) Develop a relationship to predict the discharge in the Talkeetna River based on a known discharge in the Susitna River and use it to estimate the discharge in the Talkeetna River at the time of a 100-year flood-peak discharge in the Susitna River (see Section 4.0).

(6) Estimate which condition produces the higher water surface elevation on the upstream side of the Alaska Railroad Talkeetna River Bridge: a 100-year flood on the Susitna River or a 100-year flood on the Talkeetna River (see Section 5.0).

(7) Develop a "present condition" two-dimensional surface water model of the Talkeetna River near its confluence with the Susitna River (see Section 5.0).

(8) Estimate the peak 100-year water-surface elevation at the Talkeetna Airport based on the condition (as identified in Item 6 above) likely to produce the higher water surface elevation (see Section 5.0).

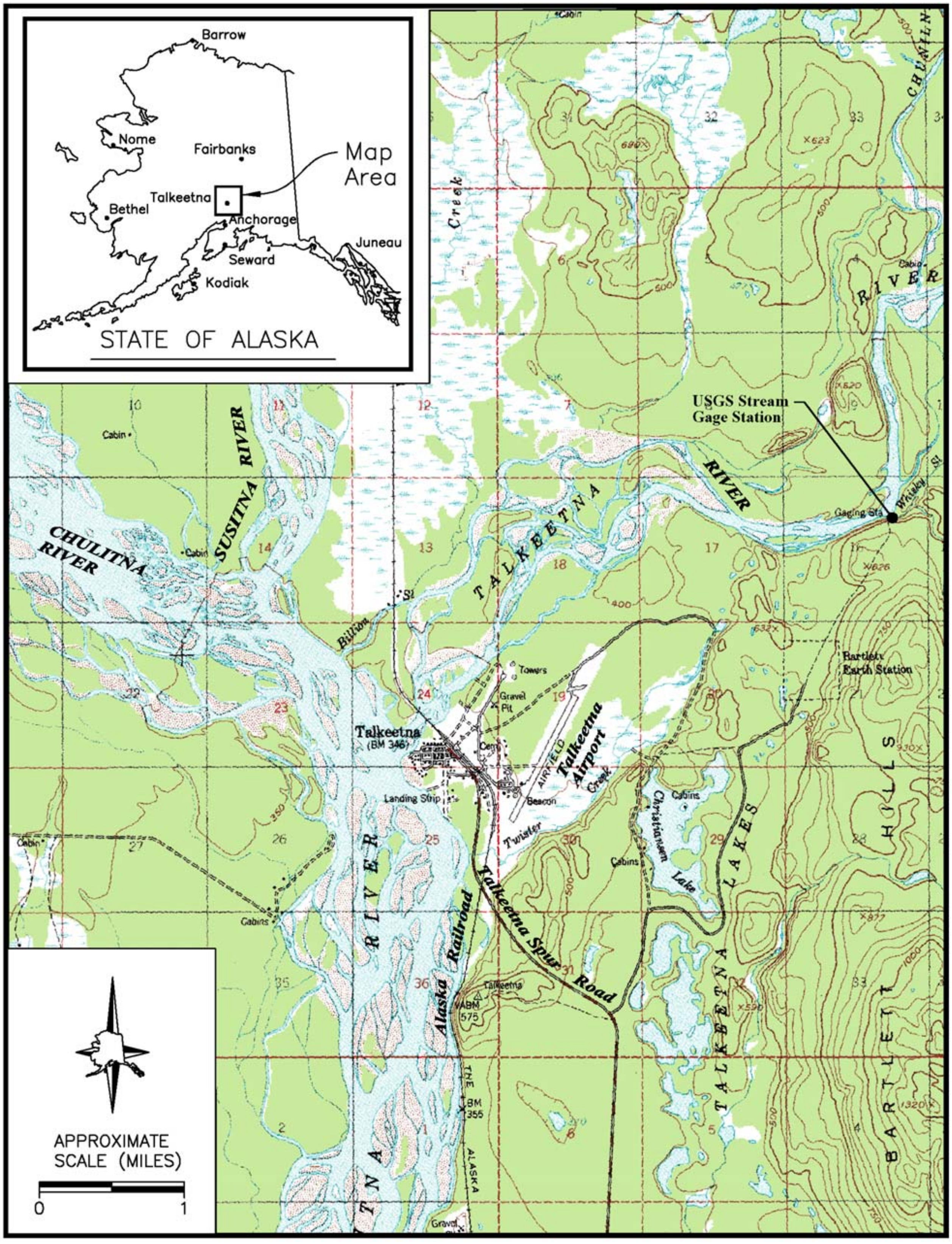
(9) Identify potential flood-mitigation alternatives (see Section 6.0).

(10) Estimate the long-term rate of erosion associated with the left bank of the Talkeetna River in the vicinity of the potential flood-mitigation alternative Dike 2a (see Appendix G).

(11) Estimate the size of the drainage structure(s) required to prevent overtopping of the Talkeetna Spur Road at Twister Creek during a 100-year flood on the Talkeetna River (see Appendix H).

[4] FEMA recommends that the lowest floor elevation of a building, located within a flood-hazard area, be at least 2-feet above the base flood elevation (Hudson 2002, Lee 2002).

Figure 1.0.1: Project Location Map



2.0 BACKGROUND DATA

Background information that was collected for the hydrologic and hydraulic analyses presented in this report include information related to the following.

(1) Past airport construction.

(2) Past floodplain delineations.

(3) Past suggestions for floodplain mitigation.

(4) Information concerning historical floods.

(5) Stage and discharge data collected on the Susitna and Talkeetna Rivers.

(6) Topographic data.

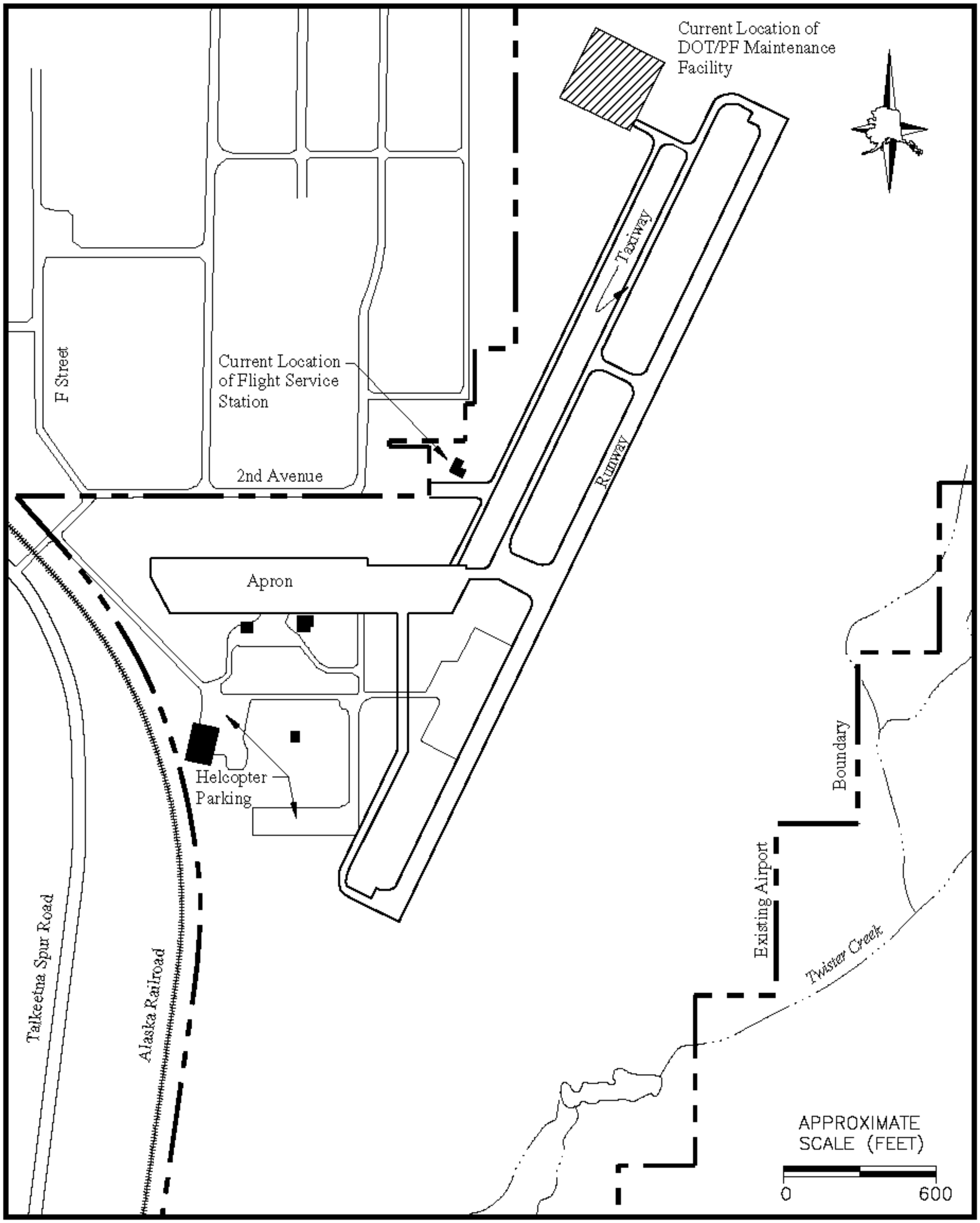
A summary of the first four items is presented in this section of the report. A description of the stage, discharge and topographic data (the last two items) is presented in Appendix A.

2.1 Airport Construction

The Talkeetna Airport (Figure 2.1.1) was constructed in 1941 (USKH 1997). Due to the presence of poor base materials, the runway was re-constructed in the early 1980s (Cinelli 2001). As a result of the re-construction, the elevation of the runway increased (Cinelli 2001).

In 1996 and 1997, additional changes were made to the Talkeetna Airport. The Federal Aviation Administration (FAA) Flight Service Station and the Alaska Department of Transportation and Public Facilities (ADOT&PF) Maintenance & Operations facilities were relocated from the southwest corner to the northern half of the airport property (USKH 1997). The taxiway located west and parallel to the runway was built (Cinelli 2001), and a ditch on the west side of the runway was filled in order to construct the taxiway (Legare 1997). Additionally, several buildings were constructed on the commercial apron at the southwest end of the airport (Cinelli 2001).

Figure 2.1.1: Talkeetna Airport Layout



2.2 Past Floodplain Delineations

The United States Army Corps of Engineers (USACE) made the first published attempt to delineate the limits of the 100-year floodplain in 1972 (USACE 1972). Based on the 1972 analysis, the USACE estimated that the 100-year flood-peak discharge on the Talkeetna River is 97,000 cubic feet per second (cfs) and the peak water surface elevation on the upstream side of the Talkeetna River railroad bridge is 356.2 feet[5] (NAVD88). The USACE also estimated that the 100-year flood would inundate the southern half of the Talkeetna Airport.

In 1985, the Federal Emergency Management Agency (FEMA) published a Flood Insurance Rate Map (FIRM) that included the community of Talkeetna. The map describes the floodplain near the Talkeetna Airport as Flood Zone A (Basich 2001), which means that the limits shown for the 100-year flood have no associated water surface elevations.

In 1996, the USACE published the results of a study (Legare 1996) conducted to better define the water surface elevations and inundated areas associated with the over-bank flow west and south of the airport during the 100-year flood[6]. The results of the USACE study suggest that during a 100-year flood, water will flow south along the north side of the railroad embankment, toward Twister Creek. The results also suggest that the water will pass over low sections of the railroad and highway embankments, and continue in a southwesterly direction to the Susitna River. As a result of this study, the USACE revised the 1972 estimate of the limits of the areas inundated by the 100-year flood at the south end of the airport.

Development at the Talkeetna Airport during 1996 and 1997 prompted the USACE to further revise their 100-year floodplain delineation in 1997 (Legare 1997). The USACE expressed concern that construction of the taxiway and the presence of spoil-piles between the airport and the railroad would restrict flow along the north side of the railroad embankment and increase water surface elevations during the 100-year flood. The USACE (Legare 1997) also stated that

[5] Plate 4 in the 1972 USACE report implies that the water surface elevation on the upstream side of the Talkeetna Railroad bridge is 351.8 feet. The datum associated with this elevation was not stated. The water surface elevation presented in the 1972 report was converted to the NAVD88 datum by comparing the low chord elevation of the Alaska Railroad Bridge at the Talkeetna River, as measured in a 2001 survey conducted by McClintock Land Associates, with the low cord elevation shown in Plate 4 of the 1972 report.
[6] This work was conducted under contract to FEMA.

a "more difficult problem is the increasing number of large buildings at the airport that will, if construction continues in the current pattern, create a wall across the overflow channel".

The 1997 floodplain delineation was revised in 1999 (Legare 1999) as a result of the removal of spoil-piles that had been located near the southwest corner of the airport. The 1999 revision is considered by FEMA to be a Preliminary Flood Insurance Rate Map for Talkeetna (Basich 2001). This map implies that the airport apron area and the gravel runway overrun at the southwest end of the runway is within the 100-year floodplain.

The Preliminary Flood Insurance Rate Map identifies the conditional regulatory water surface elevations, which reflect the existing condition of the floodplain (Basich 2001). Currently, the regulatory 100-year flood elevations are to be employed only where they are deemed to be reasonable (Basich 2001). FEMA has delayed final approval of the Preliminary Flood Insurance Rate Map until the conclusion of the Talkeetna Airport Phase II, Hydrologic/Hydraulic Assessment (Basich 2001).

2.3 Past Suggestions for Floodplain Mitigation

Several methods have been suggested for mitigating flooding at the Talkeetna Airport. The suggestions include the following.

(1) Constructing a swale between the railroad embankment and the south end of the runway.
(2) Lengthening the Alaska Railroad Bridge.
(3) Limiting future airport development to land outside the currently defined 100-year floodplain.

The preliminary cost estimates associated with constructing a drainage swale and lengthening the railroad bridge are about $5.8 and $3.7 million, respectively (Mearig 2000). The cost of three alternative airport developments located within the 100-year floodplain range from $3 to $4 million (USKH 1997). Thus, the cost of developing the airport within the floodplain might range from $7 to $10 million if provisions for flood mitigation are included. The cost of developing the airport on land outside of the 100-year floodplain ranges from $8 to $12 million (Mearig 2000).

2.4 Historical Floods

Major floods occurred at Talkeetna in 1942, 1971, and 1986. During the September 1942 flood, neither the National Weather Service (NWS) stream gage located at the Talkeetna River railroad bridge nor the U. S. Geological Survey (USGS) stream gage located upstream of Talkeetna were in service. Thus, the peak discharge, water surface elevation, and recurrence interval of the flood are unknown. However, it is known that the flood resulted from high water elevations on the Talkeetna, Chulitna and Susitna Rivers, which were caused by heavy rain and melting snow (USACE 1972).

The August 1971 flood resulted from wet antecedent conditions and heavy precipitation (Lamke 1972). Most of the damage was confined to the area downstream of the railroad embankment (USACE 1972). The peak discharge at the USGS stream gage[7] was 67,400 cubic feet per second (cfs). The peak water surface elevation was 394.31 feet (NAVD88) at the USGS stream gage and was calculated to be 351.3 feet[8] (NAVD88) at the upstream face of the Talkeetna River railroad bridge (USACE 1972).

The 1986 flood was caused by heavy precipitation falling on snow (Denkewalter 2001), and was more severe than the 1971 flood. However, neither event caused flooding at the Talkeetna Airport (Powers 2001). The peak discharge on the Talkeetna River, at the USGS stream gage, was 75,700 cfs. At the USGS stream gage, the peak water surface elevation was 395.34 feet and occurred at about 0600 on 11 October. At the NWS stream gage, located on the downstream side of the Talkeetna River railroad bridge, the highest observed water surface elevation was 350.29 feet[9] and occurred at about 1800 on 11 October. This suggests that, after the Talkeetna River discharge had peaked and began to recede, the discharge in the Susitna River was still increasing.

[7] The USGS stream gage is located approximately 5 miles upstream from the mouth of the Talkeetna River and consists of an automated water level recorder.
[8] The elevation computed by the USACE was 346.9 feet. That elevation was converted to the NAVD88 datum for this report.
[9] An observer operates the NWS stream gage manually, and measurements were only made a couple of times a day during the flood. Thus, this elevation probably does not represent the peak water surface elevation during the flood.

Several local residents described the approximate limits (Fitzgerald 2001; Mahay 2001; Lee 2001) and the peak water surface elevations (Denny 2001; Fitzgerald 2001; Mahay 2001; Maynard 2001; Post 2001) associated with the 1986 flood. The locations at which peak water surface elevation observations were made and the location of the edge of the floodwaters are shown in Figure 2.4.1. The descriptions associated with the observations are presented in Table 2.4.1. Table 2.4.1 is provided to document, as best as can be done at this time, the peak water surface elevations during the 1986 flood. As can be seen from the descriptions, most of the water surface elevations are very approximate. In no case was it possible to actually survey a high water mark. Residents simply described where the water had been as best they could, and an elevation was measured. The only exceptions are the measurements made at the USGS and NWS gages. Additionally, the water surface elevation presented for the NWS gage was not necessarily the peak water surface elevation during the flood; it is simply the highest water surface elevation that was recorded. Based on the observations made by local residents at the time of the 1986 flood, the Talkeetna Spur Road was not overtopped (Hanson, 2001), and no flow was observed in the overflow route that was described by the USACE (Denkewalter 2001; Lee 2001; Powers 2001; Ramsey 2001).

The Alaska Railroad embankment near Talkeetna has been in place since 1918. The Alaska Railroad has no record of the railroad embankment, near Talkeetna, ever being overtopped (Brooks 2001).

Figure 2.4.1: 1986 Flood Observations

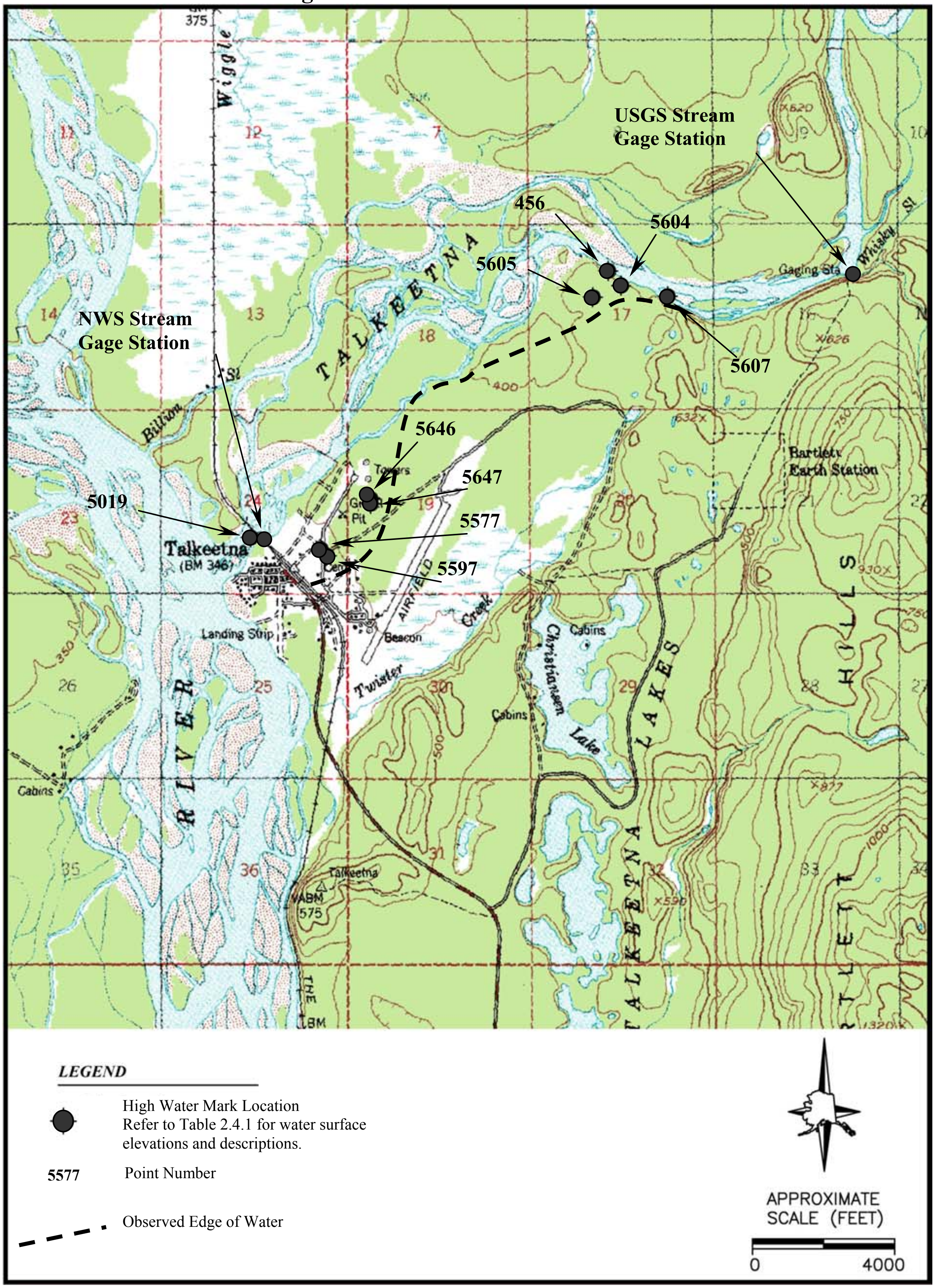


Table 2.4.1: 1986 Flood High Water Marks

Point Number	1986 Flood Elevation (NAVD88)	Estimate of Possible Error (feet)	Description
USGS [1]	395.34	+/- 0.1	U. S. Geological Survey Talkeetna River stream gage station #15292700.
5607 [2]	~382.4	+/- 0.5	The water was about 1 foot below the elevation of the yard. The ground elevation is 383.4 feet (McClintock Land Associates, Inc. 2002a).
5604 [2]	~382.1	+/- 1.5	The water was approximately 3 feet deep at the intersection of Beaver and Mercedes Road (Denny 2001), which has an elevation of 379.1 feet (McClintock Land Associates, Inc. 2002a).
456 [2]	~379.8	+/- 1.0	The water was about 1 foot below Dan Maynard's fill, which has an elevation of 380.8 feet (McClintock Land Associates, Inc. 2002a).
5605 [2]	~376.1	+/- 0.5	This is an estimate of the peak water surface elevation made by Bill Fitzgerald at his home (McClintock Land Associates, Inc. 2002a).
5646 [2]	~355.7	+/- 1.0	The water was about 2 feet below the centerline of Mercedes Road (Thomsen 2001), which has an elevation of 357.7 feet (McClintock Land Associates, Inc. 2002a).
5647 [2]	~354.8	+/- 1.0	This was the approximate elevation of the edge of water in the Thomsen yard (Thomsen 2001; McClintock Land Associates, Inc. 2002a).
5597 [2]	~352.4	+/- 0.2	The water was approximately 2 inches below the floor of Steve Mahay's Riverboat Service building (Mahay 2002). The floor has an elevation of 352.6 feet (McClintock Land Associates, Inc. 2002a).
5577 [2]	<352.7		The floor of the Swiss Alaska Inn has an elevation of 354.2 (McClintock Land Associates, Inc. 2002a). The floor is approximately 1.5 feet above the parking lot elevation. The parking lot was not flooded (Rauchenstein 2002).
NWS [3]	350.29	+/- 0.1	National Weather Service stream gage station, located on the downstream side of the Talkeetna River Railroad Bridge abutment. This is the highest water surface elevation recorded, but measurements were only made a couple of times a day during the flood.
5019 [2]	~350.0	+/- 0.5	Linda Ramsey observed a small amount of water overtopping the dike downstream of the Talkeetna River Bridge (Ramsey 2001). This is the approximate elevation of the dike, 180 feet downstream of the bridge (McClintock Land Associates, Inc. 2002a).

Notes:
1. This elevation was recorded by the U.S. Geological Survey, and adjusted to the NAVD88 datum.
2. These points were identified by Talkeetna residents and surveyed by McClintock Land Associates, Inc. in 2001.
3. This elevation was recorded by the National Weather Service, and adjusted to the NAVD88 datum.

3.0 FLOOD-PEAK FREQUENCY

A flood-frequency analysis was conducted to determine the magnitude and frequency of flood events in: (1) the Talkeetna River at its mouth, and (2) the Susitna River immediately above and below the Talkeetna River. A slightly different method was used for each river, based on the available data.

3.1 Talkeetna River at its Mouth

To estimate the magnitude and frequency of the floods on the Talkeetna River at its mouth, a single-station flood-frequency analysis was performed using data from the U.S. Geological Survey (USGS) stream gage on the Talkeetna River near Talkeetna. The flood magnitude and frequency relationship was then extrapolated to the mouth of the Talkeetna River based on the difference in drainage area. A detailed description of the data and methods is presented in Appendix B, and a summary of the results is presented in the following table.

Table 3.1.1: Flood-Peak Discharge at the Mouth of the Talkeetna River

Return Period (years)	Discharge (cubic feet per second)
2	25,700
5	36,900
10	46,300
25	60,900
50	74,200
100	90,200
200	109,000
500	141,000

A 1972 US Army Corps of Engineers report (USACE, 1972) states that "the Intermediate Regional Flood is defined as one that will occur once in 100-years on average, although it could occur in any year". The same report states that the peak discharge on the Talkeetna River at its mouth, during the Intermediate Regional Flood, was estimated to be 97,000 cubic feet per second (cfs). Use of the regression equations developed in 1994 by the USGS (Jones and Fahl, 1994) suggests that the 100-year flood-peak discharge is approximately 56,600 cfs. Due to the considerable increase in available flood-peak data since the USACE 1972 assessment, and the fact that the Talkeetna River stream gage has a relatively long flood-peak record (38 years), the estimate prepared for this assessment (90,200 cfs) is considered to be the most probable magnitude of the 100-year flood-peak discharge at the mouth of the Talkeetna River.

3.2 Susitna River Above and Below the Talkeetna River

Two different methods were evaluated to estimate the magnitude and frequency of floods on the Susitna River immediately above and below the Talkeetna River. The first method involved the development of regional regression equations based on data from USGS stream gage stations located within the Susitna River watershed. The second method involved the development of a single-station flood-frequency analysis for the Susitna River immediately above the Talkeetna River and a separate single-station flood-frequency analysis for the Susitna River below the Talkeetna River. After considering the strengths and limitations of each method and an estimate of the possible error associated with each method (Appendix B), the estimates based on the single-station frequency analysis were selected as being the most reliable. A detailed description of the methods used and the results obtained for both methods are discussed in Appendix B, but only the results of the single-station analyses are presented here.

Stream gage data are not available for the Susitna River immediately above or below the Talkeetna River. However, by extrapolating and then combining the data from the nearest upstream stream gage stations on the Chulitna, Susitna and Talkeetna Rivers, it was possible to estimate the maximum annual instantaneous peak discharge in years when there were concurrent records. Using these data, single-station flood-frequency analyses were conducted to estimate the magnitude of the flood-peak discharge on the Susitna River immediately above and below the Talkeetna River at various return periods. A summary of the flood-peak discharge estimates calculated for the Susitna River immediately above and below the Talkeetna River is presented in the following table.

Table 3.2.1: Flood-Peak Discharge on the Susitna River Above and Below the Talkeetna River

Return Period	Discharge (cfs)	
(years)	Susitna River above the Talkeetna River	Susitna River below the Talkeetna River
2	88,800	110,000
5	112,000	149,000
10	129,000	177,000
25	153,000	217,000
50	172,000	251,000
100	193,000	289,000
200	216,000	333,000
500	252,000	402,000

For the Susitna River immediately below the Talkeetna River, use of the regression equations developed in 1994 by the USGS (Jones and Fahl, 1994) suggests that the 100-year flood-peak discharge is approximately 231,000 cfs. The US Army Corps of Engineers Talkeetna report (USACE, 1972) states that the peak discharge during the Intermediate Regional Flood is approximately 268,000 cfs. Due to the considerable increase in available flood-peak data since the 1972 assessment, and the fact that the present study was designed specifically to estimate the flood-peak discharge on the Susitna River at the Talkeetna River, the estimate prepared for this assessment (289,000 cfs) is considered to be the most probable magnitude of the 100-year flood-peak discharge on the Susitna River immediately below the Talkeetna River.

For the Susitna River immediately above the Talkeetna River, use of the USGS regression equations suggests that the 100-year flood-peak discharge is approximately 199,000 cfs. For the reasons discussed above, the estimate prepared for this assessment (193,000 cfs) is considered to be the most probable magnitude of the 100-year flood-peak discharge on the Susitna River immediately above the Talkeetna River.

3.3 Summary

The estimates of the 100-year flood-peak discharge developed for the Talkeetna River at its mouth, the Susitna River immediately above the Talkeetna River, and the Susitna River immediately below the Talkeetna River, are presented in the following table. These estimates are considered to be the most probable magnitudes of the 100-year flood-peak discharges available at this time. It will be noted that the 100-year flood peak discharge on the Talkeetna River and the Susitna River above the Talkeetna River sum to about 5,800 cfs less than the value presented for the Susitna River below the Talkeetna River. As the difference is small and well within the potential error associated with the estimates, no attempt was made to explain the difference.

Table 3.3.1: Most Probable 100-Year Flood-Peak Discharge

Talkeetna River at its mouth	Susitna River above the Talkeetna River	Susitna River below the Talkeetna River
90,200 cfs	193,000 cfs	289,000 cfs

4.0 FLOOD TIMING

A flood-peak timing analysis was conducted to answer two questions. First, during a 100-year flood on the Talkeetna River, what will the most probable magnitude of the discharge on the Susitna River be? And conversely, during a 100-year flood on the Susitna River, what will the most probable magnitude of the discharge on the Talkeetna River be? A summary of the methods used to address these questions and the results of the analysis is presented in this section. A more detailed description of the methods and results is presented in Appendix D.

4.1 Susitna River Discharge Based on Talkeetna River Discharge

The maximum annual mean daily discharge on the Talkeetna River near Talkeetna and the date of its occurrence were obtained from the U.S. Geological Survey (USGS) for each year of concurrent record on the Talkeetna, Chulitna and Susitna Rivers. The discharge values were then extrapolated to the mouth of the Talkeetna River based on the difference in drainage area. For each date on which a maximum annual Talkeetna River discharge occurred, the discharge on the Susitna River immediately above the Talkeetna River was also estimated.

Using these data, a regression equation was developed to predict the discharge in the Susitna River immediately above the Talkeetna River during a flood peak of a known magnitude on the Talkeetna River, at its mouth. The magnitude of the 100-year flood-peak discharge at the mouth of the Talkeetna River is estimated to be 90,200 cubic feet per second (cfs). Based on the regression analysis, the magnitude of the concurrent discharge in the Susitna River immediately above the mouth of the Talkeetna River is estimated to be 178,000[10] cfs. Thus, the magnitude of the discharge in the Susitna River immediately below the Talkeetna River, at the time of the 100-year flood-peak discharge in the Talkeetna River, is the sum of the upper Susitna and Talkeetna River discharges: 268,000 cfs.

[10] It should be noted that the regression equation was developed with mean daily discharge data. By using an instantaneous peak discharge on the Talkeetna River to predict the concurrent discharge on the Susitna River, it might appear that the estimate of the Susitna River discharge will be systematically conservative (i.e. the estimate is higher than actual). However, such may not be the case. Although the instantaneous discharge on the Talkeetna River averages about 20 percent greater than the average daily discharge on the same day, the discharge in the Susitna River can change by more than 70 percent in a day. Thus, use of the regression equation as described herein is considered satisfactory for the purposes of this analysis.

4.2 Talkeetna River Discharge Based on Susitna River Discharge

The maximum annual mean daily discharge on the Susitna River immediately above the Talkeetna River was computed for each year of concurrent record on the Talkeetna, Chulitna and Susitna Rivers. For each date on which a maximum annual Susitna River discharge occurred, the mean daily discharge on the Talkeetna River was obtained from the USGS stream gage data. These discharge values were then extrapolated from the stream gage to the mouth of the Talkeetna River based on the difference in drainage area.

Using these data, a regression equation was developed to predict the discharge in the Talkeetna River at its mouth during a flood peak of a known magnitude on the Susitna River immediately above the Talkeetna River. The magnitude of the 100-year flood-peak discharge on the Susitna River immediately above the Talkeetna River is estimated to be 193,000 cfs. Based on the regression analysis, the concurrent discharge at the mouth of the Talkeetna River is estimated to be 56,000[11] cfs. Thus, the magnitude of the discharge in the Susitna River immediately below the Talkeetna River, at the time of the 100-year flood-peak discharge in the Susitna River immediately above the Talkeetna River, is the sum of the upper Susitna and Talkeetna discharges: 249,000 cfs.

The magnitude of the 100-year flood-peak discharge on the Susitna River immediately below the mouth of the Talkeetna River is 289,000 cfs. Using the regression equation to predict the Talkeetna River discharge based on the Susitna River discharge above the mouth of the Talkeetna River, the magnitude of the discharge on the Susitna River immediately above the mouth of the Talkeetna River and in the Talkeetna River at its mouth were computed by assuming that the sum of the two discharges must equal the 100-year flood-peak discharge in the Susitna River immediately below the Talkeetna River. Thus, at the time of the 100-year flood in the Susitna River immediately below the mouth of the Talkeetna River, the discharge in the

[11] It should be noted that the regression equation was developed with mean daily discharge data. By using an instantaneous peak discharge on the Susitna River to predict the concurrent discharge on the Talkeetna River, it might appear that the estimate of the Talkeetna River discharge will be systematically conservative (i.e. the estimate is higher than the actual). However, such may not be the case. Although the instantaneous discharge on the Susitna River at Gold Creek averages about 5 percent greater than the average daily discharge on the same day, the discharge in the Talkeetna River can change by more than 100 percent in a day. Thus, use of the regression equation as described herein is considered satisfactory for the purposes of this analysis.

Susitna River immediately above the Talkeetna River is estimated to be 222,000 cfs, and the discharge in the Talkeetna River is estimated to be 67,000 cfs.

4.3 Summary

At the time of a 100-year flood-peak discharge at the mouth of the Talkeetna River (90,200 cfs), it is most probable that the discharge in the Susitna River immediately above the Talkeetna River will be 178,000 cfs. Thus, the discharge in the Susitna River immediately below the Talkeetna River is estimated to be 268,000 cfs.

At the time of a 100-year flood-peak discharge in the Susitna River immediately above the Talkeetna River (193,000 cfs), the discharge in the Talkeetna is estimated to be 56,000 cfs. The discharge in the Susitna River immediately below the Talkeetna River is estimated to be 249,000 cfs.

At the time of a 100-year flood-peak discharge in the Susitna River immediately below the Talkeetna River (289,000 cfs), the discharge in the Talkeetna is estimated to be 67,000 cfs. The discharge in the Susitna River immediately above the Talkeetna River is estimated to be 222,000 cfs.

A summary of these values, and their associated return periods, is presented in Table 4.3.1. In reviewing Table 4.3.1, it will be noted that during a 100-year flood on the Susitna River below the Talkeetna River, the discharge in the Susitna River above the Talkeetna River has an average return period of 220 years. At first, this might seem unreasonable. However, many possible combinations of discharges on the upper Susitna and Talkeetna Rivers can produce the 100-year flood-peak discharge on the Susitna River immediately below the Talkeetna River. Another possible combination is a discharge of 99,300 cfs on the Talkeetna River and 189,700 cfs on the Susitna River above the Talkeetna River[12]. This combination of discharges is as likely to occur as the one presented in Table 4.3.1. The latter combination was not selected for use on this

[12] These values were estimated using the regression equation to predict the discharge on the Susitna River above the Talkeetna River given the discharge on the Talkeetna River.

project because the discharge on the Talkeetna River would have a return period greater than 100 years.

Table 4.3.1: Three Possible 100-Year Flood Scenarios

	Talkeetna River at its mouth	Susitna River above the Talkeetna River	Susitna River below the Talkeetna River
100-Year Flood-Peak Discharge on the Talkeetna River	90,200 cfs (RP = 100 yrs)	178,000 cfs (RP = 70 yrs)	268,000 cfs (RP = 75 yrs)
100-Year Flood-Peak Discharge on the Susitna River Above Talkeetna	56,000 cfs (RP = 20 yrs)	193,000 cfs (RP = 100 yrs)	249,000 cfs (RP = 49 yrs)
100-Year Flood-Peak Discharge on the Susitna River Below Talkeetna	67,000 cfs (RP = 32 yrs)	222,000 cfs (RP = 220 yrs)	289,000 cfs (RP = 100 yrs)

For the purposes of this project, two of the three scenarios were chosen to estimate the condition likely to produce the highest 100-year flood water-surface elevation on the upstream side of the Alaska Railroad Talkeetna River Bridge. The two scenarios were: a 100-year flood on the Talkeetna River, and a 100-year flood on the Susitna River immediately below the Talkeetna River. The other scenario, a 100-year flood on the Susitna River immediately above the Talkeetna River, was not analyzed because the flood-peak discharges on the Talkeetna and Susitna Rivers are less than those associated with one or both of the two chosen scenarios.

5.0 100-YEAR FLOOD-PEAK WATER-SURFACE

A two-dimensional surface-water model of the Susitna/Talkeetna River confluence was developed to estimate water surface elevations and velocities at the Talkeetna Airport during a 100-year flood-peak discharge on the Talkeetna River. A brief description of the two-dimensional surface-water model and the results of the 100-year flood analysis are presented in this section. A detailed description of the development of the two-dimensional surface-water model is presented in Appendix E.

5.1 Two-Dimensional Surface Water Model

The finite element mesh used in the two-dimensional surface-water model was created from topographic data collected by McClintock Land Associates (McClintock Land Associates 2002a and 2002b, and McClintock 2002). Values for kinematic eddy viscosity and hydraulic roughness[13] were assigned to each of the elements in the mesh. Water surface elevation was used to describe the downstream boundary condition, and discharge was used to describe the upstream boundary condition.

The model was calibrated to water surface elevation measurements made at the Talkeetna River NWS and USGS stream gages on two days when the discharge in the Talkeetna and Susitna Rivers was known or could be estimated. The smaller Talkeetna River event occurred on 14 July 1980, when the Talkeetna River and Susitna River above the Talkeetna River discharges were approximately 15,600 cubic feet per second (cfs) and 75,300 cfs, respectively. This event was used to calibrate the main channel hydraulic roughness coefficients. The larger Talkeetna River event occurred on 11 October 1986, when the Talkeetna River and Susitna River above the Talkeetna River discharges were approximately 58,600 cfs and 70,200 cfs, respectively. This event was used to calibrate the floodplain hydraulic roughness coefficients. Very little adjustment of the channel geometry or hydraulic roughness coefficients was required to achieve a good correlation between the observed and calculated water surface elevations (Table 5.1.1).

[13] Hydraulic roughness as used in this report refers to Manning's roughness coefficient.

Table 5.1.1: Two-Dimensional Model Calibration Summary

	Main Channel Calibration Water Surface Elevations		Floodplain Calibration Water Surface Elevations	
	Observed (feet NAVD88)	Calculated (feet NAVD88)	Observed (feet NAVD88)	Calculated (feet NAVD88)
NWS Gage	344.54	344.83	350.29	350.24
USGS Gage	386.10	386.11	393.28	393.26

5.2 100-Year Design Flood

In order to estimate cost effectively which of the 100-year flood-peak discharge scenarios discussed in Section 4.3 produces the highest water surface elevation on the upstream side of the Talkeetna River Bridge, a one-dimensional model of the Susitna/Talkeetna River confluence was developed (Appendix F). The first scenario involves a 100-year flood-peak discharge on the Susitna River immediately below the Talkeetna River. The discharge on the Susitna River immediately below the Talkeetna River is 289,000 cfs and the discharge at the mouth of the Talkeetna River is 67,000 cfs. The second scenario involves a 100-year flood-peak discharge on the Talkeetna River. The discharge at the mouth of the Talkeetna River is 90,200 cfs and the discharge on the Susitna River immediately below the Talkeetna River is 268,000 cfs. The results of the analysis suggest that a 100-year flood on the Talkeetna River produces the higher water surface elevation on the upstream side of the Talkeetna River Bridge (Table 5.2.1). Therefore, the Talkeetna River 100-year flood scenario was used in the two-dimensional surface-water model to estimate conditions at the Talkeetna Airport during a 100-year flood.

Table 5.2.1: 100-Year Water Surface Elevations at the Talkeetna River Bridge

	100-Year Flood-Peak Discharge on the Talkeetna River	100-Year Flood-Peak Discharge on the Susitna River Below Talkeetna
Water Surface Elevation on the Upstream Side of the Talkeetna River Bridge	355.71	352.76

5.3 General Flood Conditions During the 100-Year Design Flood

The water surface elevations, water velocities and flow vectors, and water depths expected to occur[14] during the peak discharge of the 100-year flood on the Talkeetna River are presented in Figures 5.3.1, 5.3.2 and 5.3.3, respectively. Additional information concerning water surface elevations and velocities during the 100-year flood is presented in Appendix E.

At the peak discharge of the 100-year flood on the Talkeetna River, the discharge through the Alaska Railroad Talkeetna River Bridge will be about 76,000 cfs. The maximum water surface elevation on the upstream side of the railroad embankment will be about 355.5 feet, which is below the low chord elevation of the bridge (355.9 feet). The average water surface elevation under the upstream face of the bridge will be about 351.3 feet[15].

The Billion Slough Bridge is likely to pass approximately 7,700 cfs at the peak discharge of the 100-year flood. The maximum water surface elevation on the upstream side of the Billion Slough Bridge will be approximately 357.7 feet. This is above the low chord elevation of the bridge (352.7 feet) but below the elevation of the bridge deck (approximately 360 feet).

[14] The purpose of this effort was to estimate water surface elevations and velocities on the upstream side of the Alaska Railroad embankment, in the vicinity of the airport. Thus, the water surface elevations on the upstream side of the Alaska Railroad embankment are considered to be more accurate than the water surface elevations on the downstream side. The water surface elevations on the upstream side of the embankment should probably be considered to be ± 0.5 feet.

[15] At the peak discharge of the 100-year flood on the Talkeetna River, the water surface elevation under the upstream face of the Alaska Railroad Talkeetna River Bridge will probably vary from about 345.6 to 352.7 feet. The lowest water surface elevations will be adjacent to the abutments. Within 30 feet of the abutments the water surface elevation is expected to be at or above 350 feet. The highest water surface elevations are expected to be near the center of the bridge. An average value of 351.3 was estimated by computing the average water surface elevation and width of each element along the upstream side of the bridge and using those values to compute a weighted average water surface elevation.

Figure 5.3.1: Water Surface Elevation Contours – 100-Year Flood Model

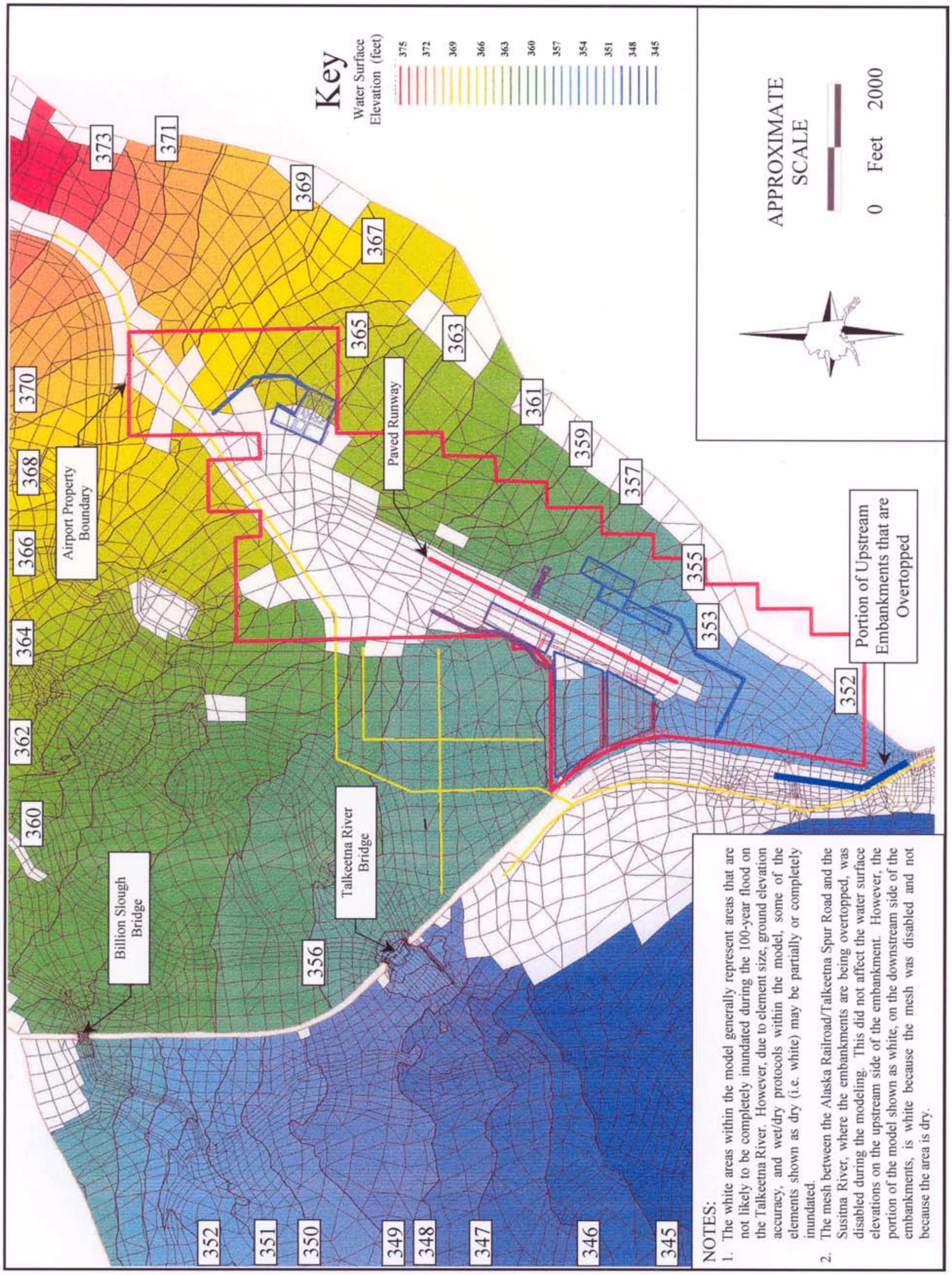


Figure 5.3.2: Velocity Contours and Flow Vectors – 100-Year Flood Model

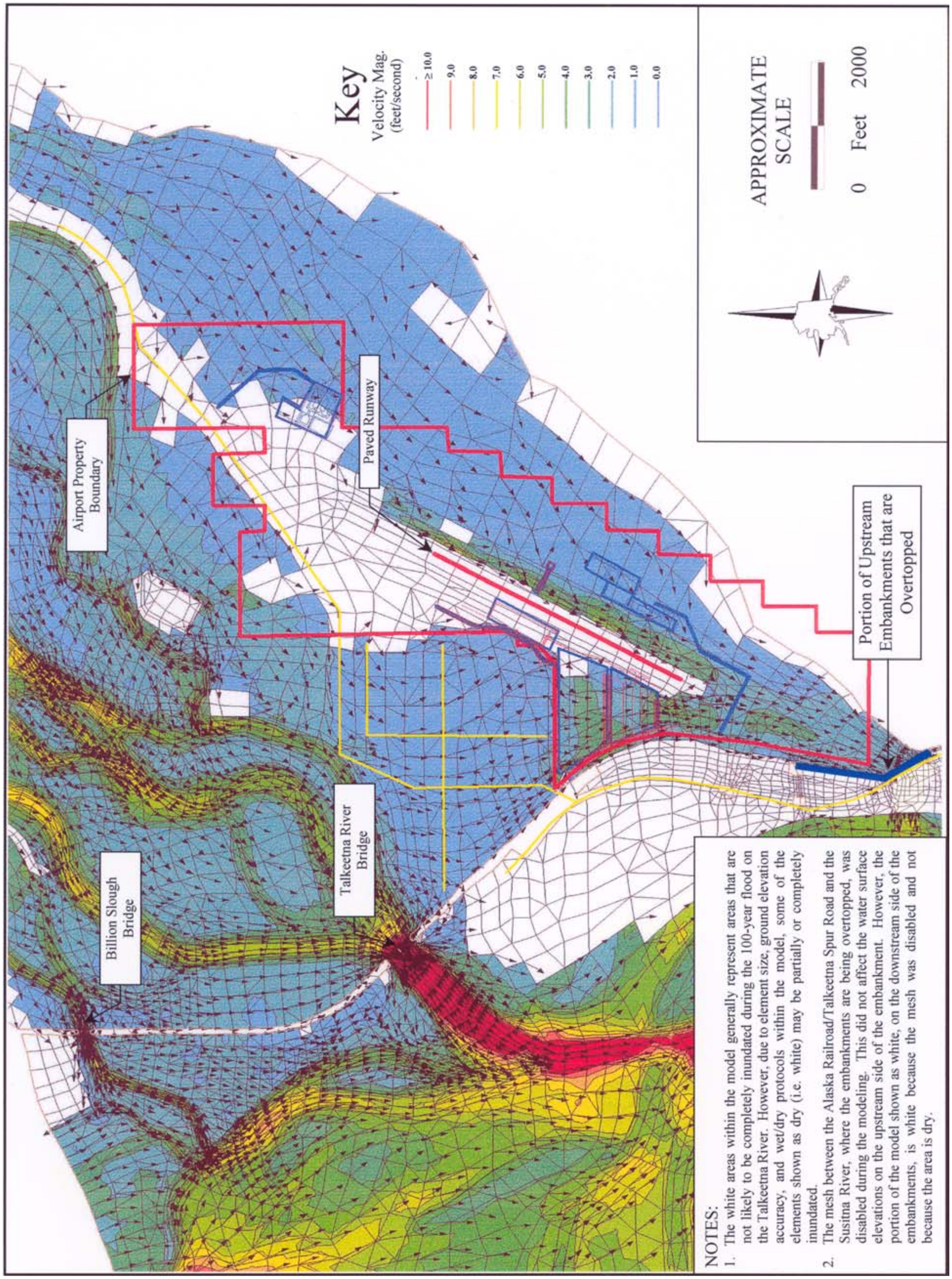
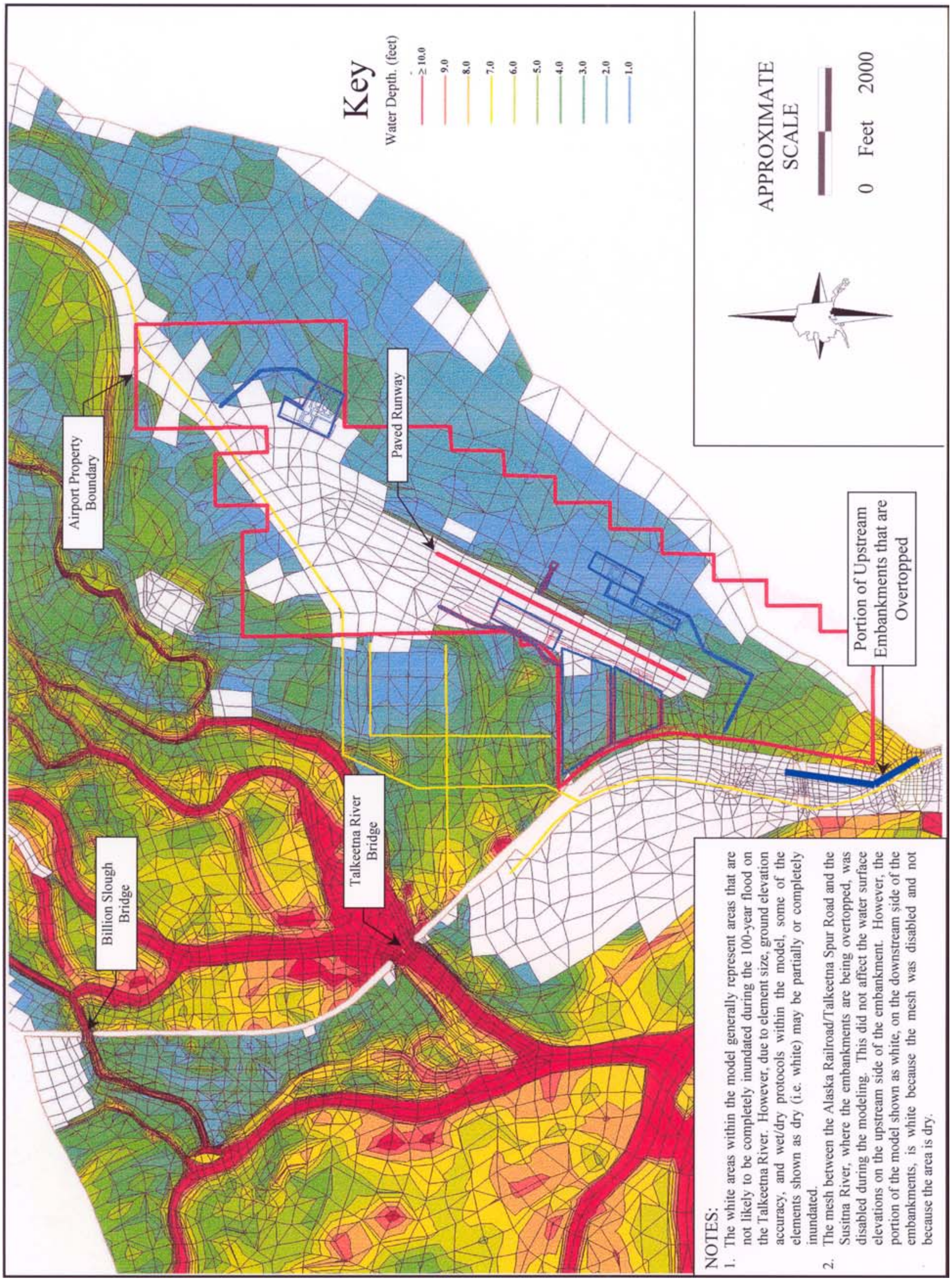


Figure 5.3.3: Water Depth Contours – 100-Year Flood Model



The water surface elevations and velocities predicted with the two-dimensional surface-water model are based on the assumption that debris will not significantly affect flow through the bridges[16]. If debris accumulates at the upstream face of a bridge, it can reduce the amount of flow that is able to pass through the structure. This is an important consideration since the Talkeetna River carried a significant amount of debris during the 1986 flood event (Mahay 2002). While debris did not collect on the Talkeetna River Bridge during the 1986 flood, the water surface elevation on the upstream side of the bridge was not as high as the 100-year water surface elevation is likely to be. During the 100-year flood, debris could accumulate on the upstream face of the railroad embankment, on either side of the bridge opening. As it collects, the debris could encroach towards the bridge opening and become snagged on the low chord of the bridge. Additionally, debris could accumulate at the center pier. Either of these situations could cause higher water surface elevations upstream of the bridge than those suggested by this assessment of the 100-year flood.

The Talkeetna Spur Road and the Alaska Railroad embankment at the level crossing southwest of the airport are overtopped during the peak discharge of the 100-year flood on the Talkeetna River. At the 100-year flood-peak discharge, approximately 6,900 cfs will overtop the embankments. Approximately 1100 feet of the Alaska Railroad (ARR) embankment will be overtopped on the north side of the crossing, and approximately 800 feet of the Talkeetna Spur Road will be overtopped on the south side of the crossing. The maximum depth of flow will occur on the Talkeetna Spur Road and will be approximately 2.4 feet. The three Talkeetna Spur Road culverts located near Twister Creek will only pass about 150 cfs.

5.4 Flooding at the Talkeetna Airport During the 100-Year Design Flood

At the peak of the 100-year flood on the Talkeetna River, water will flow past both the north and south sides of the Talkeetna Airport. On the south side of the airport approximately 2,350 cfs will flow towards Twister Creek. In the vegetated areas the water velocities can be expected to range from approximately 0.4 to 1.0 feet per second (fps), and average about 0.7 fps. In the 200-

[16] The possible impact of debris accumulation on water surface elevations along the upstream side of the Talkeenta River Bridge may be addressed during future analyses if the selected flood mitigation measures involve construction of a dike or widening of the bridge.

foot wide cleared strip adjacent to the runway, the water velocities can be expected to range from approximately 2 to 6 fps, and average about 3 fps.

Between the Alaska Railroad embankment and the southwest end of the runway, at the peak of the 100-year flood, approximately 4,550 cfs will flow towards Twister Creek. The average depth of flow on the existing commercial apron is likely to be about 1.1 feet, and the maximum depth is likely to be about 1.9 feet. The average water velocity on the existing commercial apron is likely to be about 2 fps and the maximum velocity is likely to be about 3 fps.

The paved portion of the runway is likely to remain dry during the 100-year flood. The centerline of the southwestern end of the pavement will be approximately 1.2 feet above the water surface, and the centerline of the northeastern end of the pavement will be approximately 4.5 feet above the water surface. However, the runway overrun at the southwestern end of the runway will be partially flooded, to a maximum depth of about 1.4 feet. The run-out at the northeastern end of the runway will be approximately 1.5 feet above the water surface.

The centerline of the taxiway may remain dry during the 100-year flood. However, the peak water surface may only be 0.1 feet[17] below the taxiway at the southwestern end of the pavement. Additionally, the southernmost 600 feet of the taxiway will probably be less than 0.5 feet above the water surface. The northern end of the taxiway is likely to be about 6.5 feet above the water surface.

The maintenance access road that connects the commercial apron to the Alaska Department of Transportation and Public Facility (ADOT&PF) Maintenance Facility will be partially inundated at the peak discharge of the 100-year flood. The southwestern most 300 feet will be covered by water to a maximum depth of approximately 1.7 feet at the road centerline. The remainder of the road averages about 2.6 feet higher than the peak water surface elevation.

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[17] Note that the water surface elevations predicted with the two-dimensional surface-water model, upstream from the Alaska Railroad embankment, should probably be considered to be ± 0.5 feet.

The ground elevation at the ADOT&PF Maintenance Facility is likely to be about 4.5 feet above the water surface at the peak discharge of the 100-year flood. The ground elevation at the Flight Service Station is very close to the peak water surface elevation, varying between about 0.9 feet below and 1.1 feet above the water surface.

5.5 Flooding at Proposed Airport Improvements During the 100-Year Design Flood

Several possible improvements are being considered at the Talkeetna Airport (Figure 5.5.1).

(1) New Commercial Apron. Construction of a new commercial apron on the south side of the existing commercial apron is being considered. Concept drawings suggest that the surface of the proposed commercial apron would be approximately 3 feet above the existing ground elevation and higher than the existing commercial apron.

(2) New Helicopter Landing Pad. Two sites are currently being considered for construction of a new helicopter landing area. The first site is located on the east side of the southwest end of the runway. The second site is located near the northeast corner of the airport property. Each would require construction of a new access road.

(3) New Commercial Apron Access Road. Consideration is being given to relocating the commercial apron access road. The new road would be closer to the railroad embankment. The road would extend from 2nd Street to at least the proposed new commercial apron. If the proposed helicopter-landing pad located on the east side of the southwest end of the runway was constructed, the road would extend to the helicopter-landing pad.

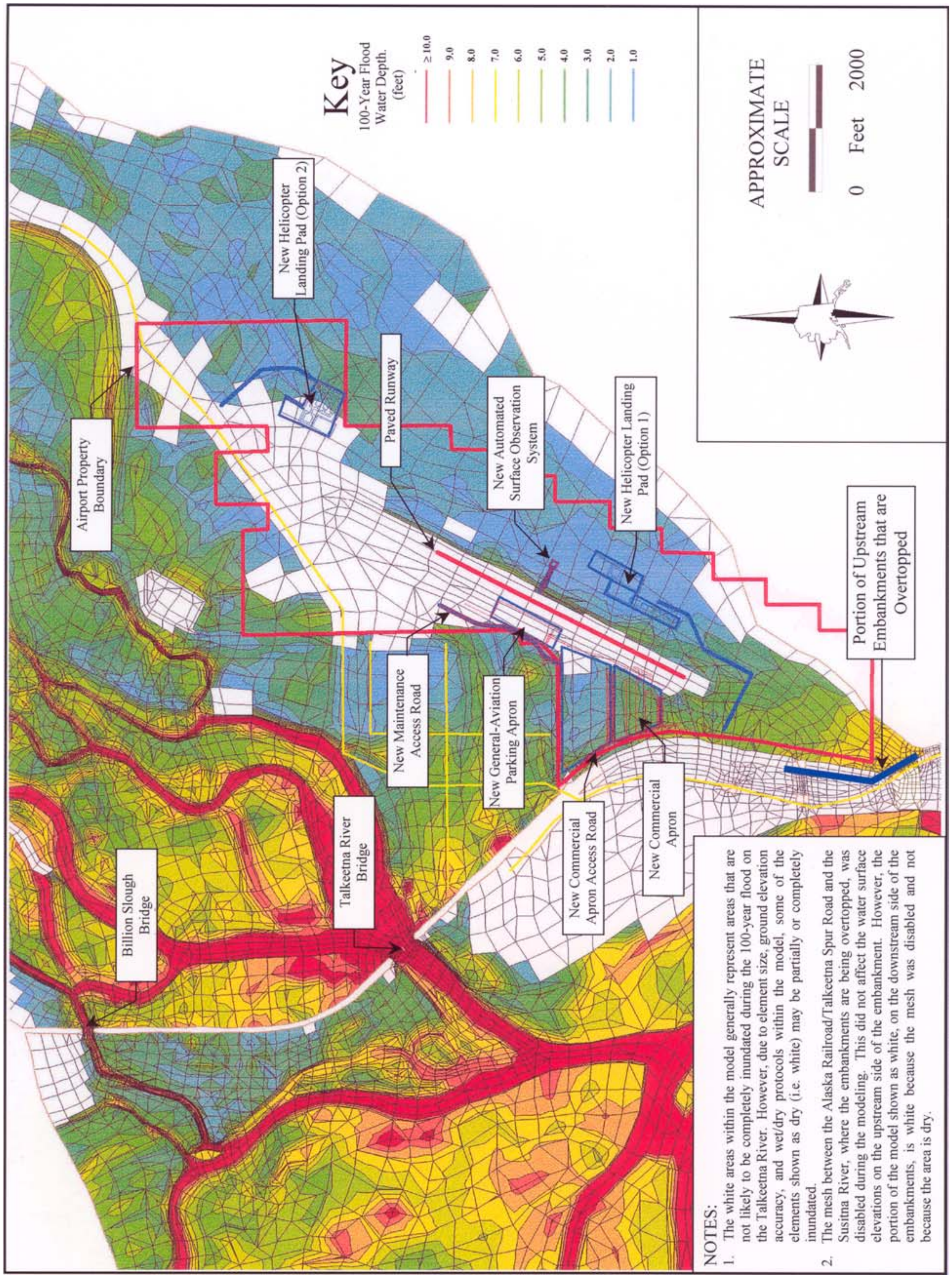
(4) New Automated Surface Observation System (ASOS). Consideration is being given to construction of a new ASOS on the east side of the runway.

(5) New Maintenance Access Road. Consideration is being given to the construction of a new maintenance access road. The new road would be located about 200 feet to the northwest of the existing road.

(6) General Aviation Parking Apron. Consideration is being given to the construction of a new general-aviation parking apron on the north side of the runway.

Some of these improvements, as presently envisioned, are within the 100-year floodplain, and construction of some of them may cause the water surface elevations near the airport to be higher during the 100-year flood on the Talkeetna River than the water surface elevations would have been if the improvements had not been made.

Figure 5.5.1: Location of Proposed Airport Improvements



Although it was beyond the scope of this analysis to determine the magnitude of the potential impact associated with construction of these improvements, the results of this analysis can be used to estimate the conditions at the sites prior to construction and in some cases to make preliminary estimates as to the order of magnitude of the impact of the proposed improvements.

5.5.1 New Commercial Apron

At the site of the proposed new commercial apron, the water depth prior to construction will vary between approximately 0 and 4.6 feet. The water velocity will vary from about 0.5 to more than 3 fps, averaging something more than 1.5 fps. The new commercial apron, as presently envisioned, might significantly increase water surface elevations adjacent to the airport during the 100-year flood (see Section 5.5.7). If this alternative is considered further, an analysis should be completed to address the likely magnitude of the increase.

5.5.2 New Helicopter Landing Pad

Two sites are currently being considered for construction of a new helicopter landing area.

5.5.2.1 Helicopter Landing Pad on East Side of Southwest End of Runway

One of the proposed sites of the new helicopter-landing pad is at the southwest end of the runway. At this site the water depth prior to construction will vary between approximately 0.5 and 1.2 feet, and the water velocity will vary from about 0.5 to 1.7 fps. This pad and in particular the access road that would accompany it, might significantly increase water surface elevations adjacent to the airport during the 100-year flood (see Section 5.5.7). If this alternative is considered further, an analysis should be completed to address the likely magnitude of the increase.

5.5.2.2 Helicopter Landing Pad on East Side of Northeast End of Runway

The other proposed site of the new helicopter-landing pad is at the northeast end of the runway. At this site the water depth prior to construction will vary between approximately 0 and 2.3 feet, and the water velocity will vary from about 0 to 1 fps. At the proposed access road leading to the helicopter-landing pad the water depth prior to construction will vary between approximately

0.5 and 1.5 feet, and the water velocity will vary from about 0 to 1 fps. This pad and access road seem less likely to significantly increase water surface elevations, than the other helicopter-landing pad option.

5.5.3 New Commercial Access Road

At the site of the proposed new commercial access road, between 2nd Avenue and the new commercial apron, the water depth prior to construction will vary between approximately 2.2 and 5.2 feet. The water velocity will vary from about 1.5 to 3.3 fps. Along the portion of the access road between the commercial apron and the helicopter-landing pad, the water depth will vary between approximately 0.5 and 5.2 feet. The water velocity will vary from about 0.5 to 1.7 fps. The new commercial access road, as presently envisioned, might significantly increase water surface elevations adjacent to the airport during the 100-year flood (see Section 5.5.7). If this alternative is considered further, an analysis should be completed to address the likely magnitude of the increase.

5.5.4 New Automated Surface Observation System

At the site of the proposed new automated surface observation system (ASOS), the water depth prior to construction will vary between approximately 0.2 and 4.5 feet, and the water velocity will vary from about 0.3 to 3.6 fps. The higher water depths and velocities will be associated with a ditch adjacent to the east side of the runway, which must be crossed to obtain access to the new ASOS. If this structure is constructed on piles, or if the structure is constructed with a footbridge over the ditch and a small pad that does not encroach on the ditch, it is likely that the structure can be constructed without significantly impacting the 100-year flood water-surface elevations adjacent to the airport.

5.5.5 New Maintenance Access Road

At the site of the new maintenance access road, the water depth prior to construction will vary between approximately 0 and 2.1 feet. The water velocity will vary from about 0 to 0.7 fps. If this road is constructed above the peak water surface elevation of the 100-year flood, it is likely that it will not significantly affect water surface elevations adjacent to the airport as long as it remains on the edge of the floodplain and provision for local drainage is provided.

5.5.6 General-Aviation Parking Apron

The proposed location of the new general-aviation parking apron does not appear to be inundated by the 100-year flood-peak discharge.

5.5.7 Development Between the Railroad Embankment and the Southwest End of the Runway

If construction of the proposed improvements completely block water from flowing between the southwest end of the runway and the railroad embankment, it is likely that the water surface elevation on the upstream side of the Alaska Railroad Talkeetna River Bridge will increase by about 0.7 feet[18] during the peak discharge of the 100-year flood on the Talkeetna River. This would make the water surface elevation on the upstream side of the railroad embankment higher than the low chord of the bridge.

[18] It was beyond the scope of this analysis to estimate the magnitude of the increase in the water surface elevation resulting from blocking the flow between the airport and the railroad embankments. Thus, this value is an order of magnitude estimate based on the computations conducted for this analysis.

6.0 FLOOD MITIGATION ALTERNATIVES

Because portions of the Talkeetna Airport will be inundated during a 100-year flood on the Talkeetna River, and some of the proposed improvements are within the 100-year floodplain, several possible flood-mitigation alternatives were identified. The alternatives presented below were discussed with personnel of the Alaska Department of Transportation and Public Facilities (ADOT&PF) and the Federal Aviation Administration (FAA). Three of the flood-mitigation alternatives were selected for further analysis, and are described in Section 6.2.

6.1 Possible Flood Mitigation Alternatives

6.1.1 No Action

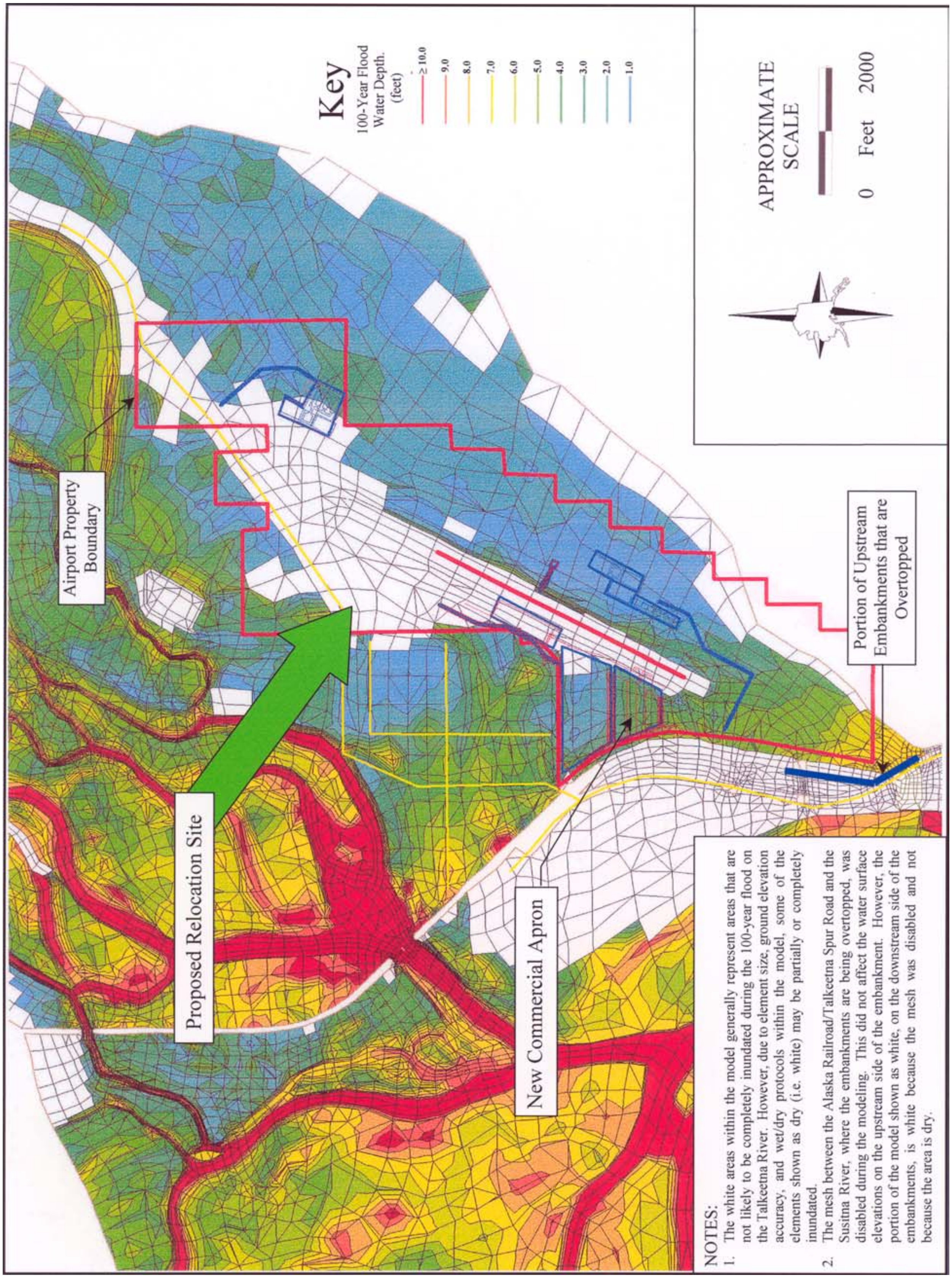
No improvements are made at the airport. The commercial apron, helicopter access, vehicular access and general-aviation parking[19] remain as they are at this time. Portions of the airport, including the commercial apron and possibly the Flight Service Station, are inundated during a 100-year flood on the Talkeetna River.

6.1.2 Relocate New Commercial Apron to Dry Ground

Move the location of the new commercial apron from the location that has previously been proposed to a location outside the 100-year floodplain (Figure 6.1.1). The results of the two-dimensional surface water model suggest that the northwest corner of the airport property is not inundated during the 100-year flood. The new general-aviation parking area and the new maintenance access road could also be constructed in this area with little or no impact on the "existing condition" 100-year-flood water-surface elevation. The existing commercial apron and possibly the Flight Service Station would still be inundated during a 100-year flood.

[19] Note that the proposed location of the general-aviation parking area is probably outside the flood limits of the 100-year flood on the Talkeetna River.

Figure 6.1.1: Relocate the Commercial Apron to Dry Ground



6.1.3 Protect Airport with Dike and Increased Drainage Capacity at Talkeetna River Bridge

Construct a dike and add additional drainage capacity at the Alaska Railroad Talkeetna River Bridge to prevent all or a portion of the airport property from being inundated during the 100-year flood on the Talkeetna River. The purpose of adding additional drainage capacity at the Alaska Railroad Bridge is to maintain the water surface elevation during the 100-year flood at the same elevation that would occur if the dike were not constructed (i.e. the present condition elevation). Thus, the dike would not worsen the flood damage on the upstream side of the Talkeetna River Bridge by raising the water surface elevation.

Simply constructing a dike will reduce or eliminate flooding at the airport. However, the dike would result in an increase in the water surface elevation at, and upstream from, the Talkeetna River Bridge during a 100-year flood on the Talkeetna River. Such an action would negatively impact other landowners in the area. Thus, in order to maintain the "existing condition" 100-year flood-peak water-surface elevation, as required by the Matanuska-Susitna Borough[20], it will be necessary to increase the drainage capacity at the Talkeetna River Bridge. Alternatively, simply increasing the drainage capacity at the Talkeetna River Bridge is not likely to be the most cost effective means of reducing flooding at the airport.

6.1.3.1 Construct Dike

Four potential dike alignments were considered to mitigate flooding at the Talkeetna Airport. Each option involves either the construction of a new embankment, raising existing road embankments, or a combination of the two. In each case it is anticipated that the dike/road embankments would have 2H:1V side slopes and be constructed with a top elevation at least 3 feet above the peak water-surface elevation of the 100-year flood. Where construction of the dike would involve the raising of an existing road, access to adjacent properties and businesses will be maintained.

[20] It is the practice of the Matanuska-Susitna Borough to enforce Title 17.29.180 for all permitted new construction within the limits of the base flood (Hudson, 2003). Title 17.29.180 requires that no improvements be made within a floodway that will result in any increase in the water surface elevation of the base flood.

All of the dike options assume that the proposed developments will not be inundated by backwater from Twister Creek. To prevent inundation by Twister Creek, one of the following must occur.

(1) If the new helicopter-landing area and access road are constructed at the southeast end of the runway, they must be constructed high enough to prevent overtopping from Twister Creek. They must also be tied to the railroad and runway embankments to prevent water from passing around the embankments and reaching airport facilities. They may be tied to the railroad and runway embankments by short dikes or by making the embankments continuous, or by a combination of the two methods.

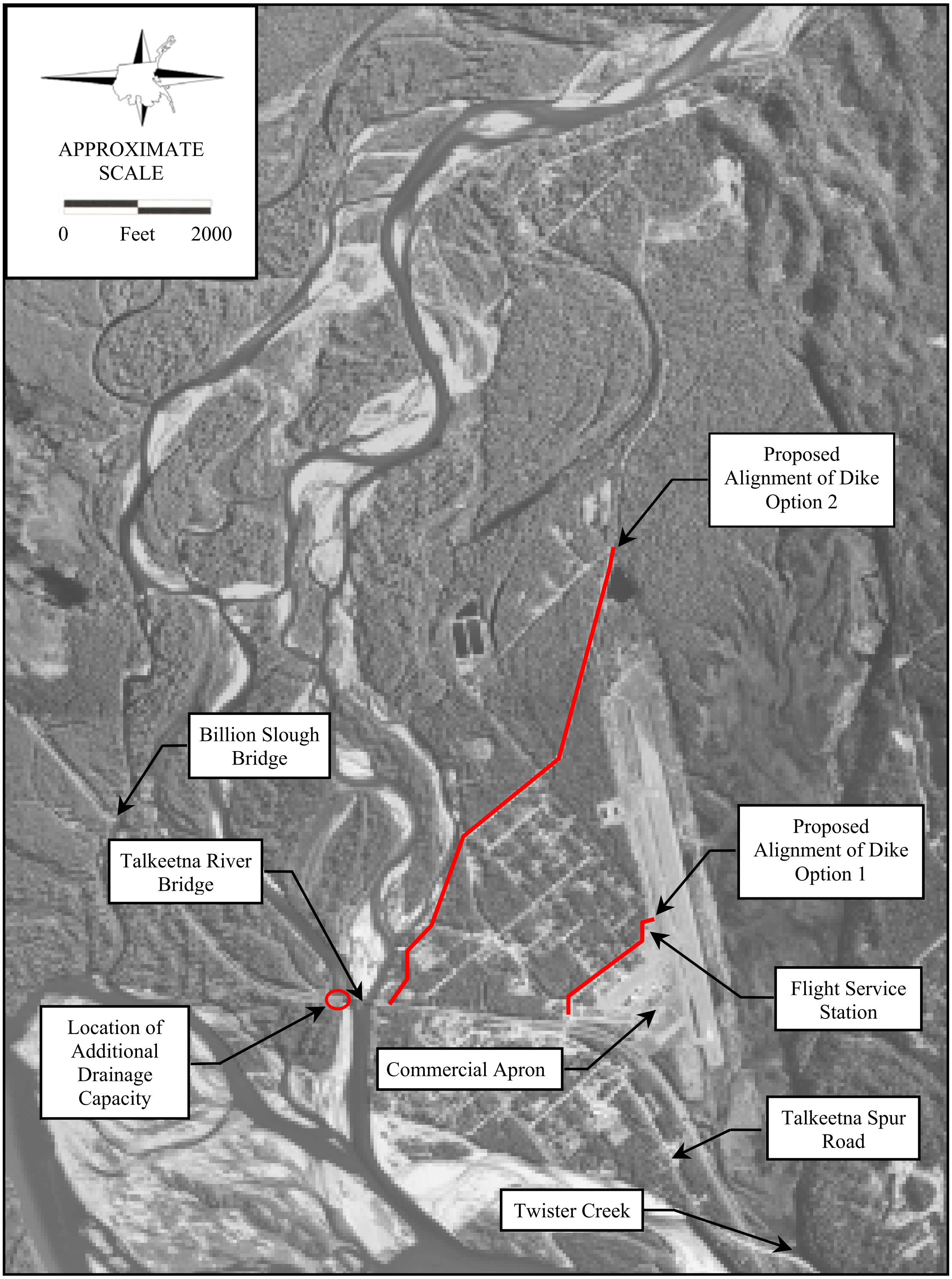
(2) If the new helicopter-landing area is not constructed at the southeast end of the runway, the new commercial apron must be constructed high enough to prevent inundation from Twister Creek. It must also be tied into the railroad and runway embankments.

(3) If raising the new commercial apron is not desirable, a dike could be constructed on the south side of the commercial apron. The total length of the dike would be about 900 feet and would require about 6,000 cubic yards of embankment material. It has been assumed that the eastern end of the dike would tie into the southwest end of the runway, which has an elevation that is only about 1.2 feet above the 100-year flood-peak water-surface elevation. It is likely that vegetation can be used to protect the dike from erosion.

6.1.3.1.1 Dike Option 1

Dike Option 1 involves raising 2nd Avenue between its intersection with the railroad embankment and the maintenance access road that connects the commercial apron and the ADOT&PF Maintenance Facility (Figure 6.1.2). If the dike were to wrap around the upstream side of the Flight Service Station, this dike would protect both the commercial apron and the Flight Service Station. The total length of the dike would be on the order of 2,000 feet. It is likely that vegetation can be used to protect the dike from erosion.

Figure 6.1.2: Dike Options 1 and 2 and Increased Capacity at the Talkeetna River Bridge



If this option is selected, there are several issues that should be addressed in addition to those associated with backwater from Twister Creek and the need for increased drainage capacity at the Talkeetna River Bridge.

(1) At the western end of the dike, the railroad is only about 1.4 feet above the peak water-surface elevation of the 100-year flood. If the dike is constructed to the height of the railroad embankment, it will only have 1.4 feet of freeboard. This is less than the original criterion of 3 feet, but is probably acceptable at this location.

(2) At the eastern end of the dike, the maintenance access road is only about 0.1 feet above the peak water-surface elevation of the 100-year flood. If the eastern end of the dike is constructed to the height of the maintenance access road, there will only be 0.1 foot of freeboard. This is not sufficient. Water might flow around the end of the dike and inundate the commercial apron and Flight Service Station. One option is to tie the dike to the runway. If this is done, there will be a high spot in the maintenance access road where the dike crosses. Additionally, provision will have to be made for the water in the drainage ditch adjacent to the runway. Another option is to raise 200 to 800 feet of the maintenance access road to obtain 1 to 3 feet (respectively) of freeboard at the eastern end of the dike.

(3) The impact of the road grade changes and the dike on local drainage, particularly around the Flight Service Station, should be considered in order to prevent excessive blockage of local drainage due to the disruption of existing drainage patterns.

(4) Provision should be made for local drainage on the commercial apron, possibly incorporating the use of culverts with flap gates.

(5) Approximately 2,350 cubic feet per second (cfs) of water will still flow over the Alaska Railroad and Talkeetna Spur Road embankments near Twister Creek during a 100-year flood on the Talkeetna River. A preliminary analysis of the size of the drainage structure(s) likely to be required to prevent overtopping at the Talkeetna Spur Road is presented in Appendix H.

6.1.3.1.2 Dike Option 2

Dike Option 2 follows the left bank of the Talkeetna River from the railroad embankment to Beaver Street, and along Beaver Street to the proposed entrance to the helicopter-landing facility at the northeast end of the runway (Figure 6.1.2). Beaver Street would be raised along its' entire length. This dike would protect the airport property north of the runway and a significant portion of East Talkeetna from inundation during the 100-year flood. The total length of the dike would be on the order of 7,200 feet.

If this option is selected, there are several issues that should be addressed in addition to those associated with backwater from Twister Creek and the need for increased drainage capacity at the Talkeetna River Bridge.

(1) A portion of the dike may need to be armored. If the section of dike that follows the left bank of the Talkeetna River can be located outside the likely area of encroachment by the river during the life of the project, the amount of armor can be minimized. Those portions of the dike that do not require armor should be vegetated. An assessment of the long-term rate of erosion associated with the left bank of the Talkeetna River in the vicinity of the proposed dike is presented in Appendix G.

(2) The elevation of Beaver Street at the upstream end of the dike is only about 1 foot above the 100-year flood-peak water-surface elevation. If the upstream end of the dike is constructed to the same elevation as Beaver Street, it will only have 1 foot of freeboard. This is less than the original criterion of 3 feet. Thus, there is a possibility that water will overtop Beaver Street at the upstream end of the dike, and flow along local drainage swales between the south side of Beaver Street and the east end of the runway, to inundate areas that are supposed to be protected by the dike. Two alternative means of constructing the upstream end of the dike are proposed to address this possibility.

- If the helicopter-landing area and access road on the northeast end of the runway are constructed, they should be constructed to an elevation that is at least 3 feet above the 100-year flood-peak water-surface elevation, and the dike (i.e. Beaver Street) should be tied into the access road at the same elevation. East of this location, the top of the dike would transition to the existing elevation of Beaver Street.

- If the helicopter-landing area and access road on the northeast end of the runway are not constructed, the dike should end closer to the east end of the runway and the dike should be tied into the runway at an elevation 3 feet above the 100-year flood-peak water-surface elevation. One possible method of constructing the upstream end of the dike is presented in the description of Dike Option 2a.

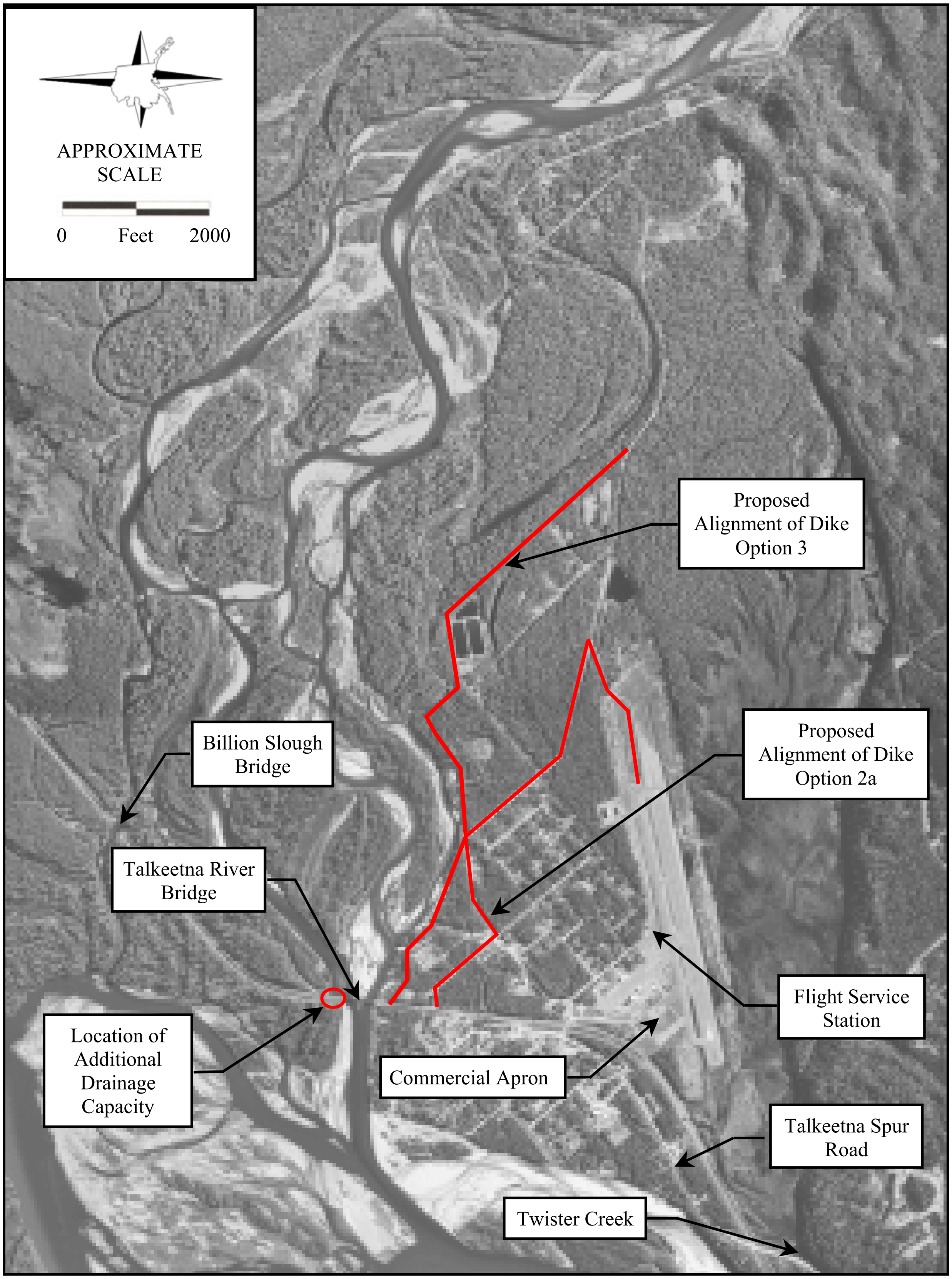
(3) Provision should be made for local drainage on the commercial apron, possibly incorporating the use of culverts with flap gates.

(4) Approximately 2,350 cfs of water will still flow over the Alaska Railroad and Talkeetna Spur Road embankments near Twister Creek during a 100-year flood on the Talkeetna River. A preliminary analysis of the size of the drainage structure(s) likely to be required to prevent overtopping at the Talkeetna Spur Road is presented in Appendix H.

6.1.3.1.3 Dike Option 2a

Dike Option 2a follows an alignment similar to Dike Option 2, but makes more use of existing easements (Figure 6.1.3). Dike Option 2a begins at the existing railroad embankment on the south side of the Talkeetna River Bridge, extends along undeveloped Front Street, and along a portion of F Street and Beaver Road to the old landfill road. The dike would then extend down the existing landfill road and terminate at the runway embankment. Portions of Front Street, F Street and Beaver Road would all be raised to form the dike. This dike would protect the airport property north of the runway and a significant portion of East Talkeetna from inundation during the 100-year flood. The length of the dike would be on the order of 8,500 feet (CH2M HILL, 2003).

Figure 6.1.3: Dike Options 2a and 3 and Increased Capacity at the Talkeetna River Bridge



If this option is selected, there are several issues that should be addressed in addition to those associated with backwater from Twister Creek and the need for increased drainage capacity at the Talkeetna River Bridge.

(1) The portion of the dike near the corner of F Street and Beaver Road will probably need to be armored to protect it from erosion by the river. Those portions of the dike that do not require armor should be vegetated. An assessment of the long-term rate of erosion associated with the left bank of the Talkeetna River in the vicinity of the proposed dike is presented in Appendix G.

(2) If the helicopter-landing area and access road on the northeast end of the runway are constructed, consideration should be given to (1): constructing them to an elevation at least 3 feet above the 100-year flood-peak water-surface elevation, and (2) extending the dike up Beaver Road and tying into the helicopter landing area access road at the same elevation. East of this location, the top of the dike would transition to the existing elevation of Beaver Street.

(3) Provision should be made for local drainage on the commercial apron, possibly incorporating the use of culverts with flap gates.

(4) Approximately 2,350 cfs of water will still flow over the Alaska Railroad and Talkeetna Spur Road embankments near Twister Creek during a 100-year flood on the Talkeetna River. A preliminary analysis of the size of the drainage structure(s) likely to be required to prevent overtopping at the Talkeetna Spur Road is presented in Appendix H.

6.1.3.1.4 Dike Option 3

Dike Option 3 follows the left bank of the Talkeetna River from the railroad embankment to the northwest corner of the sewage treatment lagoons (Figure 6.1.3). From there, the dike runs southeast until it intersects Beaver Street and than west along Beaver Street to the proposed entrance to the helicopter-landing facility at the northeast end of the runway. The dike, a portion of Beaver Street, the helicopter-landing area, and the helicopter-landing area access road would all be constructed to an elevation 3 feet above the 100-year flood-peak water-surface elevation. This dike would protect a few more residences and more land for future development than Dike Option 2. The total length of the dike would be on the order of 11,000 feet.

If this option is selected, there are several issues that should be addressed in addition to those associated with backwater from Twister Creek and the need for increased drainage capacity at the Talkeetna River Bridge.

(1) A portion of the dike may need to be armored. If the section of dike that follows the left bank of the Talkeetna River can be located outside the likely area of encroachment by the river during the life of the project, the amount of armor can be minimized. Those portions of the dike that do not require armor should be vegetated. An assessment of the long-term rate of erosion associated with the left bank of the Talkeetna River in the vicinity of the proposed dike is presented in Appendix G.

(2) If the helicopter-landing area and access road on the northeast end of the runway are not constructed, the upstream end of the dike should continue west along Beaver Street and tied into the northeast end of the runway at an elevation 3 feet above the 100-year flood-peak water-surface elevation.

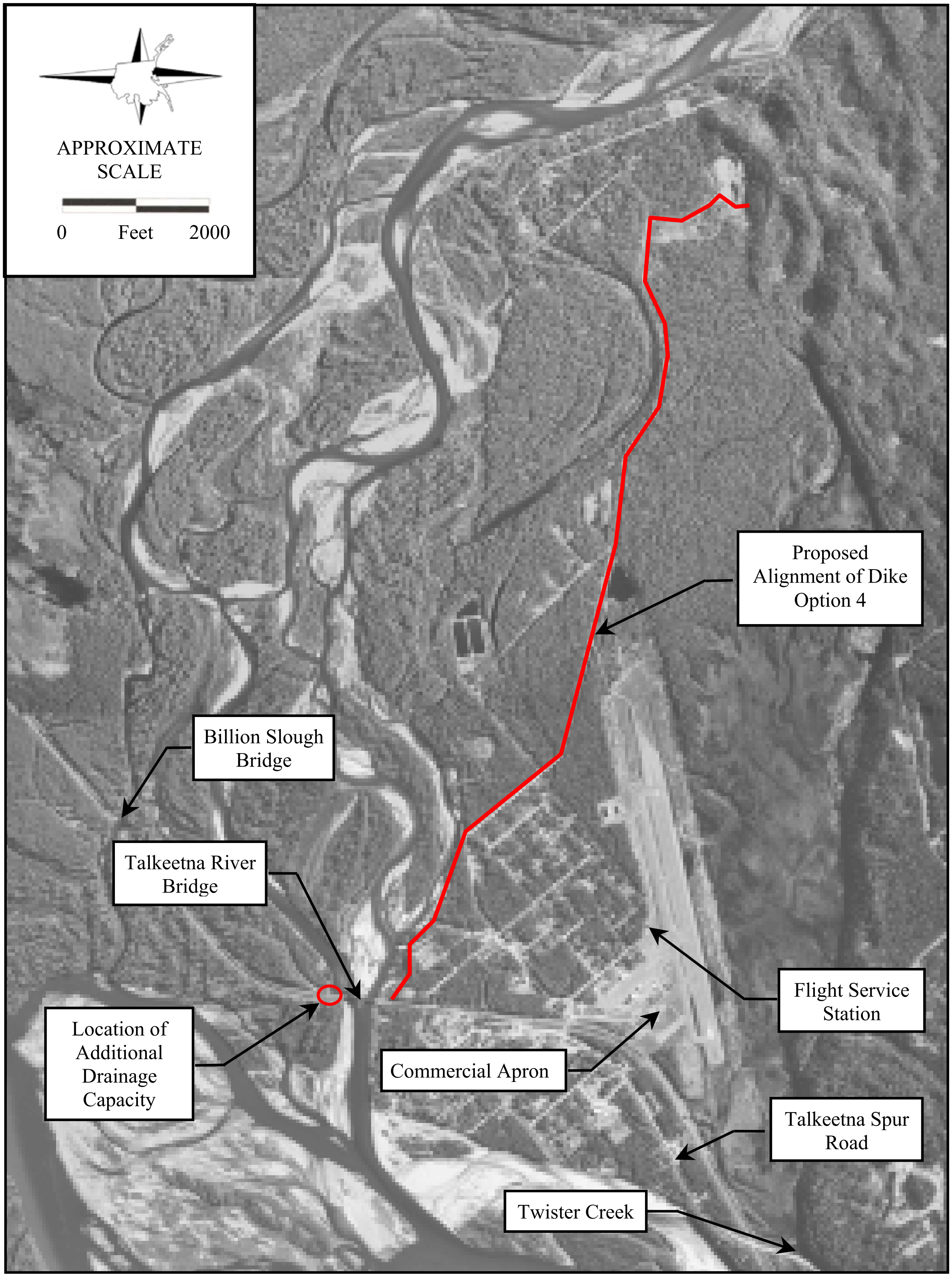
(3) Provision should be made for local drainage on the commercial apron, possibly incorporating the use of culverts with flap gates.

(4) Approximately 2,350 cfs of water will still flow over the Alaska Railroad and Talkeetna Spur Road embankments near Twister Creek during a 100-year flood on the Talkeetna River. A preliminary analysis of the size of the drainage structure(s) likely to be required to prevent overtopping at the Talkeetna Spur Road is presented in Appendix H.

6.1.3.1.5 Dike Option 4

Dike Option 4 follows an alignment similar to Dike Option 2, but Beaver Street would be raised all the way to the intersection with the quarry road (Figure 6.1.4). Additionally, the quarry road would be raised all the way to the bluff located at the south end of the quarry. This alternative protects all of the airport property as well as most of the community of Talkeetna. It prevents Talkeetna River surface water from flowing along the south side of the runway to Twister Creek, and probably eliminates the overtopping of the Alaska Railroad and the Spur Road at Twister Creek, during a 100-year flood on the Talkeetna River. Concern has been expressed that a second means of road access to the community of Talkeetna is needed, and this dike could provide a portion of that road. The total length of the dike would be on the order of 14,000 feet. If this option is selected, the need to armor at least a portion of the dike should be considered. If the section of dike that follows the left bank of the Talkeetna River can be located outside the likely area of encroachment by the river during the life of the project, the amount of armor can be minimized. Those portions of the dike that do not require armor should be vegetated. An assessment of the long-term rate of erosion associated with the left bank of the Talkeetna River in the vicinity of the proposed dike is presented in Appendix G.

Figure 6.1.4: Dike Option 4 and Increased Capacity at the Talkeetna River Bridge



6.1.3.2 Increase Drainage Capacity at the Talkeetna River Bridge

Construction of Dike Options 1, 2 or 3 will prevent floodwater from flowing between the southwest end of the runway and the railroad embankment. This will cause the 100-year flood-peak water-surface elevation on the upstream side of the Talkeetna River Bridge to increase by about 0.7 feet[21]. Construction of Dike Option 4 will eliminate floodwater from flowing on either side of the runway, and will raise the 100-year flood-peak water-surface elevation on the upstream side of the Talkeetna River Bridge by about 1 foot[22]. The magnitude of the additional backwater created by the dikes will be greatest at the bridge and decrease in an upstream direction. To eliminate the impact the dikes will have on water surface elevations, and to comply with the development requirements of the Matanuska-Susitna Borough[23], the drainage capacity of the bridge must be increased. Either an additional section of bridge or culverts could be used to provide the additional capacity. The most cost-effective location for the structure(s) is on the north side of the Talkeetna River Bridge (Figure 6.1.4).

Very preliminary computations suggest that a bridge with a length of about 100 feet would be required to maintain the "existing condition" 100-year flood-peak water-surface elevation on the upstream side of the Talkeetna River Bridge. Similarly, very preliminary computations suggest that approximately 12 ten-foot diameter culverts would be required. One advantage of the culverts is that it might be possible to horizontally bore or jack the culverts under the railroad without disrupting service. A serious disadvantage is the potential for debris to block the culverts. Constructing posts upstream from the culverts to block debris and/or adding additional culverts might be necessary to address this potential problem.

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[21] It was beyond the scope of this analysis to estimate the magnitude of the increase in the water surface elevation resulting from blocking the flow between the airport and the railroad embankments. Thus, this value is an order of magnitude estimate based on the computations conducted for this analysis.

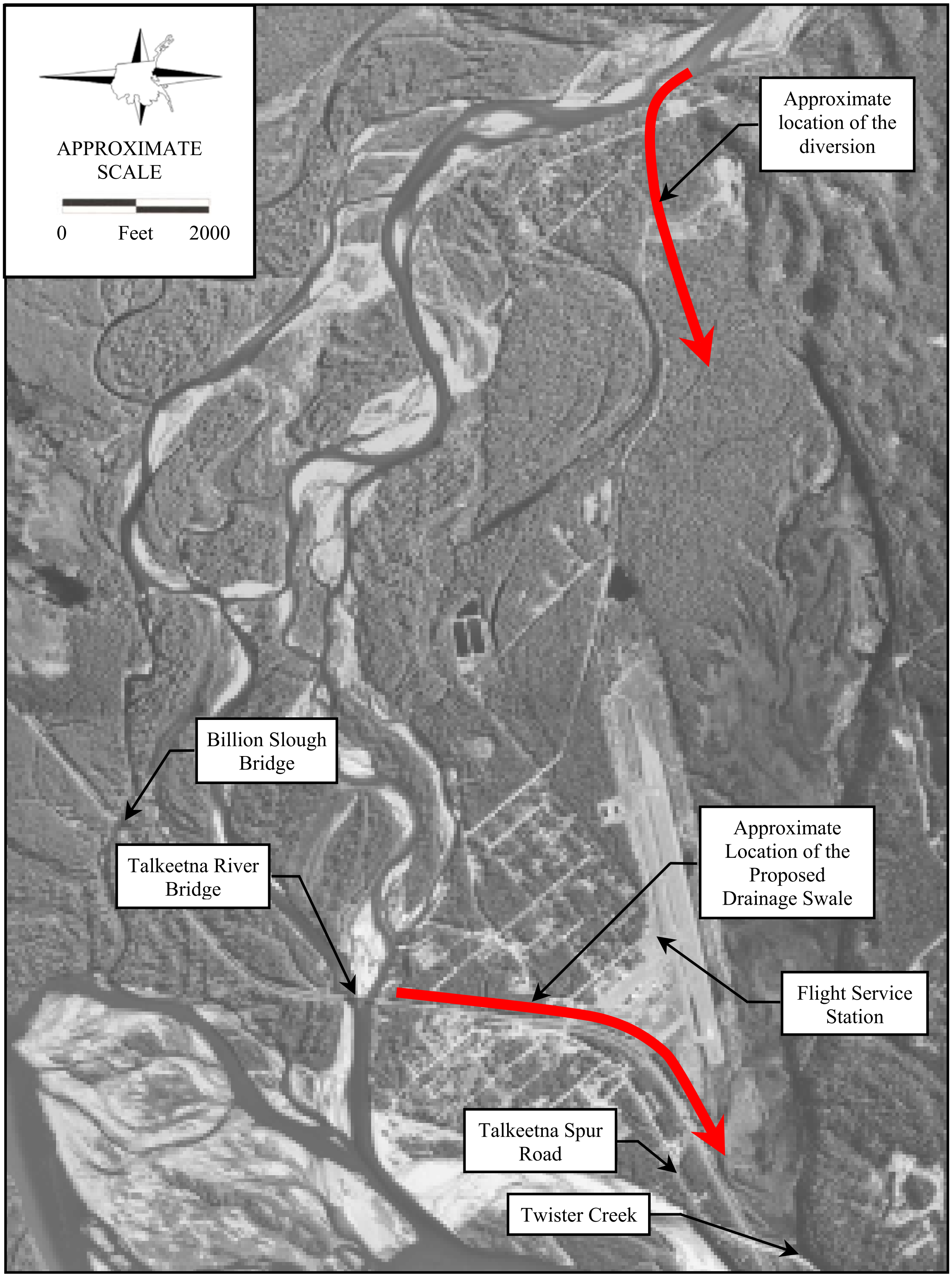
[22] It was beyond the scope of this analysis to estimate the magnitude of the increase in the water surface elevation resulting from blocking the flow between the airport and the railroad embankments. Thus, this value is an order of magnitude estimate based on the computations conducted for this analysis.

[23] It is the practice of the Matanuska-Susitna Borough to enforce Title 17.29.180 for all permitted new construction within the limits of the base flood (Hudson, 2003). Title 17.29.180 requires that no improvements be made within a floodway that will result in any increase in the water surface elevation of the base flood.

6.1.4 Construct Drainage Swale

Construct a drainage swale to pass water from the north side of the airport along the railroad embankment to Twister Creek, and increase the drainage capacity at Twister Creek (Figure 6.1.5). Both the Talkeetna Spur Road and the Alaska Railroad cross Twister Creek. In their present condition, both the Talkeetna Spur Road and the Alaska Railroad will be overtopped during a 100-year flood on the Talkeetna River, even if additional water is not intentionally diverted toward Twister Creek. Because water along the railroad embankment is flowing both west (through the embankment) and south (along the embankment), construction of a drainage swale to lower water surface elevations on the north side of the airport would probably cause more water to flow toward Twister Creek than presently flows toward Twister Creek along the railroad embankment. This will further increase the size of the drainage structures that would be required at the Talkeetna Spur Road and the Alaska Railroad. Because the road and railroad embankments are relatively low, the drainage structures will be relatively inefficient for their size (i.e. requiring a particularly long bridge or a particularly large number of culverts). Additionally, preliminary computations suggest that the drainage swale would have to be on the order of 160 feet wide (Baxter, 2003), and real estate in this area is relatively valuable. Thus, this alternative does not appear to provide the airport a significant advantage over the alternatives that involve constructing a dike and increasing drainage capacity at the Talkeetna River Bridge.

Figure 6.1.5: Drainage Swale & Diversion Alternatives



6.1.5 Divert Flow to Twister Creek

Divert enough water from the Talkeetna River into Twister Creek, to allow the area between the southwest end of the runway and the railroad embankment to be blocked, while maintaining the "existing condition" 100-year flood-peak water-surface elevation at the Talkeetna River Bridge (Figure 6.1.5). As mentioned above, both the Alaska Railroad and the Talkeetna Spur Road cross Twister Creek. In their present condition, both the Talkeetna Spur Road and the Alaska Railroad will be overtopped during a 100-year flood on the Talkeetna River, even if additional water is not intentionally diverted toward Twister Creek.

The location of the diversion, as proposed, would be upstream of the location at which Billion Slough leaves the Talkeetna River main channel. Because water along the railroad embankment flows both west (through the embankment) and south (along the embankment), and the water surface elevation at the Billion Slough Bridge is more than 2 feet higher than the water surface elevation at the Talkeetna River Bridge, maintaining the "existing condition" 100-year flood-peak water-surface elevation at the Talkeetna River Bridge may require diverting significantly more water into Twister Creek than will be blocked by the proposed airport development. This will further increase the size of the drainage structures that would be required at the Talkeetna Spur Road and the Alaska Railroad. Because the road and railroad embankments are relatively low, the drainage structures will be relatively inefficient for their size (i.e. requiring a particularly long bridge or a particularly large number of culverts). The additional water could also require construction of erosion control measures along the south side of the runway. Finally, the construction of large flow diversions has historically been very expensive and has often required a considerable maintenance effort after the initial construction. Thus, this alternative does not appear to provide the airport a significant advantage over the alternatives that involve constructing a dike and increasing drainage capacity at the Talkeetna River Bridge.

6.2 Flood Mitigation Alternatives Selected for Further Analysis

Several possible flood-mitigation alternatives were discussed with the ADOT&PF and FAA. During the discussions it was noted that several of the alternatives might be particularly appealing to the community, but went beyond FAA's responsibility to protect the airport. It was also suggested that a project, which protected more than just the airport, might be undertaken with joint funding from FAA and the community. As a result of the discussions, three alternatives were selected for further analysis.

(1) Develop the Talkeetna Airport according to the 2001 Airport Master Plan (USKH, 2001), but construct Dike Option 1 and add additional drainage capacity at the Talkeetna River Bridge in order to maintain the 100-year water surface elevation at the existing condition elevation.

(2) Develop the Talkeetna Airport according to the 2001 Airport Master Plan (USKH, 2001), but construct Dike Option 2a and add additional drainage capacity at the Talkeetna River Bridge in order to maintain the 100-year water surface elevation at the existing condition elevation.

(3) Avoid additional development in areas likely to be inundated during the 100-year flood.

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APPENDIX A

BACKGROUND DATA

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A.1 INTRODUCTION

A description of the available stage and discharge data, and a summary of the available topographic data are presented in this appendix.

A.2 TALKEETNA RIVER STAGE AND DISCHARGE DATA

A.2.1 NWS Gage

The National Weather Service (NWS) operates a stream gage located on the Alaska Railroad Bridge over the Talkeetna River at Talkeetna. The gage is situated on the downstream side of the bridge, near the left bank. The water surface elevation is noted each day by an observer, from breakup in the spring to freeze up in the fall. Data are available for each year between 1976 and the present, with the exception of 1978. The zero gage height with reference to the NAVD88 datum is 338.94 feet (McClintock Land Associates 2002a).

A.2.2 USGS Gage

The United States Geological Survey (USGS) operates Stream Gage Station Number 15292700 on the Talkeetna River near Talkeetna. The station is located approximately 5 miles upstream from the mouth of the Talkeetna River on the left bank, looking downstream. Annual peak discharge and stage data are available from 1964 through the present, and daily discharge data are available from 1 June 1964 through the present. The zero gage height with reference to the NAVD88 datum is 377.96 feet (McClintock Land Associates 2002a; Meyers 2001).

A.3 SUSITNA RIVER STAGE AND DISCHARGE DATA

Within the Susitna River drainage basin, there are several stream gage stations operated by the USGS that are of particular interest to this project.

A.3.1 Susitna River at Gold Creek

Stream Gage Station Number 15292000 is located on the left bank of the Susitna River, approximately 0.1 mile downstream from Gold Creek. Annual peak discharge data are available from 1950 through 1996. Daily discharge data are available from 1 August 1949 through 30 September 1996.

A.3.2 Chulitna River near Talkeetna

Stream Gage Station Number 15292400 is located on the right bank of the Chulitna River, approximately 18 miles upstream from its mouth. Annual peak discharge data are available for: 1957 through 1962, 1965 through 1977, and 1979 through 1987. Daily discharge data are available for: 1 February 1958 through 30 September 1972, and 1 May 1980 through 31 July 1986.

A.3.3 Skwentna River near Skwentna

Stream Gage Station Number 15294300 is located on the right bank of the Skwentna River, approximately 13 miles upstream from its mouth. Annual peak discharge data are available for: 1960 through 1982, and 1987. Daily discharge data are available from 1 October 1959 through 30 September 1982.

A.3.4 Susitna River at Susitna Station

Stream Gage Station Number 15294350 is located on the left bank of the Susitna River, approximately 1.5 miles downstream from the Yentna River. Annual peak discharge data are available from 1975 through 1992. Daily discharge data are available from 1 October 1974 through 31 March 1993.

A.3.5 Susitna River near Cantwell

Stream Gage Station Number 15291500 is located on the left bank of the Susitna River, approximately 9.7 miles downstream from the Oshetna River. Annual peak discharge data are available for: 1961 through 1972, and 1980 through 1985. Daily discharge data are available for: 1 May 1961 through 30 September 1972, and 29 May 1980 through 31 July 1986.

A.3.6 Susitna River near Denali

Stream Gage Station Number 15291000 is located on the upstream right pier of the Denali Highway bridge, approximately 0.2 miles downstream from Windy Creek. Annual peak discharge data are available for: 1957 through 1965, 1967, and 1969 through 1985. Daily discharge data are available for 30 May 1957 through 30 September 1966, and 1 July 1968 through 31 July 1986.

A.4 SURVEY DATA

A.4.1 Topographic Data

McClintock Land Associates collected aerial photography in May 2001 and used it to develop a topographic map for the area surrounding the community of Talkeetna. The mapping includes the area between the mouth of the Talkeetna River, Billion Slough, the Talkeetna River at the USGS stream gage, and Twister Creek. In general, the mapping ends at the left bank (looking downstream) of the Susitna River and does not extend into the active channel. The surface data points picked from the aerial photography to create the contour map were collected at a maximum 60-foot grid interval, and the map was prepared to National Map Accuracy for a 2-foot contour interval in visible, unobstructed areas (McClintock Land Associates 2002). The elevations of the surface data points in the mapped area have an accuracy of +/- 1 foot (McClintock 2002).

McClintock Land Associates also picked surface data points in the Susitna River floodplain from the aerial photography, in the region that lay outside the area for which the contour map was developed. The elevations of the surface data points in the Susitna River floodplain have an accuracy of +/- 2 feet (McClintock 2002). The approximate coverage areas of the surface data points are presented in Figure A.1.

The photography, topographic mapping and surface data points were tied to the Alaska State Plane NAD83 coordinate system and the NAVD88 elevation datum. The horizontal coordinates are based on a found steel rod (FSR) point 606, located near the Talkeetna Federal Aviation Administration (FAA) Airport. The monument was “Station G-38”, an Alaska Department of Transportation and Public Facilities (ADOT & PF) Global Positioning System (GPS) control point. An NAD83 (92) State Plane Zone 4 position of N: 3040382.965 (feet), E: 1622644.343 (feet) was computed for this monument from local SV-2 coordinate system values, and translation parameters, obtained from ADOT & PF. The vertical datum is based on National Geodetic Survey control monument “B 109” with a reported NAVD88 elevation of 107.891 meters (353.97 feet). This monument was surveyed to establish a NAVD88 elevation for “Station G-38” through the use of differential leveling (McClintock Land Associates 2002a).

A.4.2 Other Survey Data

Survey data related specifically to the hydraulic analysis were collected in the fall of 2001 and spring of 2002 using a Topcon RTK GPS system (McClintock 2002). The reported accuracy of the elevations is +/- 0.1 feet. The data were tied to the NAVD88 elevation datum and the Alaska State Plane NAD83 horizontal datum. The data collected include the following.

1) The location and size of selected drainage structures in the floodplain (Figure A.2, Table A.1).
2) Four cross-sections of the Susitna River near the mouth of the Talkeetna River.
3) Cross sections below the water surface at selected locations on the Talkeetna River.
4) Geometric data at the Talkeetna River and Billion Slough railroad bridge openings.
5) Simultaneous water surface elevations at the Talkeetna River and Billion Slough railroad bridges.
6) High water mark elevations associated with the 1986 flood as identified by local residents at the time of the survey (Figure 2.4.1, Table 2.4.1).
7) Datum corrections for the water surface elevations measured at the NWS and USGS stream gage stations.

The approximate locations of the surveyed cross sections are presented in Figure A.1

Figure A.1: Survey Data Location Map

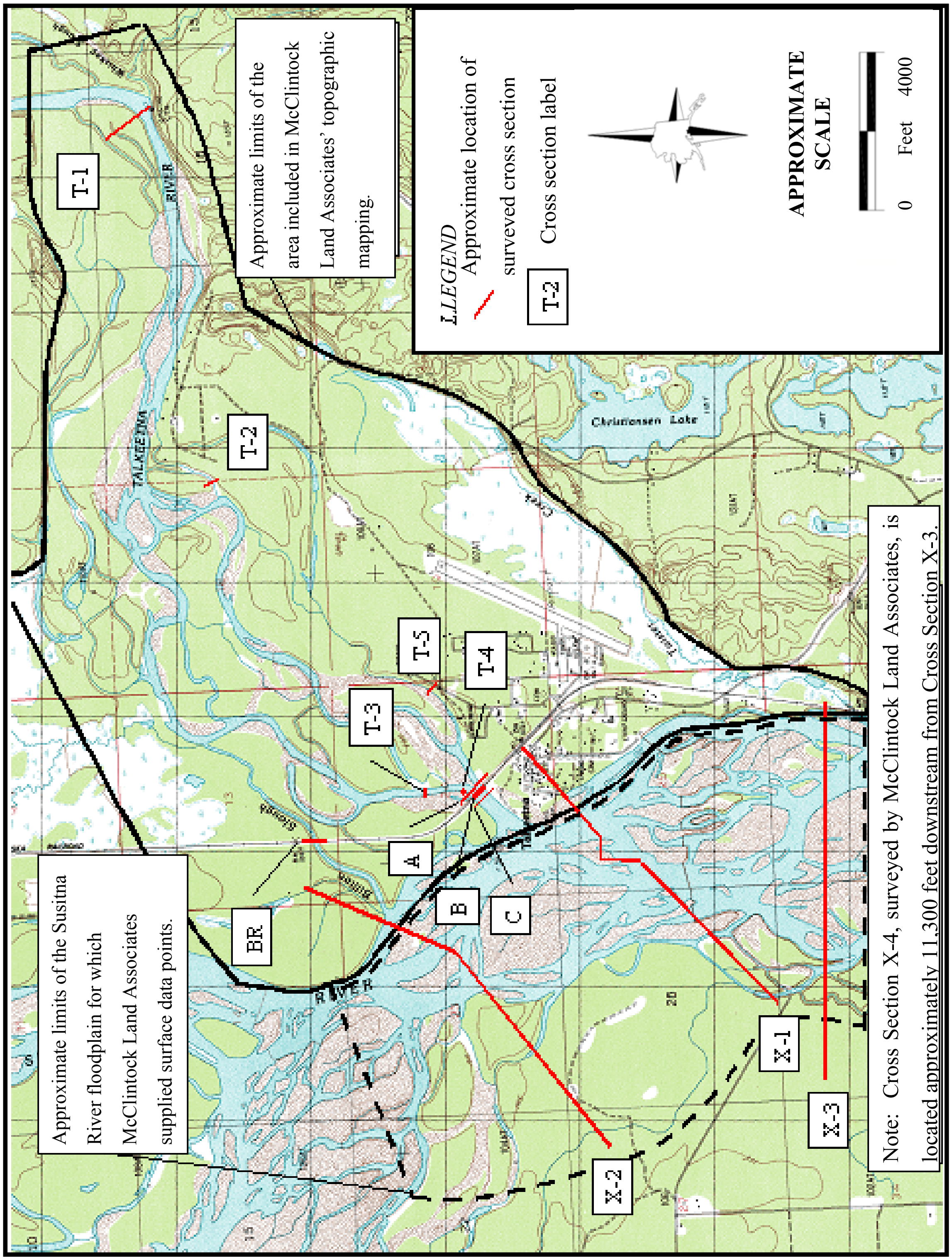

Figure A.2: Talkeetna River Floodplain Culvert Locations

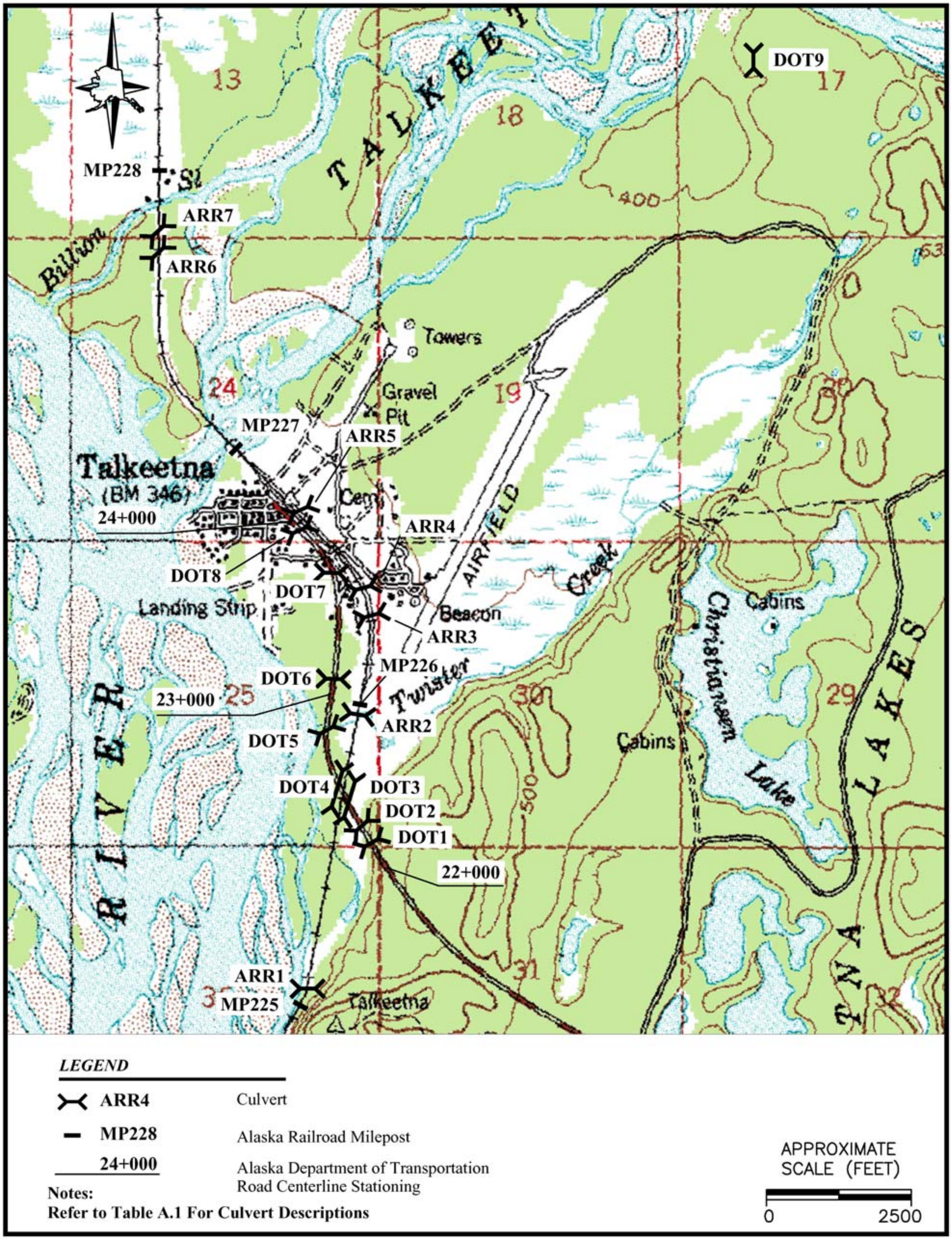

Table A.1: Talkeetna River Floodplain Drainage Structures

Structure Number	Station [2]	Diameter (inch)	Material	Length (feet)	Location
ARR1	225.1	60	CMP	84	Twister Creek Railroad Crossing
ARR2	225.9	36	CMP	32	Railroad Crossing
ARR3	226.3	36	CMP	-	Railroad Crossing
ARR4	226.4	36	RCP	-	Railroad Crossing
ARR5	226.7	36	CMP	100	Railroad Crossing
ARR6	-	60	CMP	20	Railroad Trail Crossing
ARR7	227.8	2 - 60	CMP	68 & 72	Railroad Crossing, 2 Culverts
DOT1	22+190	36	CMP	84	Twister Creek Spur Road Crossing
DOT2	22+290	36	CMP	107	Twister Creek Spur Road Crossing
DOT3	22+440	36	CMP	32	Twister Creek Spur Road Crossing
DOT4 [1]	22+460	36	CMP	139	Spur Road Crossing
DOT5 [1]	22+810	36	CMP	60	Spur Road Crossing
DOT6 [1]	23+110	36	CMP	74	Spur Road Crossing
DOT7 [1]	23+670	36	CMP	81	Spur Road Crossing
DOT8	23+950	36	CMP	74	Spur Road Crossing
DOT9	-	2 - 36	CMP	-	Road Crossing, 2 Culverts

Notes:

1. These culverts were identified from Alaska Department of Transportation as-built drawings.
2. The stationing associated with structures on the Alaska Railroad is in miles, measured along the railroad centerline. The stationing associated with structures along the highway is in feet, measured along the highway centerline.
3. Corrugated Metal Pipe is abbreviated CMP.
4. Reinforced concrete pipe is abbreviated RCP.

APPENDIX B

FLOOD-FREQUENCY ANALYSIS

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B.1 INTRODUCTION

The purpose of this flood-frequency analysis was to estimate the magnitude and frequency of flood events in: 1) the Talkeetna River at its mouth, 2) the Susitna River immediately above the Talkeetna River and 3) the Susitna River immediately below the Talkeetna River. Due to varying conditions and data availability, a slightly different type of analysis was used for each location.

To estimate the magnitude and frequency of floods on the Susitna River immediately above and below the Talkeetna River, two different methods were used. The first method involved the use of regional regression equations developed specifically for this project. The second method involved the extrapolation of discharge data collected on the Chulitna, Susitna and Talkeetna Rivers to the point of interest. The maximum annual discharge was then computed, and a single-station flood-frequency relationship developed. The methods and results of each of the analyses are discussed, and the estimates that are most likely to be representative of the actual conditions are identified.

To estimate the magnitude and frequency of floods on the Talkeetna River at its mouth, a single-station flood-frequency analysis was performed with maximum annual discharge data collected on the Talkeetna River near Talkeetna. The flood magnitude and frequency relationship was then extrapolated to the mouth of the Talkeetna River based on the difference in drainage area.

The locations of the stream gage stations used in these analyses are shown on Figure B-1.

B.2 SINGLE-STATION PROCEDURES

Single-station flood-frequency analyses were performed using annual peak discharge data collected by the U.S. Geological Survey (USGS) at selected stream gage stations in the Susitna River watershed. The analyses were based on the methods developed by the Interagency Advisory Committee On Water Data (1982), and performed using the U.S. Army Corps of Engineers' Flood Frequency Program HEC-FFA. A weighted skew, based on the station skew and a regional skew, was used in the computations. The magnitude of the regional skew (0.55) and the standard error of the regional skew (0.74) were obtained from Jones and Fahl (1994). The discharge associated with both the base curve and the expected probability were computed.

When the record length is relatively short, the base curve tends to underestimate the average exceedance probability associated with a specified discharge (Beard, 1974). Thus, the expected probability values, which have been shown to produce an unbiased estimate of the average exceedance probability (Beard, 1974), were used in this analysis. A brief explanation of expected probability is presented in Appendix C.

B.3 REGRESSION PROCEDURES

A separate regression equation was developed to predict the magnitude of the flood-peak discharge associated with each of the following average return periods: 2-, 5-, 10-, 25-, 50-, 100-, 200- and 500-year. The equations were developed from the results of the single-station flood-frequency analyses and the associated drainage basin characteristics, using the Minitab Statistical Software (Minitab Inc., Release 12). Each regression equation was developed using the following procedures.

Initially, a stepwise regression analysis was used to identify the most significant drainage basin characteristic[1] in predicting flood-peak discharge. A correlation analysis was then used to determine if a significant correlation existed between the main predictor and any of the other drainage basin characteristics. Drainage basin characteristics with a correlation coefficient equal to or greater than 0.8 and/or significance levels (P-values) above 0.05 were removed from further consideration. Using only those characteristics thus determined to be un-correlated with the main predictor, a best subset regression analysis was conducted to determine the combination of variables that produced an equation with the lowest mean square error. Because the number of predictor variables should not exceed 25-35% of the number of observations (Haan, 1977), only 1 and 2-variable equations were considered. Variables other than the main predictor were only selected if they were shown to significantly reduce the error of the estimate.

Using the drainage basin variables that were selected based on the analyses described above; a weighted regression analysis was used to develop the final regression equations. A weighted regression analysis, using record length as the weight variable, was used because the record length of the stream gage stations varies substantially, and the record length can significantly affect the expected probability estimate. Thus, regression equations of the form:

[1] Subsequently referred to as the main predictor.

$$Q_T = a(A)^x *(B)^y$$

were developed to predict the T-year discharge on drainage basins within the Susitna River watershed.

B.4 SUSITNA RIVER ABOVE AND BELOW THE TALKEETNA RIVER

B.4.1 Regression Analysis

Maximum annual instantaneous flood-peak discharge data (Table B.1) from the following USGS stream gage stations were used in this analysis: Chulitna River near Talkeetna, Skwentna River near Skwentna, Susitna River at Gold Creek, Susitna River at Susitna Station, Susitna River near Cantwell, Susitna River near Denali, and the Talkeetna River near Talkeetna. Initially, a single-station flood-frequency analysis was developed for each stream gage station (Tables and Figures B.2 through B.8). The results of the single-station flood-frequency analyses (Table B.9) were then used in combination with the drainage basin characteristics (Table B.10) to develop the regression equations.

A separate regression equation was developed to predict the magnitude of the flood-peak discharge associated with each of the following average return periods: 2-, 5-, 10-, 25-, 50-, 100-, 200- and 500-year (Tables B.11 through B.18). Based on the methods described in Section B.3, drainage basin area and mean annual precipitation were selected as the predictor variables in the 2-year discharge equation. Drainage basin area was selected as the predictor for each of the remaining discharge equations. A summary of the regression equations and the predicted discharges are presented in the following table.

Return Period (T, yrs) [1]	Regression Equation [2],[3]	R^2 Adjusted [4]	Susitna River above Talkeetna River (Q_T, cfs)	Difference Between 95 and 5 Percent Confidence Intervals (cfs) [5]	Susitna River below Talkeetna River (Q_T, cfs)	Difference Between 95 and 5 Percent Confidence Intervals (cfs) [5]
2	$Q_2 = 0.75(DA)^{0.861}(MAP)^{1.06}$	94.4%	86,000	50,000	102,000	68,000
5	$Q_5 = 224\ (DA)^{0.665}$	85.6%	95,000	71,000	109,000	93,000
10	$Q_{10} = 302(DA)^{0.647}$	85.7%	110,000	80,000	125,000	104,000
25	$Q_{25} = 457(DA)^{0.621}$	84.6%	131,000	96,000	148,000	123,000
50	$Q_{50} = 617(DA)^{0.601}$	82.9%	148,000	111,000	167,000	142,000
100	$Q_{100} = 851(DA)^{0.579}$	80.8%	167,000	129,000	187,900	165,000
200	$Q_{200} = 1202(DA)^{0.555}$	77.4%	188,000	154,000	210,000	195,000
500	$Q_{500} =1862(DA)^{0.523}$	72.5%	229,000	202,000	257,000	257,000

Notes:

1. Q_T denotes T-year discharge in cfs.
2. DA denotes drainage area of the basin in square miles. The drainage area of the Susitna River above Talkeetna River is 8,980 square miles. The drainage area of the Susitna River below Talkeetna is 10,996 square miles.
3. MAP denotes mean annual precipitation in the drainage basin based on Plate 2 in Jones and Fahl (1994). The mean annual precipitation associated with the Susitna River drainage basin above the Talkeetna River is 37 inches.
4. R^2 adjusted, also called the adjusted coefficient of determination, is defined as the proportion of variability in the Y variable accounted for by the predictors, adjusted for degrees of freedom.
5. The difference between the 95 and 5 percent confidence intervals is a measure of the potential error associated with the regression equation. Use of this parameter allows a direct comparison to be made between the error associated with these estimates and the error associated with the estimates produced by the single-station equations.

B.4.2 Single-Station Analysis

Single-station flood-frequency analyses were also conducted to predict the flood-peak discharge on the Susitna River immediately above and below the Talkeetna River. Stream gage data are not available for the Susitna River at either location. However, by extrapolating and then combining the data from the nearest upstream stream gage stations, it was possible to estimate the maximum annual instantaneous peak discharge[2].

For each year of record, the following method was used to determine the maximum annual instantaneous peak discharge on the Susitna River immediately below the Talkeetna River. First, the concurrent period of record at the three nearest upstream stream gage stations (Susitna River at Gold Creek, Chulitna River near Talkeetna, and Talkeetna River near Talkeetna) was identified. Second, the discharge recorded on the Susitna River at Gold Creek was extrapolated to the confluence of the Susitna and Talkeetna Rivers. To make the extrapolation, the discharge on the Susitna River at Gold Creek was multiplied by a coefficient. The coefficient (1.029) was calculated as the ratio of the drainage area of the Susitna River above the confluence with the Talkeetna River (6,340 square miles) divided by the drainage area above the stream gage on the Susitna River at Gold Creek (6,160 square miles). This step was repeated to extrapolate the discharge measured at the Chulitna[3] and Talkeetna[4] River stream gage stations to the mouth of the Chulitna and Talkeetna Rivers, respectively. Both mean daily discharges and maximum annual instantaneous peak discharges were extrapolated in this manner[5].

Next, for each date on which the maximum annual instantaneous peak discharge occurred on the Susitna River above the confluence, the mean daily discharge on the other two rivers was identified, and the three values summed to provide an estimate of the peak discharge in the Susitna River below the Talkeetna. This was repeated for each concurrent year of record. In the same way, two more estimates were calculated using the instantaneous peaks from the Chulitna

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[2] Data from a stream gage station located downstream from the Talkeetna River/Susitna River confluence were not used for one of two reasons: the record length was too short (Sunshine), or the stream gage was located too far from the confluence to be useful (Susitna Station).

[3] The drainage area of the Chulitna River at its mouth and at the stream gage station is 2640 and 2570 square miles, respectively. The coefficient used with the Chulitna River data was 1.028.

[4] The drainage area of the Talkeetna River at its mouth and at the stream gage station is 2016 and 1996 square miles, respectively. The coefficient used with the Talkeetna River data was 1.01.

[5] This method of extrapolation assumes a constant discharge per unit of drainage area. It is an acceptable means of extrapolating the stream gage data because the extrapolated discharge values represent drainage areas that are only slightly larger (less than 3 percent) than the drainage areas at the stream gage sites.

and Talkeetna Rivers. For each year of the concurrent record, the largest of the three estimates was then chosen as the best estimate of the maximum annual instantaneous peak discharge.

As a check of the estimate produced by the method described above, the mean daily discharge on each of the three rivers, for each day of record, were summed. The largest value for each year was then compared to the value provided by the method described above. In one case, 1965, the sum of the mean daily discharges produced the larger estimate. Therefore, the 1965 peak discharge value used in the single-station analyses is the sum of the mean daily discharge on the three rivers.

The data used in the single-station analysis are presented in Table B.19. The detailed results of the analysis are presented in Table B.20 and Figure B.9.

Using a similar method, the maximum annual instantaneous peak discharges in the Susitna River immediately above the Talkeetna River were computed, and a single-station flood-frequency analysis was conducted. The data used in the analysis are presented in Table B.21, and the detailed results of the analysis are presented in Table B.22 and Figure B.10. The flood-frequency relationships for the Susitna River above and below the Talkeetna River are presented in the following table.

Return Period (T, yrs)	Susitna River above Talkeetna River (Q_T , cfs)	Difference Between 95 and 5 Percent Confidence Intervals (cfs) [1]	Susitna River below Talkeetna River (Q_T, cfs)	Difference Between 95 and 5 Percent Confidence Intervals (cfs) [1]
2	87,900	18,000	110,000	33,000
5	112,000	27,000	149,000	54,000
10	129,000	37,000	177,000	74,000
25	153,000	54,000	217,000	111,000
50	172,000	67,000	251,000	141,000
100	193,000	81,000	289,000	173,000
200	216,000	99,000	333,000	213,000
500	252,000	123,000	402,000	269,000

Notes:

1. The difference between the 95 and 5 percent confidence intervals is a measure of the potential error associated with the single-station estimates. Use of this parameter allows a direct comparison to be made between the error associated with these estimates and the error associated with the estimates produced by the regression equations.

B.4.3 Summary

Two approaches were used to estimate flood-peak discharge on the Susitna River immediately above and below the Talkeetna River. The two approaches yield somewhat different results for the Susitna River above the Talkeetna River and substantially different results for the Susitna River below the Talkeetna River.

The regression approach is a standard method of estimating flood-peak discharge on ungaged streams, and the method initially proposed for this project. However, where it is possible to use a single-station frequency analysis, such an analysis is generally considered to be more reliable than a regression approach, since it uses data specific to the site on which the flood-peak information is required. The data used in the single-station frequency analyses conducted for the Susitna River immediately upstream and downstream of the Talkeetna River were computed from nearby stream gages and not collected at the sites. Nevertheless, the values are very reasonable estimates of the flood peaks in the years when concurrent records are available on all three streams.

The difference between the 95 and 5 percent confidence intervals can be used as a measure of the potential error associated with estimates based on differing approaches. A comparison of the differences associated with the regression and single-station approaches indicates that in general the estimates associated with the single-station approach are likely to have less error associated with them. The only exceptions are the estimates of the 100-, 200- and 500-year flood-peak discharge on the Susitna River immediately below Talkeetna. With regard to the 100-year flood-peak discharge estimates, the difference in potential error is probably not significant and thus, the estimate based on the single-station approach is statistically as good as the estimate developed with the regression equations.

Another reason the single-station results may be more reliable than the regression results is that the flood-peak estimates are required at the confluence of two large drainage areas. The size and response time of the drainages is different. The single-station analysis addressed those differences by using data specific to the sites for which the flood-peak estimates are required. With the regression approach, the flood-peak estimate is based on the drainage area alone. There is no means of addressing the difference in flood timing between the two branches. This is probably the reason the estimates for the Susitna River below the Talkeetna River vary more between the two approaches than do the estimates for the Susitna River above the Talkeetna River. Thus, it is our opinion that the results of the single-station flood-frequency analyses are more likely to reflect the actual magnitude and frequency of flood-peak discharges than are the estimates based on the regression analysis.

B.5 TALKEETNA RIVER AT ITS MOUTH

A single-station flood-frequency analysis was performed using the maximum annual instantaneous peak discharge data from the USGS stream gage station on the Talkeetna River near Talkeetna (Tables B.1, B.8, B.9 and Figure B.8). The results of the analysis were then extrapolated to the mouth of the Talkeetna River by multiplying the discharge associated with each return period by a coefficient. The coefficient (1.01) was calculated as the ratio of the drainage area above the mouth of the Talkeetna River (2016 square miles) divided by the drainage area above the stream gage on the Talkeetna River (1996 square miles)[6]. The results of the analysis are summarized in the following table.

Return Period (yrs)	Talkeetna River near Talkeetna [1] (cfs)	Talkeetna River at its Mouth [2] (cfs)
2	25,400	25,700
5	36,500	36,900
10	45,800	46,300
25	60,300	60,900
50	73,500	74,200
100	89,300	90,200
200	108,000	109,000
500	140,000	141,000

Notes:
1. Discharge estimates based on the single-station flood-frequency analysis.
2. Discharge estimates based on the extrapolation.

[6] This method of extrapolation assumes a constant discharge per unit of drainage area. It is an acceptable means of extrapolating the stream gage data because the extrapolated discharge value represents a drainage area that is only slightly larger (less than 2 percent) than the drainage area at the stream gage site.

Figure B.1: Location Of USGS Stream Gage Stations

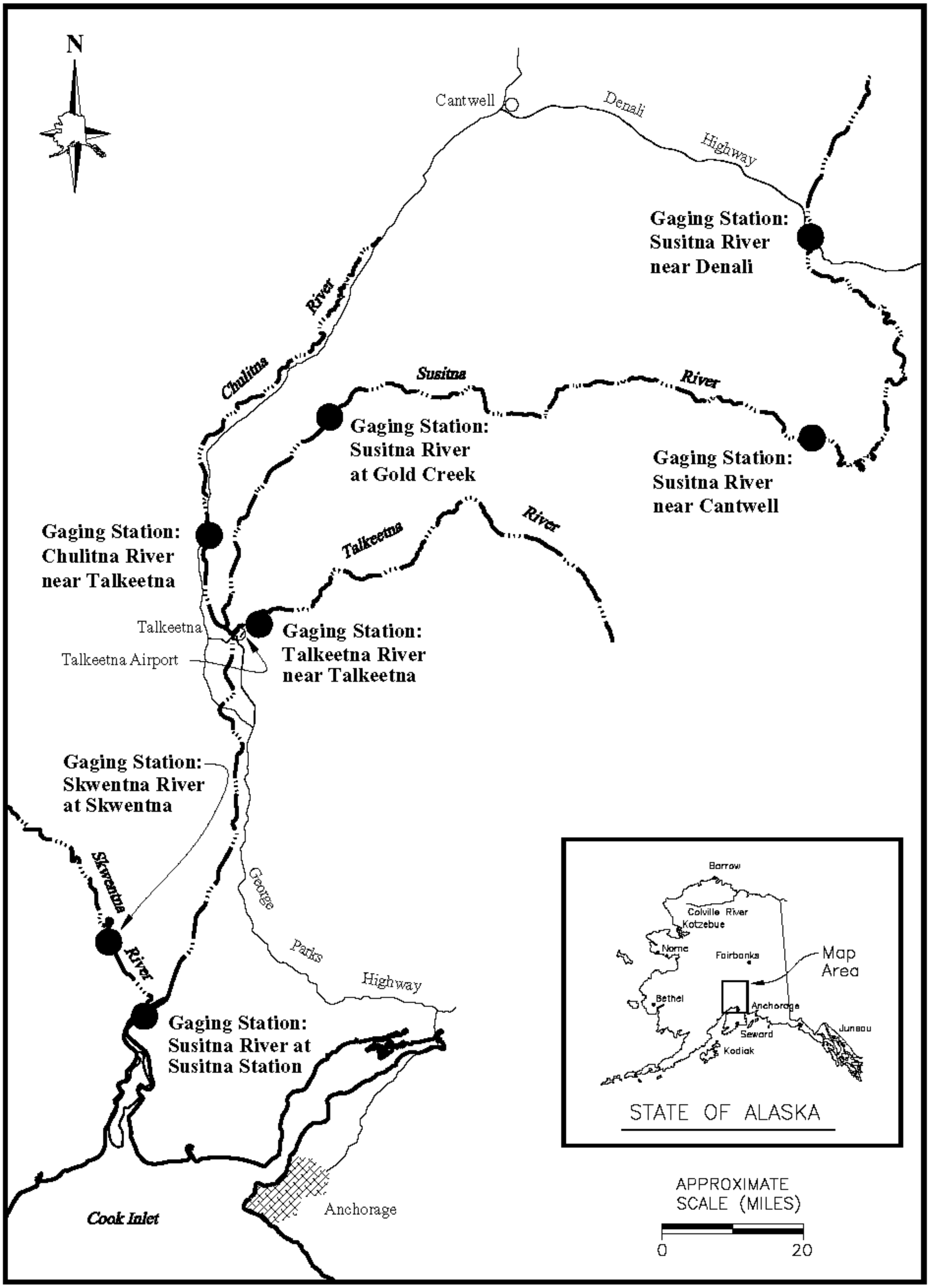

Table B.1: Summary Of Annual Peak Discharge Data For Selected USGS Stream Gages

Annual Instantaneous Peak Discharge (cfs) [1],[10]							
Year	Chulitna River near Talkeetna (DA = 2,570 mi^2)	Skwentna River near Skwentna (DA = 2,250 mi^2)	Susitna River at Gold Creek (DA = 6,160 mi^2)	Susitna River at Susitna Station (DA = 19,400 mi^2)	Susitna River near Cantwell (DA = 4,140mi^2)	Susitna River near Denali (DA = 950 mi^2)	Talkeetna River near Talkeetna (DA = 1,996 mi^2)
1950			35,600 [5]				
1951			37,400				
1952			44,700				
1953			38,400				
1954			42,400				
1955			58,100				
1956			51,700				
1957			42,200			18,700	
1958	35,100		49,600			14,500	
1959	38,800		62,300			14,800	
1960	38,000	33,200	41,900			12,900	
1961	41,100	36,800	54,000		30,400	15,500	
1962	39,600	3,0900 [6]	80,600		46,800	15,500	
1963		33,100 [6]	51,300 [5]		32,500 [3]	17,000	
1964		38,300	90,700		51,200	17,500 [4]	33,200
1965	42,100	32,600	43,600		26,400 [3]	15,800	25,900
1966	38,600	42,400	63,600		27,400 [3]		28,600
1967	75,900	31,000	80,200		38,800	28,200	59,400
1968	40,200	30,400	41,800		25,400 [3]		25,000
1969	28,400	31,600	28,400		19,300	14,900	16,800
1970	36,400	30,100	33,400		20,500	14,100	23,400
1971	50,800	50,000	87,400		55,000	38,200	67,400
1972	34,700	29,400	82,600		44,700	17,200	36,500
1973	36,700	27,800	54,100			14,100	30,200
1974	32,200	20,800	37,200			16,800	24,500
1975	36,700	33,200	47,300	173,000		21,700	22,200
1976	38,000	24,200	35,700	147,000		22,100	20,700
1977	33,400	51,600	54,300	197,000		16,500	30,600
1978		26,200	25,000	136,000		16,200	17,400
1979	35,700	37,000	41,300	185,000		13,300	32,000
1980	59,000	46,000	51,900	230,000	28,500	24,300	34,500
1981	62,700	33,500	64,900	230,000	30,900	23,200	45,700
1982	46,600	43,000	37,900	213,800 [2]	24,100	16,300	38,200
1983	48,500		37,300	223,000	25,800	18,700	16,500
1984	37,000		59,100	171,000	33,400	17,100	34,200
1985	40,700		40,400	190,000	28,200	14,900	29,000
1986	36,300		29,100	167,000			20,600
1987	57.700	69.000	47.300	312.000			75.700
1988			43.600	171.000			17.100
1989			46.800	217.000			27.600
1990			50.300	210.000			30.300
1991			35.300	173.000			18.900

Table B.1: (Continued)

Annual Instantaneous Peak Discharge (cfs) [1],[10]							
Year	Chulitna River near Talkeetna (DA = 2,570 mi^2)	Skwentna River near Skwentna (DA = 2,250 mi^2)	Susitna River at Gold Creek (DA = 6,160 mi^2)	Susitna River at Susitna Station (DA = 19,400 mi^2)	Susitna River near Cantwell (DA = 4,140mi^2)	Susitna River near Denali (DA = 950 mi^2)	Talkeetna River near Talkeetna (DA = 1,996 mi^2)
1993			36,300				25,400
1994			46,600				22,000
1995			37,800				23,000
1996			26,100				13,400
1997							19,200
1998							23,700
1999							31,700
2000							24,200[8]
2001							17,500[9]

Notes:
1. Peak discharge data obtained from USGS Alaska Surface Water website, 2 October 2001.
2. Only average daily discharge data were available for this year. The average daily discharge value for this year was multiplied by 1.028 to estimate the instantaneous peak discharge. The coefficient (1.028) is the average ratio of the instantaneous peak discharge to the average daily discharge for all years in which both values were collected.
3. Only average daily discharge data were available for this year. The average daily discharge value for this year was multiplied by 1.016 to estimate the instantaneous peak discharge. The coefficient (1.016) is the average ratio of the instantaneous peak discharge to the average daily discharge for all years in which both values were collected.
4. Only average daily discharge data were available for this year. The average daily discharge value for this year was multiplied by 1.092 to estimate the instantaneous peak discharge. The coefficient (1.092) is the average ratio of the instantaneous peak discharge to the average daily discharge for all years in which both values were collected.
5. Only average daily discharge data were available for this year. The average daily discharge value for this year was multiplied by 1.047 to estimate the instantaneous peak discharge. The coefficient (1.047) is the average ratio of the instantaneous peak discharge to the average daily discharge for all years in which both values were collected.
6. Only average daily discharge data were available for this year. The average daily discharge value for this year was multiplied by 1.104 to estimate the instantaneous peak discharge. The coefficient (1.104) is the average ratio of the instantaneous peak discharge to the average daily discharge for all years in which both values were collected.
7. Only average daily discharge data were available for this year. The average daily discharge value for this year was multiplied by 1.214 to estimate the instantaneous peak discharge. The coefficient (1.214) is the average ratio of the instantaneous peak discharge to the average daily discharge for all years in which both values were collected.
8. Peak discharge data obtained from USGS Alaska Surface Water website, 3 January 2002.
9. Peak discharge data obtained from Chad Smith of the USGS, 6 March 2002.
10. Drainage area is abbreviated DA.

Table B.2: Single-Station Flood-Frequency Analysis For The Chulitna River Near Talkeetna

```
 ************************************      *************************************
 *              FFA                  *      *                                   *
 *     FLOOD FREQUENCY ANALYSIS      *      *   U.S. ARMY CORPS OF ENGINEERS    *
 *     PROGRAM DATE:  FEB 1995       *      * THE HYDROLOGIC ENGINEERING CENTER *
 *          VERSION:  3.1            *      *         609 SECOND STREET         *
 *     RUN  DATE   AND   TIME:       *      *      DAVIS, CALIFORNIA 95616      *
 *        26 SEP 01    08:50:08      *      *          (916) 756-1104           *
 *                                   *      *                                   *
 ************************************      *************************************
  INPUT FILE NAME: CHTA.TXT
 OUTPUT FILE NAME: CHTA.OUT
    DSS FILE NAME: CHTA.DSS
    -----DSS---ZOPEN:  New File Opened,  File: CHTA.DSS
                       Unit:  71;  DSS Version: 6-JB
 **TITLE RECORD(S)**
 TT    FLOOD FLOW FREQUENCY ANALYSIS PROGRAM
 TT   GENERALIZED SKEW AND STANDARD ERROR OF GENERALIZED SKEW OBTAINED FROM
 TT   JONES AND FAHL (1994)
**JOB RECORD(S)**
      IPPC   ISKFX  IPROUT    IFMT    IWYR   IUNIT   ISMRY   IPNCH    IREG
 J1     0       2      32       0       0       0       0       0       0
        A       B  CLIMIT  NDSSCV    IEXT
 J2   .00     .00     .05       0       0
**FREQUENCY ARRAY**
 FR    13    .200    .500   1.000   2.000   4.000   5.000  10.000  20.000  50.000
 FR80.000  90.000  95.000  99.000
**STATION IDENTIFICATION**
 ID    CHULITNA RIVER NR TALKEETNA   DA=2570 SQ MI           1958-1987
**GENERALIZED SKEW**
      ISTN   GGMSE    SKEW
 GS   CHTA    .740     .55
**HP PLOT **
      HP PLOT FILE                  IHPCV  KLIMIT    IPER    BAREA
 HP  CHTA.PCL                           0       0       1570 SQ MI
      SELECTED CURVES ON HPPLOT
           EXPECTED PROBABILITY CURVE
           CONFIDENCE LIMITS
 **SYSTEMATIC EVENTS**
      27 EVENTS TO BE ANALYZED
**END OF INPUT DATA**
 ED +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
 ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

Table B.2: (Continued)

FINAL RESULTS

-PLOTTING POSITIONS- CHULITNA RIVER NR TALKEETNA DA=2570 SQ MI

EVENTS ANALYZED				ORDERED EVENTS			
			FLOW		WATER	FLOW	WEIBULL
MON	DAY	YEAR	CFS	RANK	YEAR	CFS	PLOT POS
0	0	1958	35100.	1	1967	75900.	3.57
0	0	1959	38800.	2	1981	62700.	7.14
0	0	1960	38000.	3	1980	59000.	10.71
0	0	1961	41100.	4	1987	55700.	14.29
0	0	1962	39600.	5	1971	50800.	17.86
0	0	1965	42100.	6	1983	48500.	21.43
0	0	1966	38600.	7	1982	46600.	25.00
0	0	1967	75900.	8	1965	42100.	28.57
0	0	1968	40200.	9	1961	41100.	32.14
0	0	1969	28400.	10	1985	40700.	35.71
0	0	1970	36400.	11	1968	40200.	39.29
0	0	1971	50800.	12	1962	39600.	42.86
0	0	1972	34700.	13	1959	38800.	46.43
0	0	1973	36700.	14	1966	38600.	50.00
0	0	1974	32200.	15	1976	38000.	53.57
0	0	1975	36700.	16	1960	38000.	57.14
0	0	1976	38000.	17	1984	37000.	60.71
0	0	1977	33400.	18	1975	36700.	64.29
0	0	1979	35700.	19	1973	36700.	67.86
0	0	1980	59000.	20	1970	36400.	71.43
0	0	1981	62700.	21	1986	36300.	75.00
0	0	1982	46600.	22	1979	35700.	78.57
0	0	1983	48500.	23	1958	35100.	82.14
0	0	1984	37000.	24	1972	34700.	85.71
0	0	1985	40700.	25	1977	33400.	89.29
0	0	1986	36300.	26	1974	32200.	92.86
0	0	1987	55700.	27	1969	28400.	96.43

Table B.2: (Continued)

```
-OUTLIER TESTS  -
________________________________________________________________

HIGH OUTLIER TEST
_________________


BASED ON  27 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.519


      1 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF   71719.


NOTE - COLLECTION OF HISTORICAL INFORMATION AND COMPARISONS
       WITH SIMILAR DATA SETS SHOULD BE EXPLORED IF NOT
       INCORPORATED IN THIS ANALYSIS.


_________________
LOW OUTLIER TEST
_________________


BASED ON  27 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.519


       0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF  23580.9
________________________________________________________________


-SKEW WEIGHTING -
________________________________________________________________

BASED ON  27 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW =   .357
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW =   .740
________________________________________________________________
```

Table B.2: (Continued)

FINAL RESULTS

-FREQUENCY CURVE- CHULITNA RIVER NR TALKEETNA DA=2570 SQ MI

COMPUTED CURVE FLOW IN CFS	EXPECTED PROBABILITY FLOW IN CFS	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 FLOW IN CFS	CONFIDENCE LIMITS .95 FLOW IN CFS
100000.	117000.	.20	132000.	84100.
88200.	98300.	.50	112000.	75500.
79700.	86400.	1.00	98400.	69400.
71800.	76000.	2.00	86200.	63600.
64400.	66900.	4.00	75200.	58000.
62100.	64100.	5.00	71900.	56200.
55300.	56300.	10.00	62200.	50800.
48700.	49100.	20.00	53300.	45200.
39700.	39700.	50.00	42600.	36900.
34100.	33900.	80.00	36700.	31000.
32000.	31800.	90.00	34700.	28700.
30700.	30400.	95.00	33400.	27300.
28800.	28400.	99.00	31600.	25200.

SYSTEMATIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	4.6141	HISTORIC EVENTS	0
STANDARD DEV	.0959	HIGH OUTLIERS	0
COMPUTED SKEW	1.1600	LOW OUTLIERS	0
REGIONAL SKEW	.5500	ZERO OR MISSING	0
ADOPTED SKEW	.9615	SYSTEMATIC EVENTS	27

```
HP PLOT WRITTEN TO THE FILE:    CHTA.PCL

+++++++++++++++++++++++++
+ END OF RUN            +
+ NORMAL STOP IN FFA    +
+++++++++++++++++++++++++
```

Figure B.2: Chulitna River Near Talkeetna Single-Station Flood-Frequency Relationship

BASIN AREA = 2,570 SQ MI

WATER YEARS IN RECORD: 1958-62,1965-87

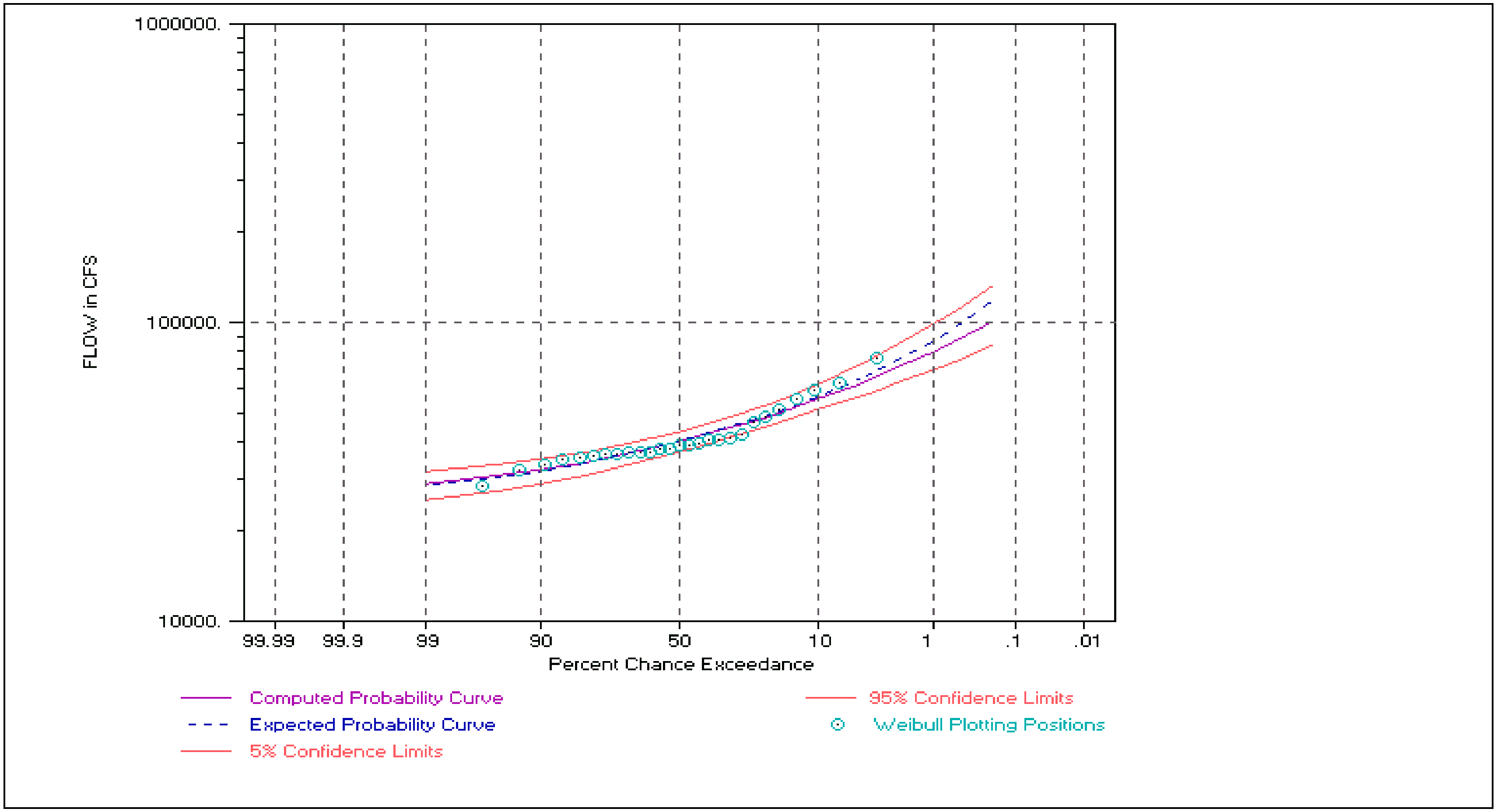

Table B.3: Single-Station Flood-Frequency Analysis For The Skwentna River At Skwentna

```
 ************************************      *************************************
*              FFA                 *      *                                    *
*     FLOOD FREQUENCY ANALYSIS     *      *   U.S. ARMY CORPS OF ENGINEERS    *
*     PROGRAM DATE:  FEB 1995      *      * THE HYDROLOGIC ENGINEERING CENTER *
*          VERSION:  3.1           *      *         609 SECOND STREET         *
*     RUN  DATE   AND   TIME:      *      *      DAVIS, CALIFORNIA 95616      *
*        01 OCT 01    16:54:24     *      *          (916) 756-1104           *
*                                  *      *                                   *
************************************      *************************************
 INPUT FILE NAME: C:\FFAT\SKSK.TXT
OUTPUT FILE NAME: SKSK.OUT
   DSS FILE NAME: SKSK.DSS
   -----DSS---ZOPEN:  New File Opened,  File: SKSK.DSS
                      Unit:  71;  DSS Version: 6-JB
**TITLE RECORD(S)**
TT    FLOOD FLOW FREQUENCY ANALYSIS PROGRAM
TT   GENERALIZED SKEW AND STANDARD ERROR OF GENERALIZED SKEW OBTAINED FROM
TT   JONES AND FAHL (1994)
**JOB RECORD(S)**
     IPPC   ISKFX  IPROUT    IFMT    IWYR   IUNIT   ISMRY   IPNCH    IREG
J1     0       2      32       0       0       0       0       0       0
       A       B  CLIMIT  NDSSCV    IEXT
J2   .00     .00     .05       0       0
**FREQUENCY ARRAY**
FR    13    .200    .500   1.000   2.000   4.000   5.000  10.000  20.000  50.000
FR80.000  90.000  95.000  99.000
**STATION IDENTIFICATION**
ID    SKWENTNA RIVER AT SKWENTNA    DA=2250 SQ MI      1960-1982,87
**GENERALIZED SKEW**
     ISTN   GGMSE    SKEW
GS   SUGC    .740     .55
**HP PLOT **
     HP PLOT FILE                  IHPCV  KLIMIT    IPER    BAREA
HP  SUGC.PCL                           0       0       1250 SQ MI
     SELECTED CURVES ON HPPLOT
          EXPECTED PROBABILITY CURVE
          CONFIDENCE LIMITS
**SYSTEMATIC EVENTS**
     24 EVENTS TO BE ANALYZED
**END OF INPUT DATA**
ED +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

Table B.3: (Continued)

FINAL RESULTS

-PLOTTING POSITIONS- SKWENTNA RIVER AT SKWENTNA DA=2250 SQ MI

EVENTS ANALYZED				ORDERED EVENTS			
			FLOW		WATER	FLOW	WEIBULL
MON	DAY	YEAR	CFS	RANK	YEAR	CFS	PLOT POS
0	0	1960	33200.	1	1987	69000.	4.00
0	0	1961	36800.	2	1977	51600.	8.00
0	0	1962	30900.	3	1971	50000.	12.00
0	0	1963	33100.	4	1980	46000.	16.00
0	0	1964	38300.	5	1982	43000.	20.00
0	0	1965	32600.	6	1966	42400.	24.00
0	0	1966	42400.	7	1964	38300.	28.00
0	0	1967	31000.	8	1979	37000.	32.00
0	0	1968	30400.	9	1961	36800.	36.00
0	0	1969	31600.	10	1981	33500.	40.00
0	0	1970	30100.	11	1975	33200.	44.00
0	0	1971	50000.	12	1960	33200.	48.00
0	0	1972	29400.	13	1963	33100.	52.00
0	0	1973	27800.	14	1965	32600.	56.00
0	0	1974	20800.	15	1969	31600.	60.00
0	0	1975	33200.	16	1967	31000.	64.00
0	0	1976	24200.	17	1962	30900.	68.00
0	0	1977	51600.	18	1968	30400.	72.00
0	0	1978	26200.	19	1970	30100.	76.00
0	0	1979	37000.	20	1972	29400.	80.00
0	0	1980	46000.	21	1973	27800.	84.00
0	0	1981	33500.	22	1978	26200.	88.00
0	0	1982	43000.	23	1976	24200.	92.00
0	0	1987	69000.	24	1974	20800.	96.00

Table B.3: (Continued)

```
-OUTLIER TESTS  -
_________________________________________________________________
HIGH OUTLIER TEST
_________________

BASED ON  24 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.467

      1 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF   66203.

NOTE - COLLECTION OF HISTORICAL INFORMATION AND COMPARISONS
       WITH SIMILAR DATA SETS SHOULD BE EXPLORED IF NOT
       INCORPORATED IN THIS ANALYSIS.

_________________
LOW OUTLIER TEST
_________________

BASED ON  24 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.467

       0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF  18183.6
_________________________________________________________________


-SKEW WEIGHTING -
_________________________________________________________________
BASED ON  24 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW =   .270
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW =   .740
_________________________________________________________________
```

Table B.3: (Continued)

FINAL RESULTS

-FREQUENCY CURVE- SKWENTNA RIVER AT SKWENTNA DA=2250 SQ MI

COMPUTED CURVE FLOW IN CFS	EXPECTED PROBABILITY FLOW IN CFS	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 FLOW IN CFS	CONFIDENCE LIMITS .95 FLOW IN CFS
90200.	107000.	.20	124000.	73600.
79400.	89700.	.50	105000.	66300.
71800.	78600.	1.00	92500.	61000.
64600.	68900.	2.00	80700.	55900.
57800.	60300.	4.00	70000.	50900.
55600.	57800.	5.00	66700.	49200.
49200.	50300.	10.00	57100.	44200.
42700.	43200.	20.00	48100.	39000.
33800.	33800.	50.00	36900.	30800.
27700.	27500.	80.00	30400.	24500.
25400.	25100.	90.00	28100.	22000.
23800.	23300.	95.00	26500.	20300.
21300.	20700.	99.00	24200.	17700.

SYSTEMATIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	4.5403	HISTORIC EVENTS	0
STANDARD DEV	.1137	HIGH OUTLIERS	0
COMPUTED SKEW	.6606	LOW OUTLIERS	0
REGIONAL SKEW	.5500	ZERO OR MISSING	0
ADOPTED SKEW	.6311	SYSTEMATIC EVENTS	24

Table B.3: (Continued)

```
HP PLOT WRITTEN TO THE FILE:    SUGC.PCL


+++++++++++++++++++++++++

+ END OF RUN            +

+ NORMAL STOP IN FFA    +

+++++++++++++++++++++++++
```

Figure B.3: Skwentna River At Skwentna Single-Station Flood-Frequency Relationship

BASIN AREA = 2,250 SQ MI

WATER YEARS IN RECORD: 1960-82,87

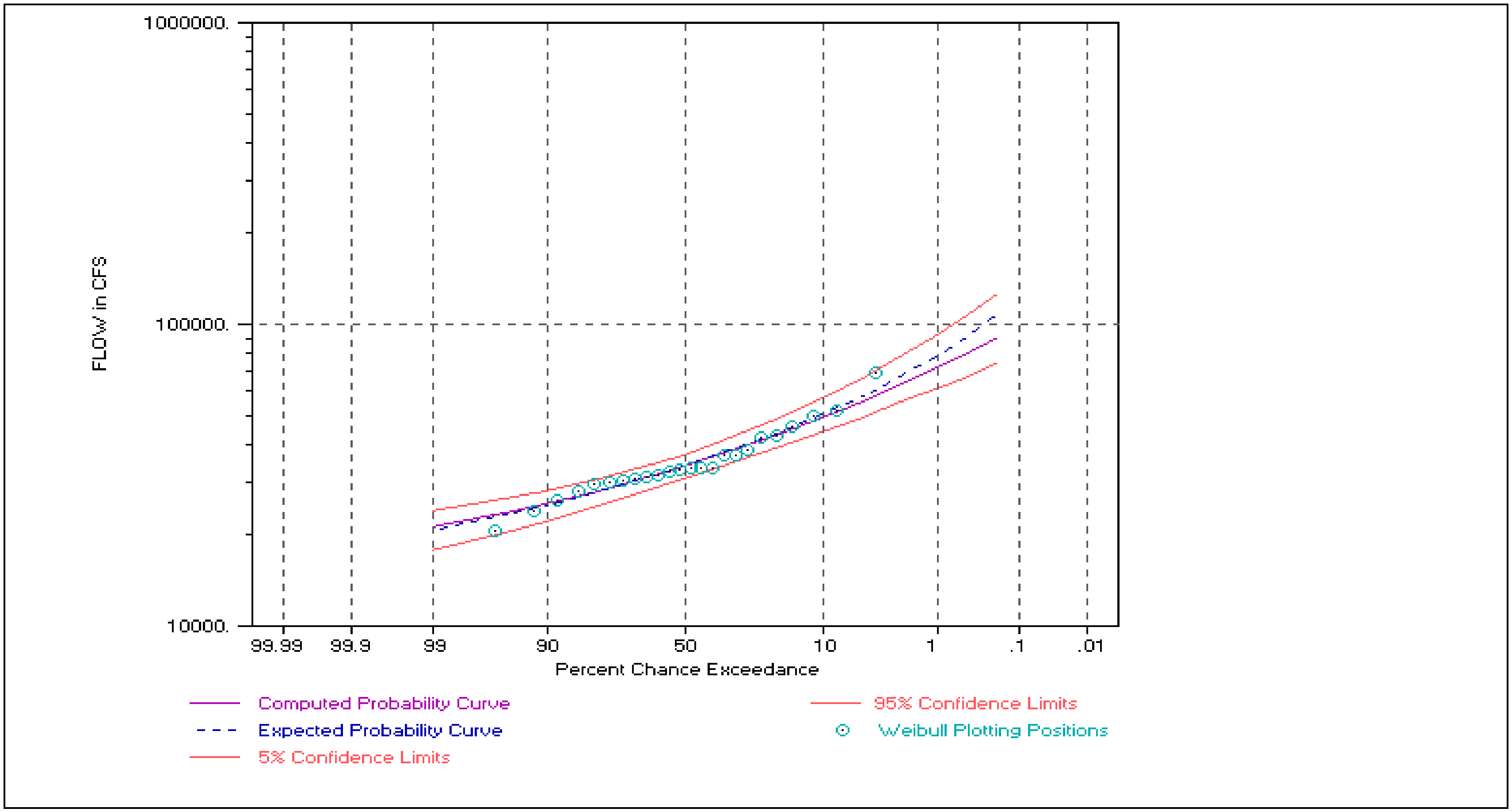

Table B.4: Single-Station Flood-Frequency Analysis For The Susitna River At Gold Creek

```
 ************************************      *************************************
 *              FFA                 *      *                                   *
 *     FLOOD FREQUENCY ANALYSIS     *      *   U.S. ARMY CORPS OF ENGINEERS    *
 *     PROGRAM DATE:  FEB 1995      *      * THE HYDROLOGIC ENGINEERING CENTER *
 *          VERSION:  3.1           *      *         609 SECOND STREET         *
 *     RUN  DATE   AND   TIME:      *      *      DAVIS, CALIFORNIA 95616      *
 *        01 OCT 01    16:55:45     *      *          (916) 756-1104           *
 *                                  *      *                                   *
 ************************************      *************************************
  INPUT FILE NAME: SUGC.TXT
 OUTPUT FILE NAME: SUGC.OUT
    DSS FILE NAME: (specify)
    -----DSS---ZOPEN:  Existing File Opened,  File: (SPECIFY).DSS
                       Unit:  71;  DSS Version: 6-JB
 **TITLE RECORD(S)**
 TT    FLOOD FLOW FREQUENCY ANALYSIS PROGRAM
 TT   GENERALIZED SKEW AND STANDARD ERROR OF GENERALIZED SKEW OBTAINED FROM
 TT   JONES AND FAHL (1994)
 **JOB RECORD(S)**
      IPPC   ISKFX  IPROUT    IFMT    IWYR   IUNIT   ISMRY   IPNCH    IREG
 J1     0       2      32       0       0       0       0       0       0
        A       B  CLIMIT  NDSSCV    IEXT
 J2   .00     .00     .05       0       0
 **FREQUENCY ARRAY**
 FR    13    .200    .500   1.000   2.000   4.000   5.000  10.000  20.000  50.000
 FR80.000  90.000  95.000  99.000
 **STATION IDENTIFICATION**
 ID    SUSITNA RIVER AT GOLD CREEK   DA=6160 SQ MI           1950-1996
 **GENERALIZED SKEW**
      ISTN   GGMSE    SKEW
 GS   SUGC    .740     .55
**HP PLOT **
      HP PLOT FILE                  IHPCV  KLIMIT    IPER    BAREA
 HP  SUGC.PCL                           0       0       1160 SQ MI
      SELECTED CURVES ON HPPLOT
           EXPECTED PROBABILITY CURVE
  CONFIDENCE LIMITS
 **SYSTEMATIC EVENTS**
      47 EVENTS TO BE ANALYZED
 **END OF INPUT DATA**
 ED ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

Table B.4: (Continued)

FINAL RESULTS

-PLOTTING POSITIONS- SUSITNA RIVER AT GOLD CREEK DA=6160 SQ MI

EVENTS ANALYZED				ORDERED EVENTS			
MON	DAY	YEAR	FLOW CFS	RANK	WATER YEAR	FLOW CFS	WEIBULL PLOT POS
0	0	1950	35600.	1	1964	90700.	2.08
0	0	1951	37400.	2	1971	87400.	4.17
0	0	1952	44700.	3	1972	82600.	6.25
0	0	1953	38400.	4	1962	80600.	8.33
0	0	1954	42400.	5	1967	80200.	10.42
0	0	1955	58100.	6	1981	64900.	12.50
0	0	1956	51700.	7	1966	63600.	14.58
0	0	1957	42200.	8	1959	62300.	16.67
0	0	1958	49600.	9	1984	59100.	18.75
0	0	1959	62300.	10	1955	58100.	20.83
0	0	1960	41900.	11	1977	54300.	22.92
0	0	1961	54000.	12	1973	54100.	25.00
0	0	1962	80600.	13	1961	54000.	27.08
0	0	1963	51300.	14	1980	51900.	29.17
0	0	1964	90700.	15	1956	51700.	31.25
0	0	1965	43600.	16	1963	51300.	33.33
0	0	1966	63600.	17	1990	50300.	35.42
0	0	1967	80200.	18	1958	49600.	37.50
0	0	1968	41800.	19	1975	47300.	39.58
0	0	1969	28400.	20	1987	47300.	41.67
0	0	1970	33400.	21	1989	46800.	43.75
0	0	1971	87400.	22	1994	46600.	45.83
0	0	1972	82600.	23	1952	44700.	47.92
0	0	1973	54100.	24	1965	43600.	50.00
0	0	1974	37200.	25	1988	43600.	52.08
0	0	1975	47300.	26	1954	42400.	54.17
0	0	1976	35700.	27	1957	42200.	56.25
0	0	1977	54300.	28	1960	41900.	58.33
0	0	1978	25000.	29	1968	41800.	60.42
0	0	1979	41300.	30	1979	41300.	62.50
0	0	1980	51900.	31	1985	40400.	64.58
0	0	1981	64900.	32	1953	38400.	66.67
0	0	1982	37900.	33	1982	37900.	68.75
0	0	1983	37300.	34	1995	37800.	70.83
0	0	1984	59100.	35	1951	37400.	72.92
0	0	1985	40400.	36	1983	37300.	75.00
0	0	1986	29100.	37	1974	37200.	77.08
0	0	1987	47300.	38	1993	36300.	79.17
0	0	1988	43600.	39	1976	35700.	81.25
0	0	1989	46800.	40	1950	35600.	83.33
0	0	1990	50300.	41	1991	35300.	85.42
0	0	1991	35300.	42	1970	33400.	87.50
0	0	1992	33300.	43	1992	33300.	89.58
0	0	1993	36300.	44	1986	29100.	91.67
0	0	1994	46600.	45	1969	28400.	93.75
0	0	1995	37800.	46	1996	26100.	95.83
0	0	1996	26100.	47	1978	25000.	97.92

Table B.4: (Continued)

-OUTLIER TESTS -

HIGH OUTLIER TEST

BASED ON 47 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.744

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 106262.

LOW OUTLIER TEST

BASED ON 47 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.744

0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 19797.4

-SKEW WEIGHTING -

BASED ON 47 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = .138

DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = .740

FINAL RESULTS

-FREQUENCY CURVE- SUSITNA RIVER AT GOLD CREEK DA=6160 SQ MI

COMPUTED CURVE FLOW IN CFS	EXPECTED PROBABILITY FLOW IN CFS	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 FLOW IN CFS	CONFIDENCE LIMITS .95 FLOW IN CFS
130000.	141000.	.20	163000.	110000.
114000.	121000.	.50	140000.	98100.
103000.	108000.	1.00	124000.	89600.
92000.	95100.	2.00	109000.	81400.
81800.	83600.	4.00	94400.	73300.
78500.	80100.	5.00	90100.	70700.
68700.	69500.	10.00	77100.	62700.
58900.	59200.	20.00	64700.	54400.
44900.	44900.	50.00	48300.	41600.
35300.	35100.	80.00	38200.	32100.
31500.	31300.	90.00	34400.	28200.
28800.	28500.	95.00	31800.	25500.
24800.	24200.	99.00	27800.	21300.

Table B.4: (Continued)

SYSTEMATIC STATISTICS			
LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	4.6615	HISTORIC EVENTS	0
STANDARD DEV	.1330	HIGH OUTLIERS	0
COMPUTED SKEW	.4037	LOW OUTLIERS	0
REGIONAL SKEW	.5500	ZERO OR MISSING	0
ADOPTED SKEW	.4267	SYSTEMATIC EVENTS	47

```
HP PLOT WRITTEN TO THE FILE:    SUGC.PCL

+++++++++++++++++++++++++

+ END OF RUN            +

+ NORMAL STOP IN FFA    +

+++++++++++++++++++++++++
```

Figure B.4: Susitna River At Gold Creek Single-Station Flood-Frequency Relationship

BASIN AREA = 6,160 SQ MI

WATER YEARS IN RECORD: 1950-96

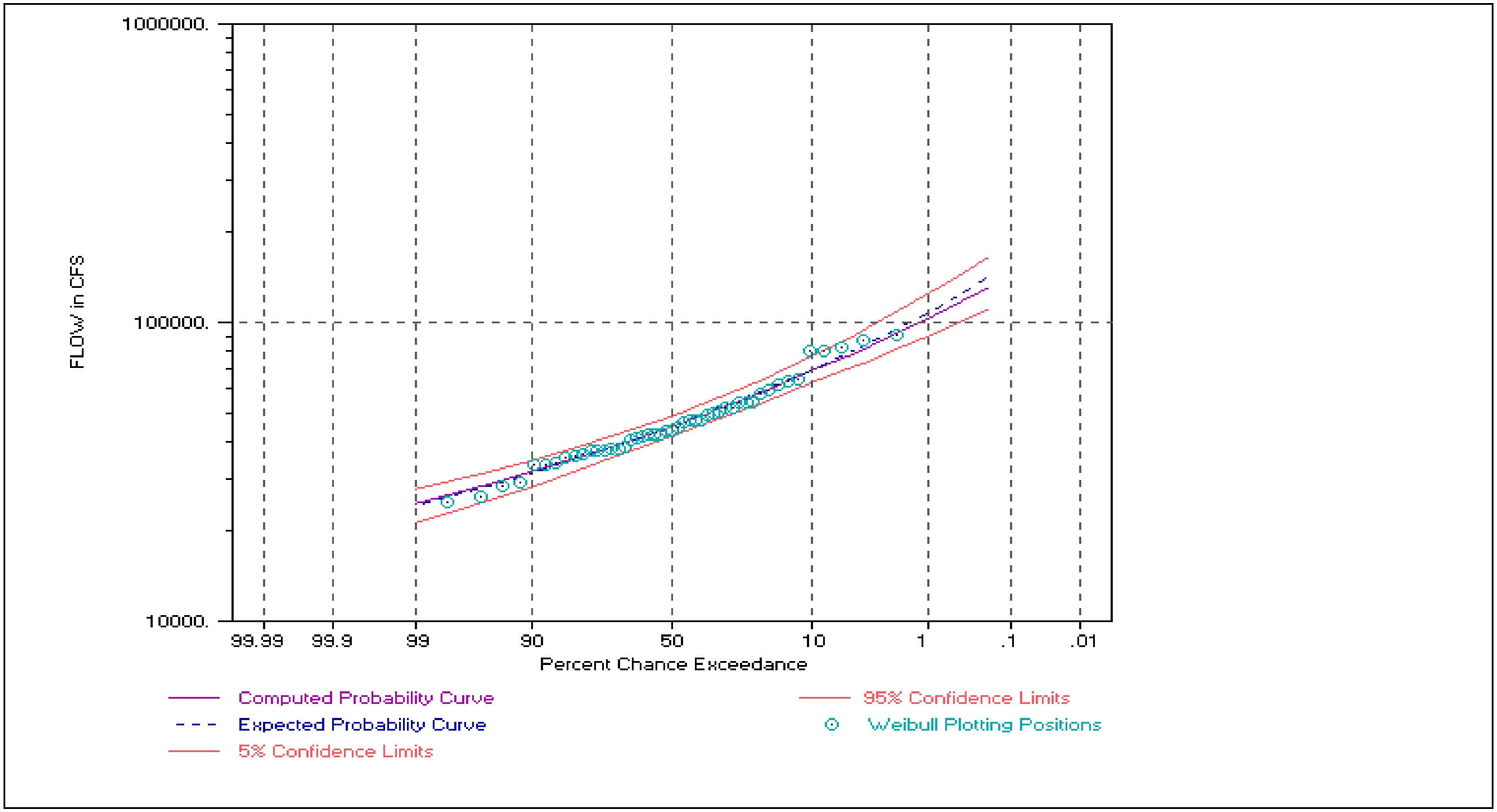

Table B.5: Single-Station Flood-Frequency Analysis For The Susitna River At Susitna Station

```
************************************      *************************************
*              FFA                 *      *                                   *
*     FLOOD FREQUENCY ANALYSIS     *      *   U.S. ARMY CORPS OF ENGINEERS    *
*     PROGRAM DATE:  FEB 1995      *      * THE HYDROLOGIC ENGINEERING CENTER *
*          VERSION:  3.1           *      *         609 SECOND STREET         *
*     RUN  DATE   AND   TIME:      *      *      DAVIS, CALIFORNIA 95616      *
*        01 OCT 01    16:56:20     *      *          (916) 756-1104           *
*                                  *      *                                   *
************************************      *************************************
 INPUT FILE NAME: SUSU.TXT
OUTPUT FILE NAME: SUSU.OUT
   DSS FILE NAME: (specify)
   -----DSS---ZOPEN:  Existing File Opened,  File: (SPECIFY).DSS
                      Unit:  71;  DSS Version: 6-JB
**TITLE RECORD(S)**
TT    FLOOD FLOW FREQUENCY ANALYSIS PROGRAM
TT   GENERALIZED SKEW AND STANDARD ERROR OF GENERALIZED SKEW OBTAINED FROM
TT   JONES AND FAHL (1994)
**JOB RECORD(S)**
     IPPC   ISKFX  IPROUT    IFMT    IWYR   IUNIT   ISMRY   IPNCH    IREG
J1     0       2      32       0       0       0       0       0       0
       A       B  CLIMIT  NDSSCV    IEXT
J2   .00     .00     .05       0       0
**FREQUENCY ARRAY**
FR    13    .200    .500   1.000   2.000   4.000   5.000  10.000  20.000  50.000
FR80.000  90.000  95.000  99.000
**STATION IDENTIFICATION**
ID    SUSITNA RIVER AT SUSITNA     DA=19400 SQ MI           1975-1992
**GENERALIZED SKEW**
     ISTN   GGMSE    SKEW
GS   SUSU    .740     .55
**HP PLOT **
     HP PLOT FILE                  IHPCV  KLIMIT    IPER    BAREA
HP  SUSU.PCL                           0       0       1400 SQ MI
     SELECTED CURVES ON HPPLOT
          EXPECTED PROBABILITY CURVE
          CONFIDENCE LIMITS
**SYSTEMATIC EVENTS**
     18 EVENTS TO BE ANALYZED
**END OF INPUT DATA**
ED ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

Table B.5: (Continued)

FINAL RESULTS

-PLOTTING POSITIONS- SUSITNA RIVER AT SUSITNA DA=19400 SQ MI

EVENTS ANALYZED				ORDERED EVENTS			
MON	DAY	YEAR	FLOW CFS	RANK	WATER YEAR	FLOW CFS	WEIBULL PLOT POS
0	0	1975	173000.	1	1987	312000.	5.26
0	0	1976	147000.	2	1980	230000.	10.53
0	0	1977	197000.	3	1981	230000.	15.79
0	0	1978	136000.	4	1983	223000.	21.05
0	0	1979	185000.	5	1989	217000.	26.32
0	0	1980	230000.	6	1982	213800.	31.58
0	0	1981	230000.	7	1990	210000.	36.84
0	0	1982	213800.	8	1977	197000.	42.11
0	0	1983	223000.	9	1985	190000.	47.37
0	0	1984	171000.	10	1979	185000.	52.63
0	0	1985	190000.	11	1975	173000.	57.89
0	0	1986	167000.	12	1991	173000.	63.16
0	0	1987	312000.	13	1988	171000.	68.42
0	0	1988	171000.	14	1984	171000.	73.68
0	0	1989	217000.	15	1986	167000.	78.95
0	0	1990	210000.	16	1992	157000.	84.21
0	0	1991	173000.	17	1976	147000.	89.47
0	0	1992	157000.	18	1978	136000.	94.74

-OUTLIER TESTS -

HIGH OUTLIER TEST

BASED ON 18 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.335
1 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 302322.
NOTE - COLLECTION OF HISTORICAL INFORMATION AND COMPARISONS
WITH SIMILAR DATA SETS SHOULD BE EXPLORED IF NOT
INCORPORATED IN THIS ANALYSIS.

LOW OUTLIER TEST

BASED ON 18 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.335
0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 120606.1

-SKEW WEIGHTING -

BASED ON 18 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = .328
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = .740

Table B.5: (Continued)

FINAL RESULTS

-FREQUENCY CURVE- SUSITNA RIVER AT SUSITNA DA=19400 SQ MI

COMPUTED CURVE FLOW IN CFS	EXPECTED PROBABILITY FLOW IN CFS	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 FLOW IN CFS	CONFIDENCE LIMITS .95 FLOW IN CFS
386000.	461000.	.20	517000.	326000.
352000.	399000.	.50	455000.	303000.
327000.	359000.	1.00	412000.	286000.
303000.	324000.	2.00	371000.	268000.
279000.	292000.	4.00	332000.	251000.
272000.	282000.	5.00	320000.	245000.
248000.	254000.	10.00	284000.	227000.
224000.	226000.	20.00	249000.	207000.
187000.	187000.	50.00	203000.	173000.
161000.	160000.	80.00	175000.	145000.
151000.	149000.	90.00	164000.	133000.
143000.	140000.	95.00	157000.	124000.
131000.	127000.	99.00	146000.	111000.

SYSTEMATIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	5.2809	HISTORIC EVENTS	0
STANDARD DEV	.0855	HIGH OUTLIERS	0
COMPUTED SKEW	.5895	LOW OUTLIERS	0
REGIONAL SKEW	.5500	ZERO OR MISSING	0
ADOPTED SKEW	.5774	SYSTEMATIC EVENTS	18

HP PLOT WRITTEN TO THE FILE: SUSU.PCL

```
+++++++++++++++++++++++++
+ END OF RUN            +
+ NORMAL STOP IN FFA    +
+++++++++++++++++++++++++
```

Figure B.5: Susitna River At Susitna Station Single-Station Flood-Frequency Relationship

BASIN AREA = 19,400 SQ MI

WATER YEARS IN RECORD: 1975-92

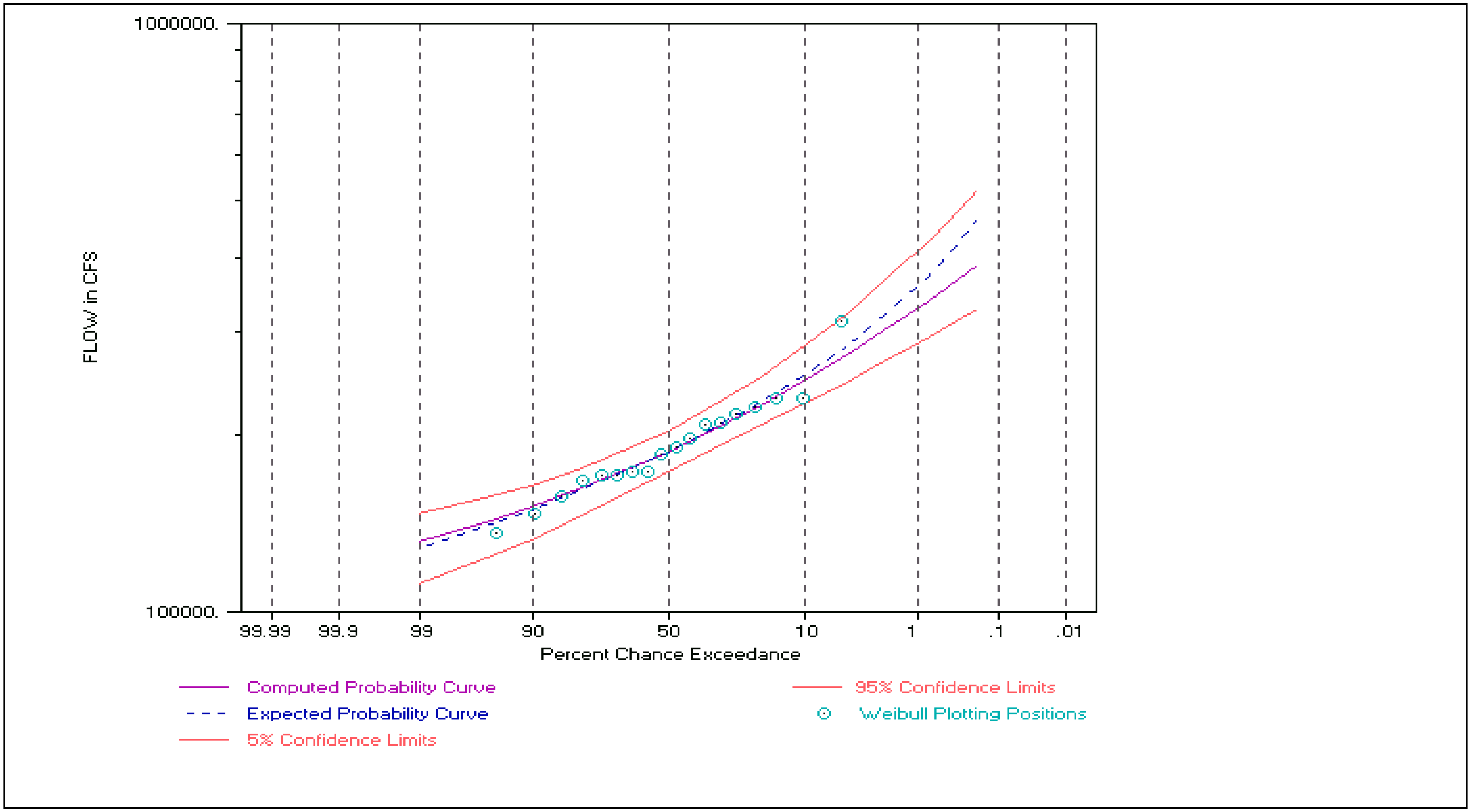

Table B.6: Single-Station Flood-Frequency Analysis For The Susitna River Near Cantwell

```
************************************      *************************************
*             FFA                 *      *                                   *
*     FLOOD FREQUENCY ANALYSIS     *      *   U.S. ARMY CORPS OF ENGINEERS    *
*     PROGRAM DATE:  FEB 1995      *      * THE HYDROLOGIC ENGINEERING CENTER *
*          VERSION:  3.1           *      *         609 SECOND STREET         *
*     RUN  DATE   AND   TIME:      *      *      DAVIS, CALIFORNIA 95616      *
*        01 OCT 01    16:55:25     *      *          (916) 756-1104           *
*                                  *      *                                   *
************************************      *************************************
 INPUT FILE NAME: SUCA.TXT
OUTPUT FILE NAME: SUCA.OUT
   DSS FILE NAME: (specify)
   -----DSS---ZOPEN:  Existing File Opened,  File: (SPECIFY).DSS
                      Unit:  71;  DSS Version: 6-JB
**TITLE RECORD(S)**
TT    FLOOD FLOW FREQUENCY ANALYSIS PROGRAM
TT   GENERALIZED SKEW AND STANDARD ERROR OF GENERALIZED SKEW OBTAINED FROM
TT   JONES AND FAHL (1994)
**JOB RECORD(S)**
     IPPC   ISKFX  IPROUT    IFMT    IWYR   IUNIT   ISMRY   IPNCH    IREG
J1     0       2      32       0       0       0       0       0       0
       A       B  CLIMIT  NDSSCV    IEXT
J2   .00     .00     .05       0       0
**FREQUENCY ARRAY**
FR    13    .200    .500   1.000   2.000   4.000   5.000  10.000  20.000  50.000
FR80.000  90.000  95.000  99.000
**STATION IDENTIFICATION**
ID    SUSITNA RIVER AT CANTWELL    DA=4140 SQ MI           1961-72,80-85
**GENERALIZED SKEW**
     ISTN   GGMSE    SKEW
GS   SUCA    .740     .55
**HP PLOT **
     HP PLOT FILE                  IHPCV  KLIMIT    IPER    BAREA
HP  SUCA.PCL                           0       0       1140 SQ MI
     SELECTED CURVES ON HPPLOT
          EXPECTED PROBABILITY CURVE
          CONFIDENCE LIMITS
**SYSTEMATIC EVENTS**
     18 EVENTS TO BE ANALYZED
**END OF INPUT DATA**
ED +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

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Table B.6: (Continued)

FINAL RESULTS

-PLOTTING POSITIONS- SUSITNA RIVER AT CANTWELL DA=4140 SQ MI

EVENTS ANALYZED				ORDERED EVENTS			
			FLOW		WATER	FLOW	WEIBULL
MON	DAY	YEAR	CFS	RANK	YEAR	CFS	PLOT POS
0	0	1961	30400.	1	1971	55000.	5.26
0	0	1962	46800.	2	1964	51200.	10.53
0	0	1963	32500.	3	1962	46800.	15.79
0	0	1964	51200.	4	1972	44700.	21.05
0	0	1965	26400.	5	1967	38800.	26.32
0	0	1966	27400.	6	1984	33400.	31.58
0	0	1967	38800.	7	1963	32500.	36.84
0	0	1968	25400.	8	1981	30900.	42.11
0	0	1969	19300.	9	1961	30400.	47.37
0	0	1970	20500.	10	1980	28500.	52.63
0	0	1971	55000.	11	1985	28200.	57.89
0	0	1972	44700.	12	1966	27400.	63.16
0	0	1980	28500.	13	1965	26400.	68.42
0	0	1981	30900.	14	1983	25800.	73.68
0	0	1982	24100.	15	1968	25400.	78.95
0	0	1983	25800.	16	1982	24100.	84.21
0	0	1984	33400.	17	1970	20500.	89.47
0	0	1985	28200.	18	1969	19300.	94.74

-OUTLIER TESTS -

HIGH OUTLIER TEST

BASED ON 18 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.335

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 63127.

LOW OUTLIER TEST

BASED ON 18 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.335

0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 15550.9

-SKEW WEIGHTING -

BASED ON 18 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = .313

DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = .740

Table B.6: (Continued)

FINAL RESULTS

-FREQUENCY CURVE- SUSITNA RIVER AT CANTWELL DA=4140 SQ MI

COMPUTED CURVE FLOW IN CFS	EXPECTED PROBABILITY FLOW IN CFS	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 FLOW IN CFS	CONFIDENCE LIMITS .95 FLOW IN CFS
88400.	113000.	.20	136000.	68800.
77500.	92500.	.50	114000.	61900.
69800.	79600.	1.00	98300.	56900.
62500.	68600.	2.00	84600.	52000.
55500.	59100.	4.00	72100.	47100.
53300.	56300.	5.00	68300.	45500.
46600.	48100.	10.00	57200.	40600.
40000.	40600.	20.00	47000.	35400.
30600.	30600.	50.00	34500.	27000.
24200.	24000.	80.00	27400.	20500.
21700.	21300.	90.00	24800.	17800.
20000.	19400.	95.00	23100.	16000.
17300.	16400.	99.00	20500.	13200.

SYSTEMATIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	4.4960	HISTORIC EVENTS	0
STANDARD DEV	.1303	HIGH OUTLIERS	0
COMPUTED SKEW	.4459	LOW OUTLIERS	0
REGIONAL SKEW	.5500	ZERO OR MISSING	0
ADOPTED SKEW	.4769	SYSTEMATIC EVENTS	18

HP PLOT WRITTEN TO THE FILE: SUCA.PCL

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+ END OF RUN            +

+ NORMAL STOP IN FFA    +

+++++++++++++++++++++++++
```

Figure B.6: Susitna River Near Cantwell Single-Station Flood-Frequency Relationship

BASIN AREA = 4,140 SQ MI

WATER YEARS IN RECORD: 1961-72,1980-85

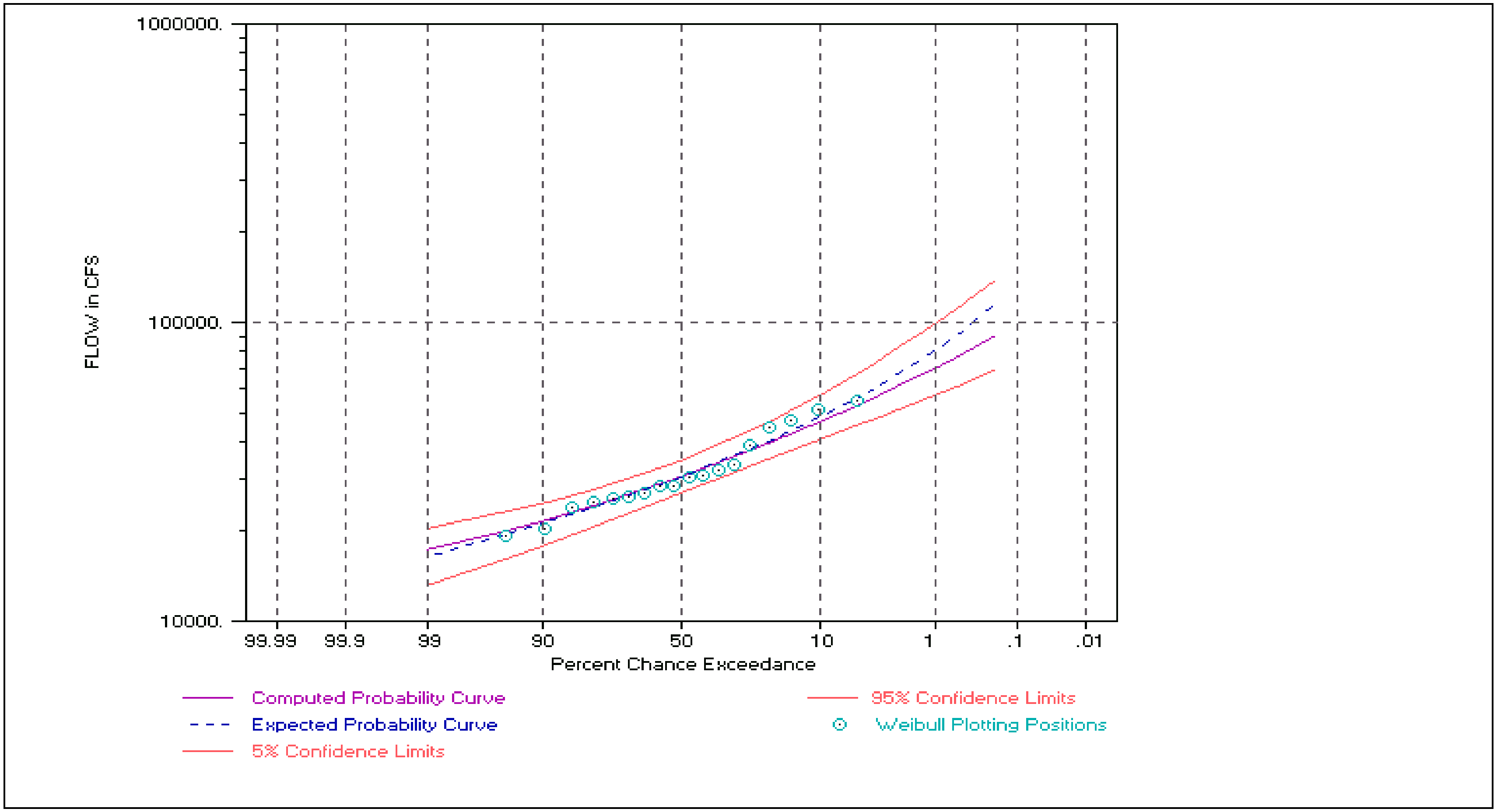

Table B.7: Single-Station Flood-Frequency Analysis For The Susitna River Near Denali

```
************************************      ************************************
*              FFA                 *      *                                  *
*     FLOOD FREQUENCY ANALYSIS     *      *   U.S. ARMY CORPS OF ENGINEERS   *
*     PROGRAM DATE:  FEB 1995      *      * THE HYDROLOGIC ENGINEERING CENTER *
*          VERSION:  3.1           *      *         609 SECOND STREET        *
*     RUN  DATE   AND   TIME:      *      *      DAVIS, CALIFORNIA 95616     *
*        01 OCT 01    16:55:06     *      *          (916) 756-1104          *
*                                  *      *                                  *
************************************      ************************************
 INPUT FILE NAME: SUDA.TXT
OUTPUT FILE NAME: SUDA.OUT
   DSS FILE NAME: (specify)
   -----DSS---ZOPEN:  New File Opened,  File: (SPECIFY).DSS
                      Unit:  71;  DSS Version: 6-JB
**TITLE RECORD(S)**
TT    FLOOD FLOW FREQUENCY ANALYSIS PROGRAM
TT   GENERALIZED SKEW AND STANDARD ERROR OF GENERALIZED SKEW OBTAINED FROM
TT   JONES AND FAHL (1994)
**JOB RECORD(S)**
     IPPC   ISKFX  IPROUT    IFMT    IWYR   IUNIT   ISMRY   IPNCH    IREG
J1     0       2      32       0       0       0       0       0       0
       A       B  CLIMIT  NDSSCV    IEXT
J2   .00     .00     .05       0       0
**FREQUENCY ARRAY**
FR    13    .200    .500   1.000   2.000   4.000   5.000  10.000  20.000  50.000
FR80.000  90.000  95.000  99.000
**STATION IDENTIFICATION**
ID    SUSITNA RIVER NR DENALI        DA=950 SQ MI           1957-1985
**GENERALIZED SKEW**
     ISTN   GGMSE    SKEW
GS   SUDE    .740     .55
**HP PLOT **
     HP PLOT FILE                  IHPCV  KLIMIT    IPER    BAREA
HP  SUDE.PCL                           0       0       0950 SQ MI
     SELECTED CURVES ON HPPLOT
          EXPECTED PROBABILITY CURVE
          CONFIDENCE LIMITS
**SYSTEMATIC EVENTS**
     27 EVENTS TO BE ANALYZED
**END OF INPUT DATA**
ED ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

Table B.7: (Continued)

FINAL RESULTS

-PLOTTING POSITIONS- SUSITNA RIVER NR DENALI DA=950 SQ MI

EVENTS ANALYZED				ORDERED EVENTS			
MON	DAY	YEAR	FLOW CFS	RANK	WATER YEAR	FLOW CFS	WEIBULL PLOT POS
0	0	1957	18700.	1	1971	38200.	3.57
0	0	1958	14500.	2	1967	28200.	7.14
0	0	1959	14800.	3	1980	24300.	10.71
0	0	1960	12900.	4	1981	23200.	14.29
0	0	1961	15500.	5	1976	22100.	17.86
0	0	1962	15500.	6	1975	21700.	21.43
0	0	1963	17000.	7	1957	18700.	25.00
0	0	1964	17500.	8	1983	18700.	28.57
0	0	1965	15800.	9	1964	17500.	32.14
0	0	1967	28200.	10	1972	17200.	35.71
0	0	1969	14900.	11	1984	17100.	39.29
0	0	1970	14100.	12	1963	17000.	42.86
0	0	1971	38200.	13	1974	16800.	46.43
0	0	1972	17200.	14	1977	16500.	50.00
0	0	1973	14100.	15	1982	16300.	53.57
0	0	1974	16800.	16	1978	16200.	57.14
0	0	1975	21700.	17	1965	15800.	60.71
0	0	1976	22100.	18	1961	15500.	64.29
0	0	1977	16500.	19	1962	15500.	67.86
0	0	1978	16200.	20	1969	14900.	71.43
0	0	1979	13300.	21	1985	14900.	75.00
0	0	1980	24300.	22	1959	14800.	78.57
0	0	1981	23200.	23	1958	14500.	82.14
0	0	1982	16300.	24	1973	14100.	85.71
0	0	1983	18700.	25	1970	14100.	89.29
0	0	1984	17100.	26	1979	13300.	92.86
0	0	1985	14900.	27	1960	12900.	96.43

-OUTLIER TESTS -

HIGH OUTLIER TEST

BASED ON 27 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.519
1 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 32604.
NOTE - COLLECTION OF HISTORICAL INFORMATION AND COMPARISONS
WITH SIMILAR DATA SETS SHOULD BE EXPLORED IF NOT
INCORPORATED IN THIS ANALYSIS.

LOW OUTLIER TEST

BASED ON 27 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.519
0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 9461.4

-SKEW WEIGHTING -

BASED ON 27 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = .511
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = .740

Table B.7: (Continued)

FINAL RESULTS

-FREQUENCY CURVE- SUSITNA RIVER NR DENALI DA=950 SQ MI

COMPUTED CURVE FLOW IN CFS	EXPECTED PROBABILITY FLOW IN CFS	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 FLOW IN CFS	CONFIDENCE LIMITS .95 FLOW IN CFS
50000.	60400.	.20	68900.	40600.
42600.	48700.	.50	56200.	35600.
37700.	41600.	1.00	48100.	32200.
33300.	35600.	2.00	41000.	29000.
29200.	30600.	4.00	34800.	26000.
28000.	29100.	5.00	33000.	25000.
24400.	25000.	10.00	27800.	22200.
21100.	21300.	20.00	23300.	19400.
16800.	16800.	50.00	18100.	15400.
14300.	14200.	80.00	15500.	12800.
13400.	13300.	90.00	14600.	11900.
12900.	12800.	95.00	14100.	11300.
12200.	12000.	99.00	13500.	10600.

SYSTEMATIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	4.2446	HISTORIC EVENTS	0
STANDARD DEV	.1067	HIGH OUTLIERS	0
COMPUTED SKEW	1.5527	LOW OUTLIERS	0
REGIONAL SKEW	.5500	ZERO OR MISSING	0
ADOPTED SKEW	1.1430	SYSTEMATIC EVENTS	27

HP PLOT WRITTEN TO THE FILE: SUDE.PCL

+++++++++++++++++++++++++

+ END OF RUN +

+ NORMAL STOP IN FFA +

+++++++++++++++++++++++++

Figure B.7: Susitna River Near Denali Single-Station Flood-Frequency Relationship

BASIN AREA = 950 SQ MI

WATER YEARS IN RECORD: 1957-65,67,1969-85

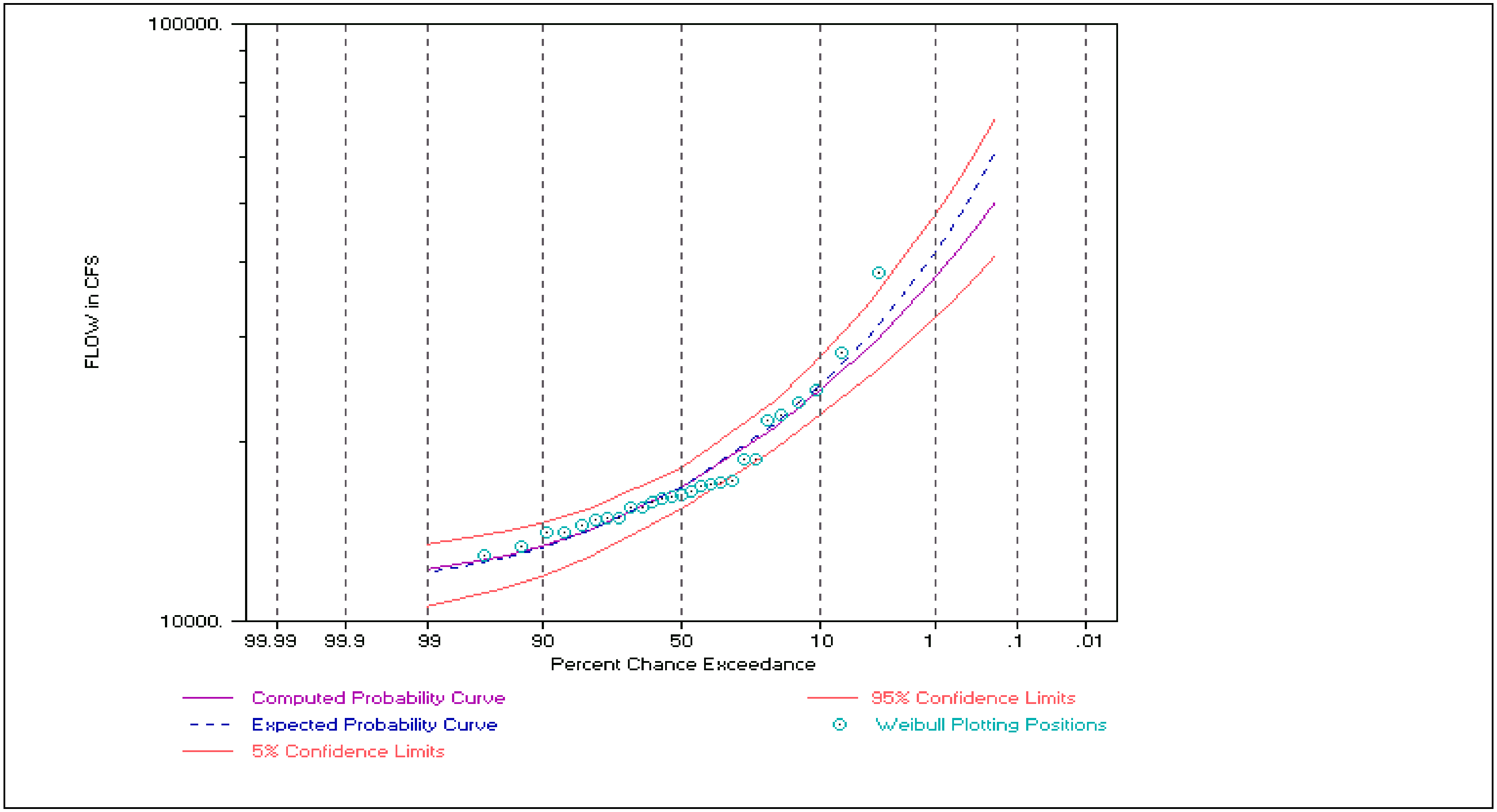

Table B.8: Single-Station Flood-Frequency Analysis For The Talkeetna River Near Talkeetna

```
***********************************      ************************************
*              FFA                *      *                                  *
*     FLOOD FREQUENCY ANALYSIS    *      *   U.S. ARMY CORPS OF ENGINEERS   *
*     PROGRAM DATE:  FEB 1995     *      * THE HYDROLOGIC ENGINEERING CENTER *
*          VERSION:  3.1          *      *         609 SECOND STREET        *
*     RUN  DATE   AND   TIME:     *      *      DAVIS, CALIFORNIA 95616     *
*        07 MAR 02    11:19:36    *      *          (916) 756-1104          *
*                                 *      *                                  *
***********************************      ************************************
 INPUT FILE NAME: tat2.txt
OUTPUT FILE NAME: TAT2.OUT
   DSS FILE NAME: TAT2.DSS
   -----DSS---ZOPEN:  Existing File Opened,  File: TAT2.DSS
                      Unit:  71;  DSS Version: 6-JB
**TITLE RECORD(S)**
TT    FLOOD FLOW FREQUENCY ANALYSIS PROGRAM
TT   GENERALIZED SKEW AND STANDARD ERROR OF GENERALIZED SKEW OBTAINED FROM
TT   JONES AND FAHL (1994)
**JOB RECORD(S)**
     IPPC   ISKFX  IPROUT    IFMT    IWYR   IUNIT   ISMRY   IPNCH    IREG
J1     0       2      32       0       0       0       0       0       0
       A       B  CLIMIT  NDSSCV    IEXT
J2   .00     .00     .05       0       0
**FREQUENCY ARRAY**
FR    13    .200    .500   1.000   2.000   4.000   5.000  10.000  20.000  50.000
FR80.000  90.000  95.000  99.000
**STATION IDENTIFICATION**
ID    TALKEETNA RIVER NR TALKEETNA  DA=1996 SQ MI           1964-2001
**GENERALIZED SKEW**
     ISTN   GGMSE    SKEW
GS   TATA    .740     .55
**HP PLOT **
     HP PLOT FILE                  IHPCV  KLIMIT    IPER    BAREA
HP  TATA.PCL                           0       0       1996 SQ MI
     SELECTED CURVES ON HPPLOT
          EXPECTED PROBABILITY CURVE
          CONFIDENCE LIMITS
**SYSTEMATIC EVENTS**
     38 EVENTS TO BE ANALYZED
**END OF INPUT DATA**
ED +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
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Table B.8: (Continued)

FINAL RESULTS

-PLOTTING POSITIONS- TALKEETNA RIVER NR TALKEETNA DA=1996 SQ MI

EVENTS ANALYZED				ORDERED EVENTS			
			FLOW		WATER	FLOW	WEIBULL
MON	DAY	YEAR	CFS	RANK	YEAR	CFS	PLOT POS
0	0	1964	33200.	1	1987	75700.	2.56
0	0	1965	25900.	2	1971	67400.	5.13
0	0	1966	28600.	3	1967	59400.	7.69
0	0	1967	59400.	4	1981	45700.	10.26
0	0	1968	25000.	5	1982	38200.	12.82
0	0	1969	16800.	6	1972	36500.	15.38
0	0	1970	23400.	7	1980	34500.	17.95
0	0	1971	67400.	8	1984	34200.	20.51
0	0	1972	36500.	9	1964	33200.	23.08
0	0	1973	30200.	10	1979	32000.	25.64
0	0	1974	24500.	11	1999	31700.	28.21
0	0	1975	22200.	12	1977	30600.	30.77
0	0	1976	20700.	13	1990	30300.	33.33
0	0	1977	30600.	14	1973	30200.	35.90
0	0	1978	17400.	15	1985	29000.	38.46
0	0	1979	32000.	16	1966	28600.	41.03
0	0	1980	34500.	17	1989	27600.	43.59
0	0	1981	45700.	18	1965	25900.	46.15
0	0	1982	38200.	19	1993	25400.	48.72
0	0	1983	16500.	20	1968	25000.	51.28
0	0	1984	34200.	21	1974	24500.	53.85
0	0	1985	29000.	22	2000	24200.	56.41
0	0	1986	20600.	23	1998	23700.	58.97
0	0	1987	75700.	24	1970	23400.	61.54
0	0	1988	17100.	25	1995	23000.	64.10
0	0	1989	27600.	26	1975	22200.	66.67
0	0	1990	30300.	27	1994	22000.	69.23
0	0	1991	18900.	28	1976	20700.	71.79
0	0	1992	17000.	29	1986	20600.	74.36
0	0	1993	25400.	30	1997	19200.	76.92
0	0	1994	22000.	31	1991	18900.	79.49
0	0	1995	23000.	32	2001	17500.	82.05
0	0	1996	13400.	33	1978	17400.	84.62
0	0	1997	19200.	34	1988	17100.	87.18
0	0	1998	23700.	35	1992	17000.	89.74
0	0	1999	31700.	36	1969	16800.	92.31
0	0	2000	24200.	37	1983	16500.	94.87
0	0	2001	17500.	38	1996	13400.	97.44

-OUTLIER TESTS -

HIGH OUTLIER TEST

BASED ON 38 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.661
1 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 75015.
NOTE - COLLECTION OF HISTORICAL INFORMATION AND COMPARISONS
WITH SIMILAR DATA SETS SHOULD BE EXPLORED IF NOT
INCORPORATED IN THIS ANALYSIS.

Table B.8: (Continued)

```
LOW OUTLIER TEST

BASED ON  38 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.661
       0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF   9473.9

-SKEW WEIGHTING -

BASED ON  38 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW =   .209
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW =   .740

FINAL RESULTS
-FREQUENCY CURVE-  TALKEETNA RIVER NR TALKEETNA  DA=1996 SQ MI
```

COMPUTED CURVE FLOW IN CFS	EXPECTED PROBABILITY FLOW IN CFS	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 FLOW IN CFS	CONFIDENCE LIMITS .95 FLOW IN CFS
118000.	140000.	.20	171000.	91300.
96100.	108000.	.50	133000.	76600.
81700.	89300.	1.00	109000.	66600.
69000.	73500.	2.00	88800.	57600.
57800.	60300.	4.00	71700.	49400.
54400.	56400.	5.00	66700.	46900.
44800.	45800.	10.00	53000.	39400.
36100.	36500.	20.00	41300.	32400.
25400.	25400.	50.00	28100.	22800.
19100.	19000.	80.00	21400.	16700.
16900.	16800.	90.00	19100.	14500.
15500.	15300.	95.00	17700.	13100.
13500.	13200.	99.00	15600.	11100.

SYSTEMATIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	4.4258	HISTORIC EVENTS	0
STANDARD DEV	.1689	HIGH OUTLIERS	0
COMPUTED SKEW	.8488	LOW OUTLIERS	0
REGIONAL SKEW	.5500	ZERO OR MISSING	0
ADOPTED SKEW	.7829	SYSTEMATIC EVENTS	38

```
HP PLOT WRITTEN TO THE FILE:    TATA.PCL
+++++++++++++++++++++++++
+ END OF RUN            +
+ NORMAL STOP IN FFA    +
+++++++++++++++++++++++++
```

Figure B.8: Talkeetna River Near Talkeetna Single-Station Flood-Frequency Relationship

BASIN AREA = 1,996 SQ MI

WATER YEARS IN RECORD: 1964-99

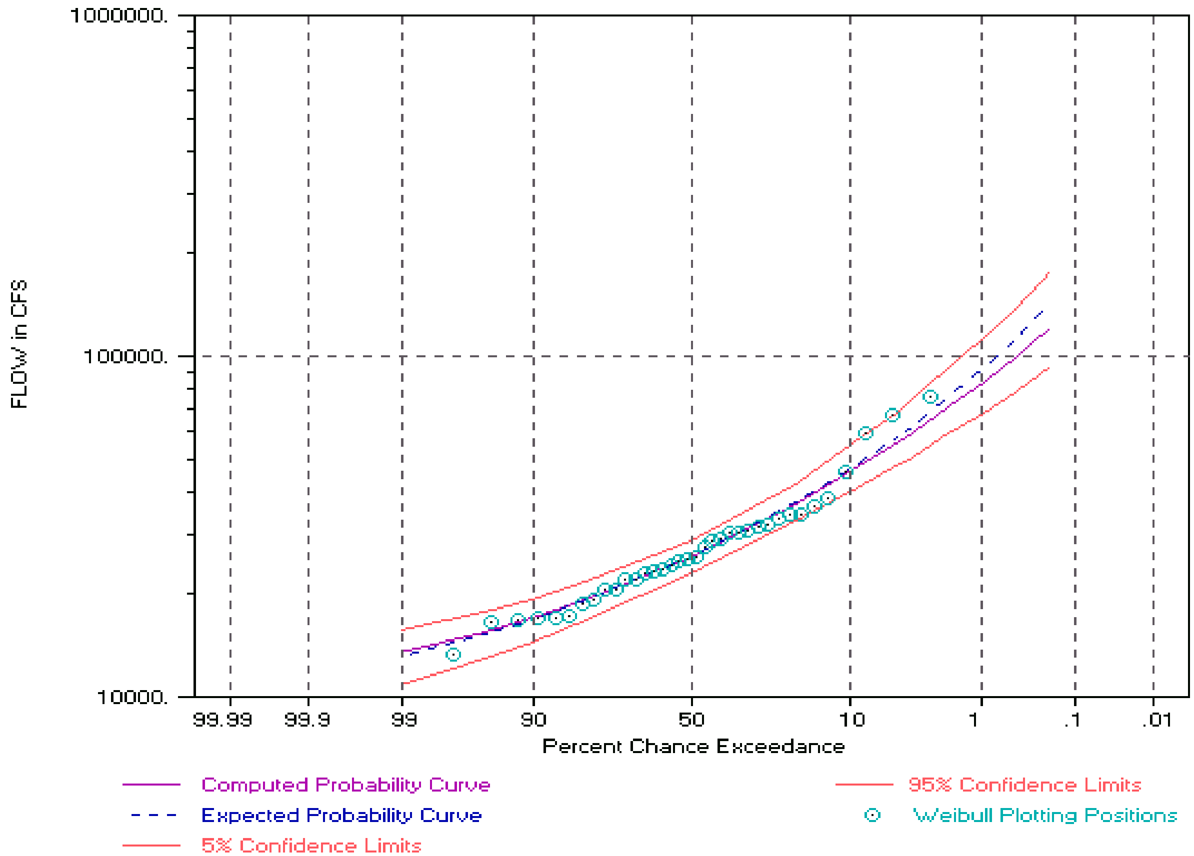

Table B.9: Summary Of Single-Station Expected-Probability Flood-Peak Discharge Estimates

			Instantaneous Peak Discharge (cfs) (Expected Probability Curve) [1]							
Station	Record Length (years)	Drainage Area (square miles)	2-Year Return Period	5-Year Return Period	10-Year Return Period	25-Year Return Period	50-Year Return Period	100-Year Return Period	200-Year Return Period	500-Year Return Period
Chulitna River near Talkeetna	27	2,570	39,700	49,100	56,300	66,900	76,000	86,400	98,300	117,000
Skwentna River at Skwentna	24	2,250	33,800	43,200	50,300	60,300	68,900	78,600	89,700	107,000
Susitna River at Gold Creek	47	6,160	44,900	59,200	69,500	83,600	95,100	108,000	121,000	141,000
Susitna River at Susitna Station	18	19,400	187,000	226,000	254,000	292,000	324,000	359,000	399,000	461,000
Susitna River near Cantwell	18	4,140	30,600	40,600	48,100	59,100	68,600	79,600	92,500	113,000
Susitna River near Denali	27	950	16,800	21,300	25,000	30,600	35,600	41,600	48,700	60,400
Talkeetna River near Talkeetna	36	1,996	25,400	36,500	45,800	60,300	73,500	89,300	108,000	140,000

Notes:

1. Peak discharges were estimated using the methods presented in: Interagency Advisory Committee on Water Data. 1982. *Guidelines for Determining Flood Flow Frequency*. U.S. Geological Survey, Office of Water Data Coordination, Washington D. C. Bulletin 17B.

Table B.10: Drainage Basin Characteristics

Station	Record Length (years) [2]	Drainage Area (sq. miles) [2]	Area of Forest (%)	Area of Glaciers (%)	Area Of Lakes and Ponds (%)	Main Channel Slope (ft/mi)	Main Channel Length (mi)	Mean Basin Elevation (ft)	Mean Annual Precipitation (in)	Mean Minimum January Temp. (deg F)
Chulitna River near Talkeetna	27	2,570	22	27	1	23.0	87.0	3,760	55	-5
Skwentna River near Skwentna	24	2,250	34	11	5	30.6	98.0	2,810	45	-5
Susitna River at Gold Creek	47	6,160	7	5	1	10.2	189	3,420	30	-5
Susitna River at Susitna Station	18	19,400	21	11	2	11.0	289	3,200	35	0
Susitna River near Cantwell	18	4,140	5	7	2	10.0	107	3,560	30	-6
Susitna River near Denali	27	950	1	25	1	56.6	51.0	4,510	50	-6
Talkeetna River near Talkeetna	36	1,996	25	7	0	35.0	90.3	3,630	35	-2

Notes:
1. Unless otherwise specified, the data were obtained from: Jones and Fahl. 1994. *Magnitude and Frequency of Floods in Alaska and Conterminous Basins of Canada.* US Geological Survey. Water-Resources Investigations Report 93-4179. Anchorage, Alaska.
2. Data obtained from USGS website, 3 October 2001.

Table B.11: Regression Analysis, 2-Year Return Period

Weighted analysis using weights in Record Length (years)

The regression equation is

$$(\log_{10})Q_2 = -\ 0.127 + 0.861\ (\log_{10})DA + 1.06\ (\log_{10})MAP$$

Predictor	Coef	SE Coef	T	P
Constant	-0.1265	0.7373	-0.17	0.872
DA	0.86051	0.08936	9.63	0.001
MAP	1.0562	0.3183	3.32	0.029

S = 0.3558   R-Sq = 96.2%   R-Sq(adj) = 94.4%

PRESS = 0.524958   R-Sq(pred) = 96.10%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	2	12.9605	6.4803	51.19	0.001
Residual Error	4	0.5064	0.1266		
Total	6	13.4669			

Source	DF	Seq SS
DA	1	11.5662
MAP	1	1.3943

Table B.12: Regression Analysis, 5-Year Return Period

Weighted analysis using weights in Record Length (years)

The regression equation is

$$(\log_{10})Q_5 = 2.35 + 0.665\ (\log_{10})DA$$

Predictor	Coef	SE Coef	T	P
Constant	2.3500	0.3882	6.05	0.002
DA	0.6646	0.1099	6.05	0.002

S = 0.5482 R-Sq = 88.0% R-Sq(adj) = 85.6%

PRESS = 1.54308 R-Sq(pred) = 87.64%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	10.985	10.985	36.56	0.002
Residual Error	5	1.502	0.300		
Total	6	12.488			

Table B.13: Regression Analysis, 10-Year Return Period

Weighted analysis using weights in Record Length (years)

The regression equation is

$$(\log_{10})Q_{10} = 2.48 + 0.647\ (\log_{10})DA$$

Predictor	Coef	SE Coef	T	P
Constant	2.4834	0.3766	6.59	0.001
DA	0.6471	0.1066	6.07	0.002

S = 0.5318 R-Sq = 88.0% R-Sq(adj) = 85.7%

PRESS = 1.45191 R-Sq(pred) = 87.72%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	10.413	10.413	36.82	0.002
Residual Error	5	1.414	0.283		
Total	6	11.827			

Table B.14: Regression Analysis, 25-Year Return Period

Weighted analysis using weights in Record Length (years)

The regression equation is

$$(\log_{10})Q_{25} = 2.66 + 0.621\ (\log_{10})DA$$

Predictor	Coef	SE Coef	T	P
Constant	2.6597	0.3766	7.06	0.001
DA	0.6215	0.1066	5.83	0.002

S = 0.5318 R-Sq = 87.2% R-Sq(adj) = 84.6%

PRESS = 1.45080 R-Sq(pred) = 86.83%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	9.6053	9.6053	33.96	0.002
Residual Error	5	1.4140	0.2828		
Total	6	11.0193			

Table B.15: Regression Analysis, 50-Year Return Period

Weighted analysis using weights in Record Length (years)

The regression equation is

$$(\log_{10})Q_{50} = 2.79 + 0.601\ (\log_{10})DA$$

Predictor	Coef	SE Coef	T	P
Constant	2.7946	0.3865	7.23	0.001
DA	0.6009	0.1094	5.49	0.003

S = 0.5458 -Sq = 85.8% R-Sq(adj) = 82.9%

PRESS = 1.52734 R-Sq(pred) = 85.41%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	8.9812	8.9812	30.15	0.003
Residual Error	5	1.4895	0.2979		
Total	6	10.4707			

Table B.16: Regression Analysis, 100-Year Return Period

Weighted analysis using weights in Record Length (years)

The regression equation is

$$(\log_{10})Q_{100} = 2.93 + 0.579\ (\log_{10})DA$$

Predictor	Coef	SE Coef	T	P
Constant	2.9330	0.3988	7.36	0.001
DA	0.5793	0.1129	5.13	0.004

S = 0.5631 R-Sq = 84.0% R-Sq(adj) = 80.8%

PRESS = 1.62500 R-Sq(pred) = 83.64%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	8.3451	8.3451	26.31	0.004
Residual Error	5	1.5857	0.3171		
Total	6	9.9307			

Table B.17: Regression Analysis, 200-Year Return Period

Weighted analysis using weights in Record Length (years)

The regression equation is

$$(\log_{10})Q_{200} = 3.08 + 0.555\ (\log_{10})DA$$

Predictor	Coef	SE Coef	T	P
Constant	3.0809	0.4218	7.30	0.001
DA	0.5546	0.1194	4.64	0.006

S = 0.5956 R-Sq = 81.2% R-Sq(adj) = 77.4%

PRESS = 1.81726 R-Sq(pred) = 80.72%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	7.6509	7.6509	21.56	0.006
Residual Error	5	1.7739	0.3548		
Total	6	9.4248			

Table B.18: Regression Analysis, 500-Year Return Period

Weighted analysis using weights in Record Length (years)

The regression equation is

$$(\log_{10})Q_{500} = 3.27 + 0.523\ (\log_{10})DA$$

Predictor	Coef	SE Coef	T	P
Constant	3.2739	0.4508	7.26	0.001
DA	0.5230	0.1277	4.10	0.009

S = 0.6367 R-Sq = 77.0% R-Sq(adj) = 72.5%

PRESS = 2.07571 R-Sq(pred) = 76.49%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	6.8023	6.8023	16.78	0.009
Residual Error	5	2.0270	0.4054		
Total	6	8.8292			

Table B.19: Summary Of Annual Peak Discharge Data For The Susitna River Below Talkeetna

	Discharge (cfs)			
Date of Peak Discharge	Susitna River at Chulitna River [4]	Chulitna River at its Mouth [5]	Talkeetna River at its Mouth [6]	**Susitna River below Talkeetna** [7]
8/16/1965	33,600 [2]	34,800 [2]	21,600 [2]	**90,000** [3]
6/6/1966	65,500 [1]	28,800 [2]	22,800 [2]	**117,100**
8/15/1967	82,600 [1]	75,000 [2]	26,100 [2]	**183,700**
6/13/1968	39,200 [2]	39,900 [2]	25,300 [1]	**104,400**
6/17/1969	22,500 [2]	29,200 [1]	6,600 [2]	**58,300**
8/2/1970	32,500 [2]	37,400 [1]	12,200 [2]	**82,100**
8/10/1971	90,000 [1]	41,100 [2]	63,600 [2]	**194,700**
6/17/1972	85,000 [1]	28,800 [2]	27,800 [2]	**141,600**
7/28/1980	46,500 [2]	57,300 [2]	34,800 [1]	**138,600**
8/2/1981	55,700 [2]	64,400 [1]	36,900 [2]	**157,000**
7/25/1982	32,800 [2]	43,200 [2]	38,600 [1]	**114,600**
8/9/1983	30,800 [2]	49,800 [1]	16,100 [2]	**96,700**
8/25/1984	30,700 [2]	32,900 [2]	34,500 [1]	**98,100**
7/21/1985	39,500 [2]	32,200 [2]	29,300 [1]	**101,000**
7/21/1986	25,000 [2]	33,100 [2]	20,800 [1]	**78,900**

Notes:
1. These values represent instantaneous maximum annual peak discharges.
2. These values represent mean daily discharges.
3. This value represents a maximum annual mean daily discharge.
4. The discharge on the Susitna River at its confluence with the Chulitna River was calculated as the discharge at the Susitna River at Gold Creek gaging station multiplied by a drainage area adjustment ratio. The ratio (1.029) was calculated as the drainage area of the Susitna River at the confluence with the Chulitna, divided by the drainage area of the Susitna River at Gold Creek.
5. The discharge on the Chulitna River at its mouth was calculated as the discharge at the Chulitna River near Talkeetna gaging station multiplied by an drainage area adjustment ratio. The ratio (1.028) was calculated as the drainage area of the Chulitna River at its mouth divided by the drainage area of the Chulitna River at the gaging station.
6. The discharge on the Talkeetna River at its mouth was calculated as the discharge at the Talkeetna River gaging station, multiplied by a drainage area adjustment ratio. The ratio (1.01) was calculated as the drainage area of the Talkeetna River at its mouth divided by the drainage area of the Talkeetna River near Talkeetna.
7. The discharge for the Susitna River below Talkeetna was calculated as the sum of the discharges for the Susitna River at the confluence with the Chulitna and the Chulitna River at its mouth, and the Talkeetna River at its mouth. The discharge values presented here represent annual peak discharges, unless noted otherwise.

Table B.20: Single-Station Flood-Frequency Analysis For The Susitna River Below Talkeetna

```
************************************      ************************************
*              FFA                 *      *                                  *
*     FLOOD FREQUENCY ANALYSIS     *      *   U.S. ARMY CORPS OF ENGINEERS   *
*     PROGRAM DATE:  FEB 1995      *      * THE HYDROLOGIC ENGINEERING CENTER *
*          VERSION:  3.1           *      *         609 SECOND STREET        *
*     RUN  DATE   AND   TIME:      *      *      DAVIS, CALIFORNIA 95616     *
*        02 JAN 02    11:47:41     *      *          (916) 756-1104          *
*                                  *      *                                  *
************************************      ************************************
 INPUT FILE NAME: SUBT.TXT
OUTPUT FILE NAME: SUBT.OUT
   DSS FILE NAME: SUBT.DSS
   -----DSS---ZOPEN:  New File Opened,  File: SUBT.DSS
                      Unit:  71;  DSS Version: 6-JB
**TITLE RECORD(S)**
TT    FLOOD FLOW FREQUENCY ANALYSIS PROGRAM
TT   GENERALIZED SKEW AND STANDARD ERROR OF GENERALIZED SKEW OBTAINED FROM
TT   JONES AND FAHL (1994) FOR REGION 2
**JOB RECORD(S)**
     IPPC   ISKFX  IPROUT    IFMT    IWYR   IUNIT   ISMRY   IPNCH    IREG
J1     0       2      32       0       0       0       0       0       0
       A       B  CLIMIT  NDSSCV    IEXT
J2   .00     .00     .05       0       0
**FREQUENCY ARRAY**
FR    13    .200    .500   1.000   2.000   4.000   5.000  10.000  20.000  50.000
FR80.000  90.000  95.000  99.000
**STATION IDENTIFICATION**
ID    SUSITNA RIVER BELOW TALKEETNA    DA=10996 SQ MI           1965-1972,1980-1986
**GENERALIZED SKEW**
     ISTN   GGMSE    SKEW
GS   SUAa    .740     .55
**HP PLOT **
     HP PLOT FILE                  IHPCV  KLIMIT    IPER    BAREA
HP  SUAa.PCL                           0       0       10996 SQ MI
     SELECTED CURVES ON HPPLOT
          EXPECTED PROBABILITY CURVE
          CONFIDENCE LIMITS
**SYSTEMATIC EVENTS**
     15 EVENTS TO BE ANALYZED
**END OF INPUT DATA**
ED ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
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Table B.20: (Continued)

FINAL RESULTS

-PLOTTING POSITIONS- SUSITNA RIVER BELOW TALKEETNA DA=10996 SQ M

EVENTS ANALYZED				ORDERED EVENTS			
MON	DAY	YEAR	FLOW CFS	RANK	WATER YEAR	FLOW CFS	WEIBULL PLOT POS
0	0	1965	90000.	1	1971	194700.	6.25
0	0	1966	117100.	2	1967	183700.	12.50
0	0	1967	183700.	3	1981	157000.	18.75
0	0	1968	104400.	4	1972	141600.	25.00
0	0	1969	58300.	5	1980	138600.	31.25
0	0	1970	82100.	6	1966	117100.	37.50
0	0	1971	194700.	7	1982	114600.	43.75
0	0	1972	141600.	8	1968	104400.	50.00
0	0	1980	138600.	9	1985	101000.	56.25
0	0	1981	157000.	10	1984	98100.	62.50
0	0	1982	114600.	11	1983	96700.	68.75
0	0	1983	96700.	12	1965	90000.	75.00
0	0	1984	98100.	13	1970	82100.	81.25
0	0	1985	101000.	14	1986	78900.	87.50
0	0	1986	78900.	15	1969	58300.	93.75

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 15 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.247

0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 53177.5

HIGH OUTLIER TEST

BASED ON 15 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.247

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 233234.

-SKEW WEIGHTING -

BASED ON 15 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = .321

DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = .740

Table B.20: (Continued)

FINAL RESULTS

-FREQUENCY CURVE- SUSITNA RIVER At TALKEETNA DA=10996 SQ M

COMPUTED CURVE FLOW IN CFS	EXPECTED PROBABILITY FLOW IN CFS	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 FLOW IN CFS	CONFIDENCE LIMITS .95 FLOW IN CFS
309000.	402000.	.20	503000.	235000.
275000.	333000.	.50	427000.	215000.
250000.	289000.	1.00	373000.	199000.
226000.	251000.	2.00	324000.	183000.
202000.	217000.	4.00	277000.	167000.
194000.	207000.	5.00	263000.	162000.
171000.	177000.	10.00	220000.	145000.
146000.	149000.	20.00	180000.	127000.
110000.	110000.	50.00	128000.	95100.
84200.	82800.	80.00	97400.	68600.
73600.	71200.	90.00	86400.	57300.
66000.	62700.	95.00	78700.	49400.
54100.	48600.	99.00	66900.	37600.

SYSTEMATIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	5.0468	HISTORIC EVENTS	0
STANDARD DEV	.1429	HIGH OUTLIERS	0
COMPUTED SKEW	.0196	LOW OUTLIERS	0
REGIONAL SKEW	.5500	ZERO OR MISSING	0
ADOPTED SKEW	.1802	SYSTEMATIC EVENTS	15

HP PLOT WRITTEN TO THE FILE: SUAa.PCL

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+++++++++++++++++++++++++
+ END OF RUN            +
+ NORMAL STOP IN FFA    +
+++++++++++++++++++++++++
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Figure B.9: Susitna River Below Talkeetna Single-Station Flood-Frequency Relationship

BASIN AREA = 10,996 SQ MI

WATER YEARS IN RECORD: 1965-72,1980-85

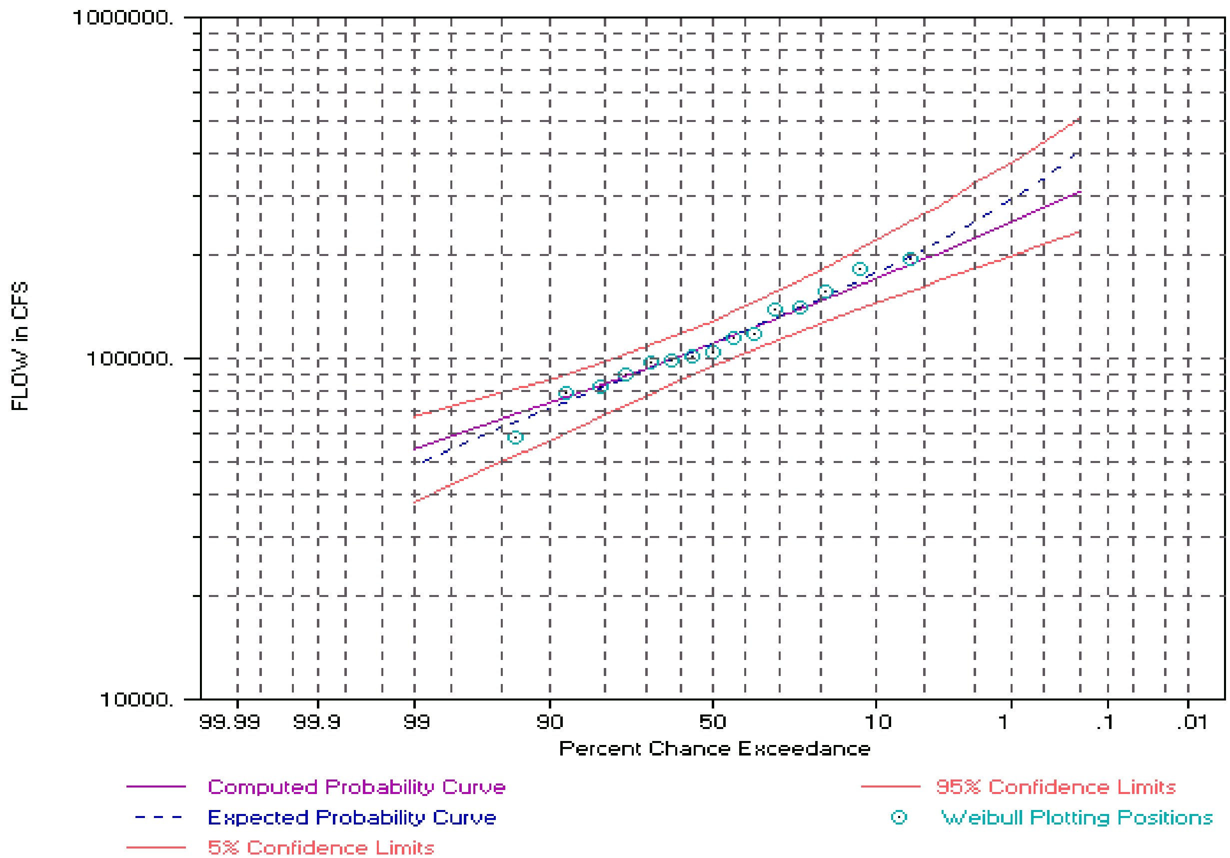

Table B.21: Summary Of Annual Peak Discharge Data For The Susitna River Above Talkeetna

	Discharge (cfs)		
Date of Peak Discharge	Susitna River at Chulitna River [4]	Chulitna River at its Mouth [5]	**Susitna River above Talkeetna** [6]
8/3/1958	51,100 [1]	34,700 [2]	**85,800**
8/24/1959	61,400 [2]	35,000 [2]	**96,400** [3]
5/26/1960	41,200 [2]	39,000 [1]	**80,200**
6/23/1961	58,200 [1]	25,100 [2]	**83,300**
6/15/1962	83,000 [1]	34,400 [2]	**117,400**
9/17/1965	28,200 [2]	43,300 [1]	**71,500**
6/6/1966	65,500 [1]	28,800 [2]	**94,300**
8/15/1967	82,600 [1]	75,000 [2]	**157,600**
6/13/1968	39,200 [2]	41,300 [1]	**80,500**
6/17/1969	22,500 [1]	29,200 [2]	**51,700**
8/2/1970	32,500 [2]	37,400 [1]	**69,900**
8/10/1971	90,000 [1]	41,100 [2]	**131,100**
6/17/1972	85,000 [1]	28,800 [2]	**113,800**
7/28/1980	46,500 [2]	60,600 [1]	**107,100**
8/2/1981	55,700 [2]	64,400 [1]	**120,100**
7/25/1982	32,800 [2]	47,900 [1]	**76,000**
8/9/1983	30,800 [2]	49,800 [1]	**80,600**
6/17/1984	60,800 [1]	20,600 [2]	**81,400**
7/2/1985	39,800 [2]	41,800 [1]	**81,600**
7/14/1986	27,900 [2]	37,300 [1]	**65,200**

Notes:

1. These values represent instantaneous maximum annual peak discharges.
2. These values represent mean daily discharges.
3. This value represents a maximum annual mean daily discharge.
4. The discharge on the Susitna River at its confluence with the Chulitna River was calculated as the discharge at the Susitna River at Gold Creek gaging station multiplied by an drainage area adjustment ratio. The ratio (1.029) was calculated as the drainage area of the Susitna River at the confluence with the Chulitna, divided by the drainage area of the Susitna River at Gold Creek.
5. The discharge on the Chulitna River at its mouth was calculated as the discharge at the Chulitna River near Talkeetna gaging station multiplied by an drainage area adjustment ratio. The ratio (1.028) was calculated as the drainage area of the Chulitna River at its mouth divided by the drainage area of the Chulitna River at the gaging station.
6. The discharge for the Susitna River above Talkeetna was calculated as the sum of the discharges for the Susitna River at the confluence with the Chulitna and the Chulitna River at its mouth.
The discharge values presented here represent maximum annual peak discharges, unless noted otherwise.

Table B.22: Single-Station Flood-Frequency Analysis For The Susitna River Above Talkeetna

```
************************************      *************************************
*              FFA                  *      *                                   *
*     FLOOD FREQUENCY ANALYSIS      *      *   U.S. ARMY CORPS OF ENGINEERS    *
*     PROGRAM DATE:  FEB 1995       *      * THE HYDROLOGIC ENGINEERING CENTER *
*          VERSION:  3.1            *      *         609 SECOND STREET         *
*     RUN  DATE   AND   TIME:       *      *      DAVIS, CALIFORNIA 95616      *
*        02 JAN 02    11:47:24      *      *          (916) 756-1104           *
*                                   *      *                                   *
************************************      *************************************
 INPUT FILE NAME: SUAT.TXT
OUTPUT FILE NAME: SUAT.OUT
   DSS FILE NAME: SUAT.DSS
   -----DSS---ZOPEN:  Existing File Opened,  File: SUAT.DSS
                      Unit:  71;  DSS Version: 6-JB
**TITLE RECORD(S)**
TT    FLOOD FLOW FREQUENCY ANALYSIS PROGRAM
TT   GENERALIZED SKEW AND STANDARD ERROR OF GENERALIZED SKEW OBTAINED FROM
TT   JONES AND FAHL (1994) FOR REGION 2
**JOB RECORD(S)**
     IPPC   ISKFX  IPROUT    IFMT    IWYR   IUNIT   ISMRY   IPNCH    IREG
J1     0       2      32       0       0       0       0       0       0
       A       B  CLIMIT  NDSSCV    IEXT
J2   .00     .00     .05       0       0
**FREQUENCY ARRAY**
FR    13    .200    .500   1.000   2.000   4.000   5.000  10.000  20.000  50.000
FR80.000  90.000  95.000  99.000
**STATION IDENTIFICATION**
ID    SUSITNA RIVER ABOVE TALKEETNA   DA=8980 SQ MI           1958-1972,1980-1986
**GENERALIZED SKEW**
     ISTN   GGMSE    SKEW
GS   SUAT    .740     .55
**HP PLOT **
     HP PLOT FILE                  IHPCV  KLIMIT    IPER    BAREA
HP  SUAT.PCL                           0       0       8980 SQ MI
     SELECTED CURVES ON HPPLOT
          EXPECTED PROBABILITY CURVE
          CONFIDENCE LIMITS
**SYSTEMATIC EVENTS**
     20 EVENTS TO BE ANALYZED
**END OF INPUT DATA**
ED ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
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Table B.22: (Continued)

FINAL RESULTS

-PLOTTING POSITIONS- SUSITNA RIVER ABOVE TALKEETNA DA=8980 SQ

EVENTS ANALYZED				ORDERED EVENTS			
MON	DAY	YEAR	FLOW CFS	RANK	WATER YEAR	FLOW CFS	WEIBULL PLOT POS
0	0	1958	85800.	1	1967	157600.	4.76
0	0	1959	96400.	2	1971	131100.	9.52
0	0	1960	80200.	3	1981	120100.	14.29
0	0	1961	83300.	4	1962	117400.	19.05
0	0	1962	117400.	5	1972	113800.	23.81
0	0	1965	71500.	6	1980	107100.	28.57
0	0	1966	94300.	7	1959	96400.	33.33
0	0	1967	157600.	8	1966	94300.	38.10
0	0	1968	80500.	9	1958	85800.	42.86
0	0	1969	51700.	10	1961	83300.	47.62
0	0	1970	69900.	11	1985	81600.	52.38
0	0	1971	131100.	12	1984	81400.	57.14
0	0	1972	113800.	13	1983	80600.	61.90
0	0	1980	107100.	14	1968	80500.	66.67
0	0	1981	120100.	15	1960	80200.	71.43
0	0	1982	76000.	16	1982	76000.	76.19
0	0	1983	80600.	17	1965	71500.	80.95
0	0	1984	81400.	18	1970	69900.	85.71
0	0	1985	81600.	19	1986	65200.	90.48
0	0	1986	65200.	20	1969	51700.	95.24

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 20 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.385
0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 47553.8

HIGH OUTLIER TEST

BASED ON 20 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.385
0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 167383.

-SKEW WEIGHTING -

BASED ON 20 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = .268
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = .740

Table B.22: (Continued)

FINAL RESULTS

-FREQUENCY CURVE- SUSITNA RIVER ABOVE TALKEETNA DA=8980 SQ

COMPUTED CURVE FLOW IN CFS	EXPECTED PROBABILITY FLOW IN CFS	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 FLOW IN CFS	CONFIDENCE LIMITS .95 FLOW IN CFS
212000.	252000.	.20	297000.	174000.
191000.	216000.	.50	258000.	159000.
176000.	193000.	1.00	231000.	149000.
161000.	172000.	2.00	205000.	138000.
146000.	153000.	4.00	180000.	127000.
141000.	147000.	5.00	172000.	124000.
126000.	129000.	10.00	149000.	112000.
111000.	112000.	20.00	127000.	100000.
87900.	87900.	50.00	97100.	79400.
71200.	70600.	80.00	78900.	62100.
64300.	63200.	90.00	72000.	54700.
59400.	57800.	95.00	67200.	49300.
51600.	48900.	99.00	59600.	41000.

SYSTEMATIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	4.9504	HISTORIC EVENTS	0
STANDARD DEV	.1146	HIGH OUTLIERS	0
COMPUTED SKEW	.2590	LOW OUTLIERS	0
REGIONAL SKEW	.5500	ZERO OR MISSING	0
ADOPTED SKEW	.3364	SYSTEMATIC EVENTS	20

HP PLOT WRITTEN TO THE FILE: SUAT.PCL

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+++++++++++++++++++++++++
+ END OF RUN            +
+ NORMAL STOP IN FFA    +
+++++++++++++++++++++++++
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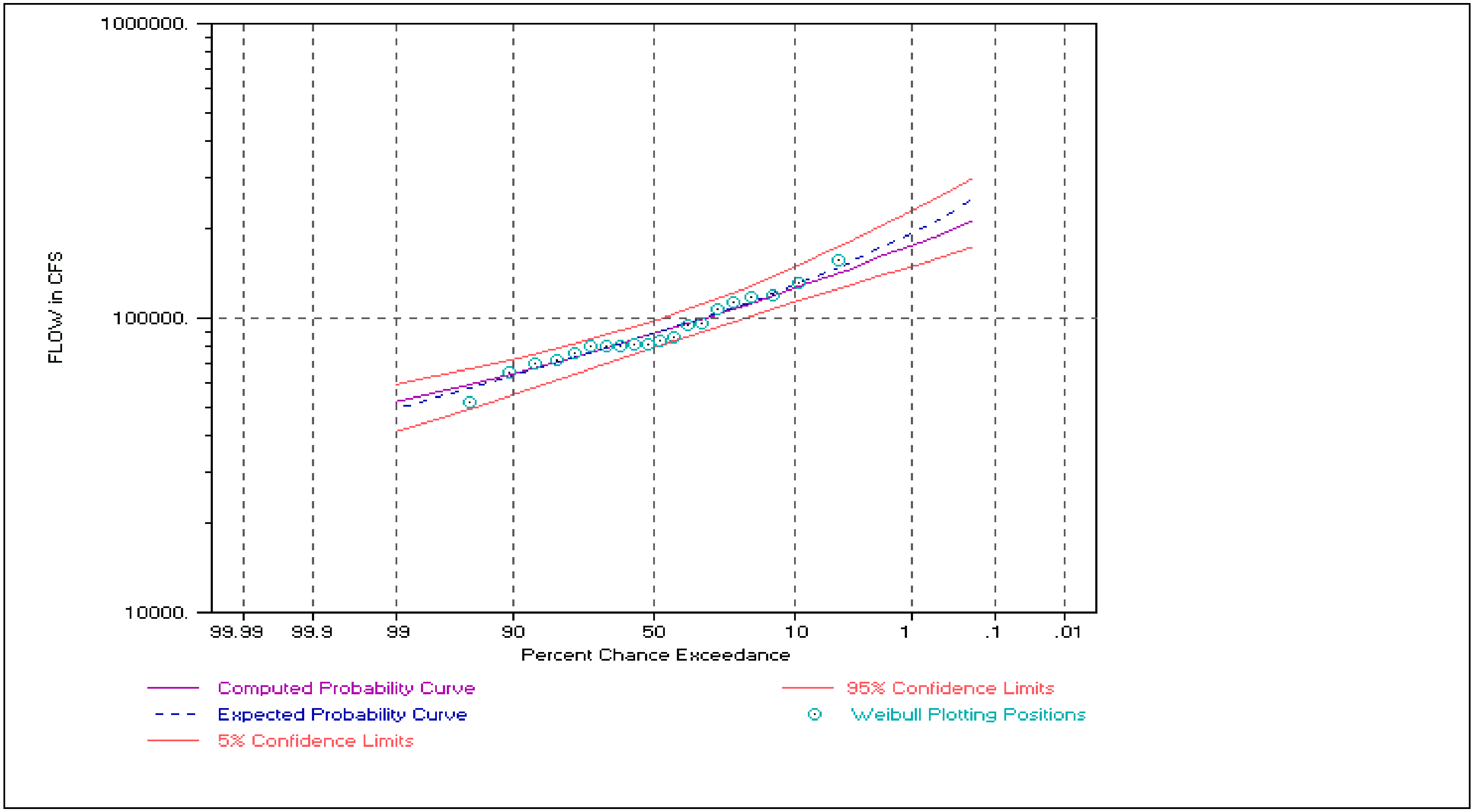
Figure B.10: Susitna River Above Talkeetna Single-Station Flood-Frequency Relationship

BASIN AREA = 8,980 SQ MI

WATER YEARS IN RECORD: 1958-72,1980-86



APPENDIX C

EXPECTED PROBABILITY

TABLE OF CONTENTS

LIST OF FIGURES

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C.1 INTRODUCTION

The expected probability adjustment was made to the base curves associated with the single-station flood frequency analyses developed for this project (Section B.2, Appendix B). The following discussion is based on the description of expected probability provided in Appendix 11 of *Guidelines for Determining Flood Flow Frequency* (Interagency Advisory Committee on Water Data, 1982).

C.2 WHAT IS EXPECTED PROBABILITY?

The base curve of a flood frequency analysis is the average discharge associated with a given exceedance probability.[1] In other words, the base curve presents the average discharge that will be exceeded X or more times per 100 events. However, once a structure is built, the discharge that the structure can safely accommodate is fixed. We are not interested in the average discharge the structure can safely accommodate. Instead, we need to know the average number of times the design discharge will be exceeded per 100 events. Unfortunately, the average number of times the discharge is likely to be exceeded per 100 events is usually not the same as the exceedance probability associated with the base curve. The average exceedance probability is referred to as the expected probability. The following example will help clarify the difference between the base curve and the expected probability curve, and demonstrate the need to use the expected probability curve in the design of water resources structures.

Based on the base curve (0.50) in Figure C.1, a discharge of 1,140 cubic feet per second (cfs) will be exceeded an average of 5 times per 100 events. If we build a structure based on a design discharge of 1,140 cfs, what is the average number of times the design discharge is likely to be exceeded per 100 events? Your first answer might be that the design event will be exceeded an average of 5 times per 100 events. But is that correct?

The average number of times the design discharge will be exceeded per 100 events is computed from the confidence limits on the base curve. For example, at a design discharge of 1,140 cfs there is a 5 percent chance that the design discharge will be exceeded 23 or more times per 100 events (Figure C.1). There is a 10 percent chance that the design discharge will be exceeded 17

[1] Exceedance Probability is the number of times a discharge will be equaled or exceeded per 100 events.

or more times per 100 events, and a 25 percent chance that the design discharge will be exceeded 10 or more times per 100 events. Similarly, there is a 50, 75, 90, and 95 percent chance that the design discharge will be exceeded 5, 2.4, 1.0, 0.6, or more times per 100 events, respectively.

The average of the number of times the design discharge will be exceeded is the average exceedance probability (or expected probability). As shown in Table C.1, the design discharge will be exceeded an average of 8.4 times per 100 events, not 5 times per 100 events as one might have expected.

If the acceptable risk for which the structure was designed is 5 times per 100 events, the structure was under designed. In order for the average number of exceedances to be 5 times per 100 events, the design discharge would have to be greater than 1,140 cfs. Use of the mathematically derived expected probability curve will provide an estimate of the discharge for which the average number of exceedances per 100 events is 5. Based on Figure C.1, and the expected probability curve, the discharge with an average number of exceedances of 5 per 100 events is 1,260 cfs. This can be confirmed by following the procedure that is described in the paragraph above, using a discharge of 1,260 cfs. The results of conducting such an analysis are presented in Table C.2. Finally, it should be noted that as the number of years of record increases, the confidence limits on the base curve get tighter, and the expected probability curve approaches the base curve.

Figure C.1: Exceedance Frequency in Percent

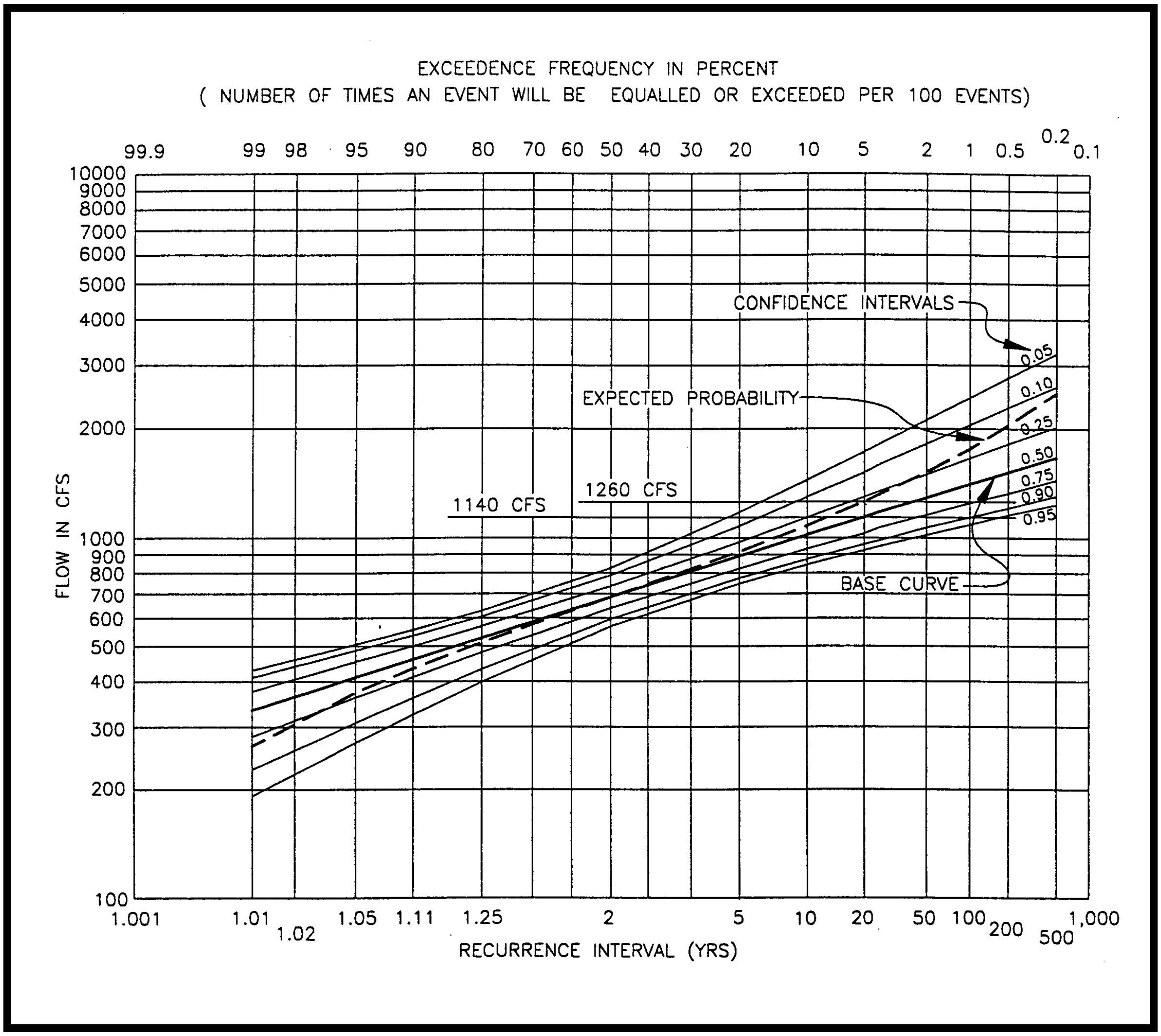

Table C.1: Exceedance Per 100 Events Based on the Confidence Intervals Shown on Figure C.1 Design Flow = 1,140 cfs

Confidence Interval	Exceedance Per 100 Events
0.05	23.0
0.10	17.0
0.25	10.0
0.50	5.0
0.75	2.4
0.90	1.0
0.95	0.6
Average = 0.50	Average = 8.4

Table C.2: Exceedance Per 100 Events Based on the Confidence Intervals Shown on Figure C.1 Design Flow = 1,260 cfs

Confidence Interval	Exceedance Per 100 Events
0.05	15.9
0.10	10.4
0.25	5.6
0.50	2.3
0.75	0.7
0.90	0.3
0.95	0.1
Average = 0.50	Average = 5.0

APPENDIX D

FLOOD-PEAK TIMING

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D.1 INTRODUCTION

A flood-peak timing analysis was conducted to answer two questions. First, during a 100-year flood on the Talkeetna River, what will the magnitude of the discharge on the Susitna River be? Second, during a 100-year flood on the Susitna River, what will the magnitude of the discharge on the Talkeetna River be?

To address these questions, discharge data from three U.S. Geological Survey (USGS) stream gage stations were used to develop two regression equations. The first regression equation can be used to estimate the discharge in the Susitna River immediately above the Talkeetna River, given the discharge in the Talkeetna River at its mouth. The second regression equation can be used to estimate the discharge in the Talkeetna River at its mouth, given the discharge in the Susitna River immediately above the Talkeetna River. Thus, the equations can be used to estimate: (1) the discharge in the Susitna River at the time of the 100-year flood-peak discharge on the Talkeetna River, and (2) the discharge in the Talkeetna River at the time of the 100-year flood-peak discharge on the Susitna River.

D.2 DATA

Mean daily discharge data from three USGS stream gage stations were used: the Susitna River at Gold Creek, the Chulitna River near Talkeetna, and the Talkeetna River near Talkeetna. The locations of the stations are presented in Figure D.1.

To develop the regression equations, it was necessary to identify the years in which mean daily discharge data had been collected at all three locations. Sixteen years of concurrent record were available: 1964 through 1972, and 1980 through 1986. Using this data, the discharge at the mouth of the Talkeetna River and the discharge on the Susitna River immediately above the Talkeetna River were computed.

The discharge at the mouth of the Talkeetna River was computed by multiplying the discharge at the Talkeetna River stream gage by a coefficient. The coefficient (1.01) was the ratio of the drainage area above the mouth of the Talkeetna River (2,016 square miles) divided by the drainage area above the stream gage on the Talkeetna River (1,996 square miles)[1].

To estimate the discharge on the Susitna River immediately above the Talkeetna River, a similar approach was used. The discharges at the Susitna and Chulitna River stream gages were independently extrapolated to the confluence of the Chulitna and Susitna Rivers based on drainage area ratios[2]. For each day of interest, the discharge in the Susitna River at the mouth of the Chulitna River and the discharge in the Chulitna River at its mouth were summed.

D.3 SUSITNA RIVER DISCHARGE BASED ON TALKEETNA RIVER DISCHARGE

The maximum annual mean daily discharge on the Talkeetna River near Talkeetna and the date of its occurrence were obtained from the USGS record for each year of concurrent record. The discharge values were then extrapolated to the mouth of the Talkeetna River using the method described in Section D.2. For each date on which a maximum annual Talkeetna River discharge occurred, the discharge on the Susitna River immediately above the Talkeetna River was also estimated as described in Section D.2. A tabulation of the Talkeetna and Susitna River discharges is presented in Table D.1.

Using the data in Table D.1, a regression equation was then developed to predict the discharge in the Susitna River immediately above the Talkeetna River during a flood peak of a known magnitude at the mouth of the Talkeetna River. The regression equation was developed using the Minitab Statistical Software (Minitab Inc., Release 13). A summary of the computations is presented in Table D.2 and Figure D.2. The regression equation is:

$$Q_{su} = 100(Q_{ta})^{0.656}$$

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[1] This method of extrapolation assumes a constant discharge per unit of drainage area. It is an acceptable means of extrapolating the stream gage data because the extrapolated discharge value represents a drainage area that is only slightly larger (about 1 percent) than the drainage area at the stream gage site.

[2] The drainage area of the Susitna River at the mouth of the Chulitna River and at the Gold Creek stream gage is 6,340 and 6,160 square miles, respectively. The coefficient used to extrapolate the Susitna River data is 1.029. The drainage area of the Chulitna River at its mouth and at the stream gage is 2,640 and 2,570 square miles, respectively. The coefficient used to extrapolate the Chulitna River data is 1.028.

where Q_{su}= the discharge in the Susitna River above Talkeetna, and Q_{ta} = the discharge in the Talkeetna River at its mouth.

Using the regression equation, the discharge in the Susitna River immediately above the mouth of the Talkeetna River was computed for a number of flood events on the Talkeetna River. The results are presented in Table D.3.

As shown in Table D.3, the magnitude of the 100-year flood-peak discharge at the mouth of the Talkeetna River is expected to be 90,200 cubic feet per second (cfs). Based on the regression analysis, the magnitude of the concurrent discharge in the Susitna River immediately above the mouth of the Talkeetna River is expected to be 178,000 cfs. Thus, the magnitude of the discharge in the Susitna River immediately below the Talkeetna River, at the time of the 100-year flood-peak discharge in the Talkeetna River, is expected to be 268,000 cfs.

D.4 TALKEETNA RIVER DISCHARGE BASED ON SUSITNA RIVER DISCHARGE

The maximum annual mean daily discharge on the Susitna River immediately above the Talkeetna River was computed for each year of concurrent record, as described in Section D.2. For each date on which a maximum annual Susitna River discharge occurred, the mean daily discharge on the Talkeetna River was obtained from the USGS stream gage data. These discharge values were then extrapolated from the stream gage to the mouth of the Talkeetna River using a ratio of the drainage areas. A tabulation of the Susitna and Talkeetna River discharges is presented in Table D.4.

Using the data in Table D.4, a regression equation was then developed to predict the discharge at the mouth of the Talkeetna River during a flood peak of a known magnitude on the Susitna River immediately above the Talkeetna River. The regression equation was developed using the Minitab Statistical Software (Minitab Inc., Release 13). A summary of the computations is presented in Table D.5 and Figure D.3. The regression equation is:

$$Q_{ta} = 0.00851(Q_{su})^{1.29}$$

where Q_{su}= the discharge in the Susitna River above Talkeetna, and Q_{ta} = the discharge in the Talkeetna River at its mouth.

Using the regression equation, the discharge in the Talkeetna River at its mouth was computed for a number of flood events on the Susitna River. The results are presented in Table D.6.

As shown in Table D.6, the magnitude of the 100-year flood-peak discharge on the Susitna River immediately below the mouth of the Talkeetna River is 289,000 cfs. Using the regression equation, the magnitude of the discharge on the Susitna River immediately above the mouth of the Talkeetna River and in the Talkeetna River at its mouth can be computed by assuming that the sum of the two discharges must equal the discharge in the Susitna River immediately below the Talkeetna River. Thus, at the time of the 100-year flood in the Susitna River immediately below the mouth of the Talkeetna River, the discharge in the Susitna River immediately above the Talkeetna River is estimated to be 222,000 cfs. The concurrent discharge in the Talkeetna River at its mouth is estimated to be 67,000 cfs.

Figure D.1: Location Of USGS Stream Gage Stations

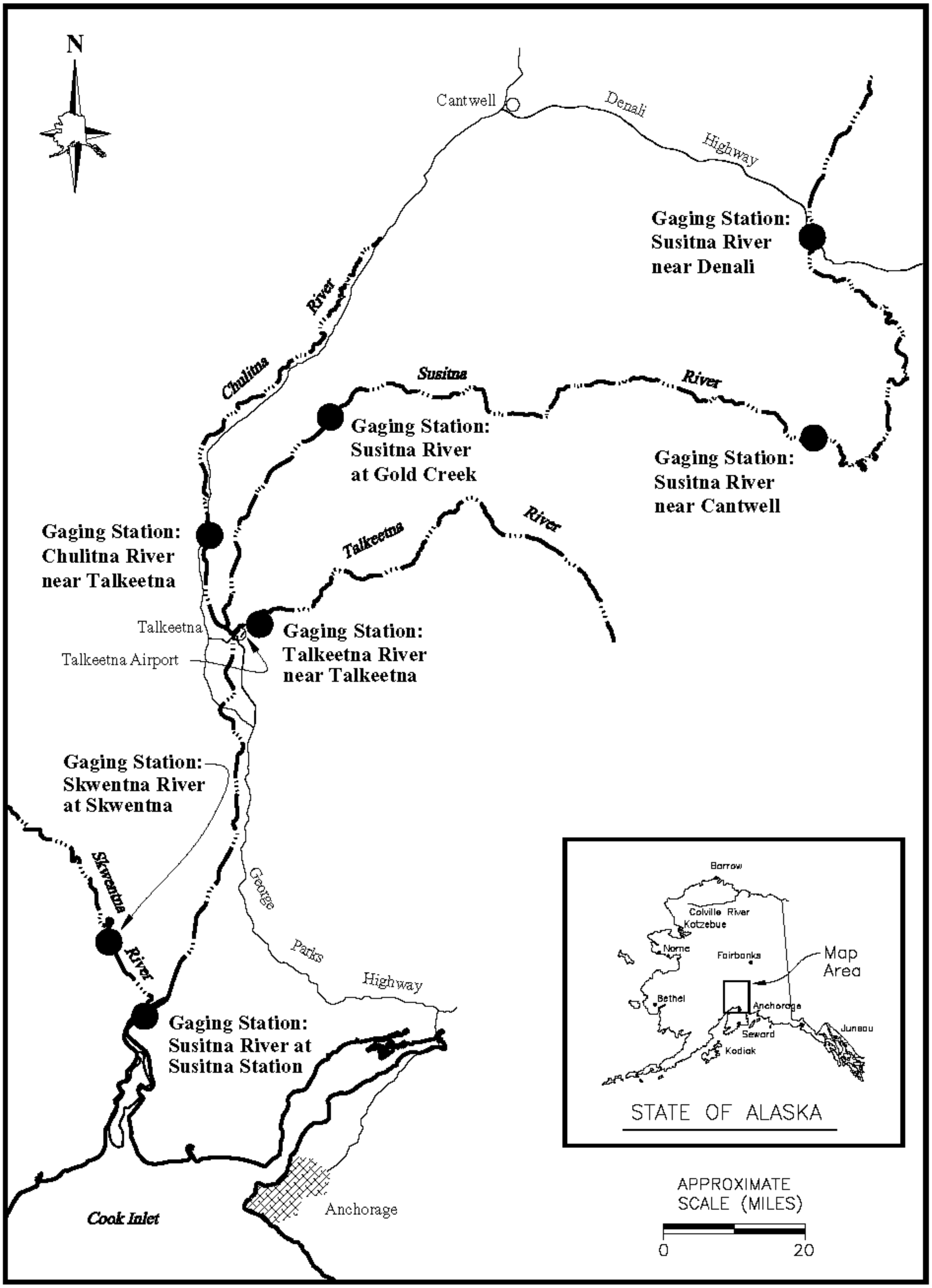

Table D.1: Susitna River Discharge During Annual Peak Discharge On The Talkeetna River

Date Discharge Occurred		Mean Daily Discharge (cfs)	
Water Year	Month/Day	Talkeetna River at its mouth [1]	Susitna River above the Talkeetna River [2]
1964	6/1	27,300	97,000
1965	9/27	23,600	56,800
1966	6/5	24,200	87,900
1967	7/20	40,400	120,800
1968	6/13	22,200	79,100
1969	5/25	13,600	38,900
1970	6/28	18,100	52,700
1971	8/10	63,600	121,100
1972	6/17	27,800	101,600
1980	7/28	29,800	103,900
1981	7/11	40,900	100,800
1982	7/25	27,900	76,000
1983	8/9	16,100	78,900
1984	8/25	24,400	63,600
1985	7/21	22,800	71,700
1986	7/21	16,700	58,100

Notes:

1. These values are the maximum annual mean daily discharge at the mouth of the Talkeetna River. The values were computed by adjusting the discharge measured at the USGS Talkeetna River stream gage for the difference in drainage area, as described in Sections D.2 and D.3.
2. The discharge on the Susitna River immediately above the Talkeetna River was computed as described in Sections D.2 and D.3.

Table D.2: Regression Analysis To Predict Susitna River Discharge

The regression equation is

Susitna $(\log_{10})$Q = 2.00 + 0.656 Talkeetna $(\log_{10})$Q

Predictor	Coef	SE Coef	T	P
Constant	2.0025	0.5910	3.39	0.004
Talkeetna $(\log_{10})$Q	0.6556	0.1340	4.89	0.000

S = 0.08747	R-Sq = 63.1%	R-Sq(adj) = 60.5%
PRESS = 0.147146	R-Sq(pred) = 49.33%	

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	0.18327	0.18327	23.95	0.000
Residual Error	14	0.10711	0.00765		
Total	15	0.29038			

Figure D.2: Talkeetna River Discharge Versus Susitna River Discharge

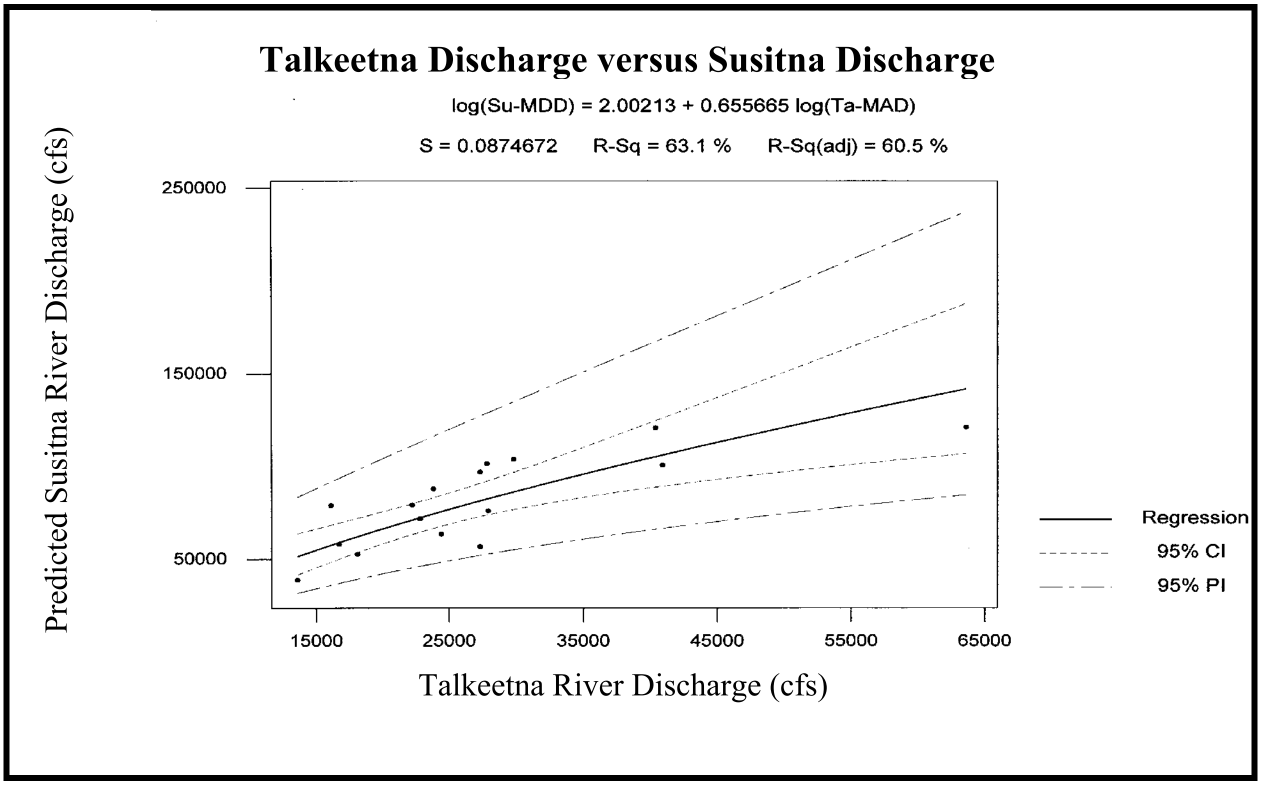

Table D.3: Predicted Susitna River Discharge During Specified Talkeetna River Discharge

Talkeetna River at its mouth		Predicted Discharge (cfs)	
Return Period (years)	Instantaneous Flood-Peak Discharge (cfs) [1]	Susitna River above Talkeetna River [2]	Susitna River below Talkeetna River
2	25,700	78,100	104,000
5	36,900	99,000	136,000
10	46,300	115,000	161,000
25	60,900	138,000	199,000
50	74,200	157,000	231,000
100	90,200	178,000	268,000
200	109,000	202,000	311,000
500	141,000	239,000	380,000

Notes:
1. The values for the instantaneous flood-peak discharge at the mouth of the Talkeetna River are from Appendix B, Section B.5.
2. A regression equation was developed, based on the data presented in Table D.1, to predict the discharge in the Susitna River above Talkeetna, given the discharge at the mouth of the Talkeetna River. The equation is as follows: $Q_{su} = 100(Q_{ta})^{0.656}$.

Table D.4: Talkeetna River Discharge During Annual Peak Discharge On The Susitna River

Date Discharge Occurred		Mean Daily Discharge (cfs)	
Water Year	Month/Day	Talkeetna River at its mouth [1]	Susitna River above the Talkeetna River [2]
1964	6/7	20,700	134,700
1965	9/7	11,100	70,000
1966	6/6	22,800	88,900
1967	8/15	26,100	153,300
1968	6/13	22,200	79,100
1969	6/17	6,600	51,400
1970	8/2	12,200	69,100
1971	8/11	40,700	124,400
1972	6/17	27,800	101,600
1980	7/28	29,800	103,900
1981	8/2	36,900	114,800
1982	7/25	27,900	76,000
1983	8/9	16,100	78,900
1984	6/17	15,200	74,100
1985	7/2	18,900	80,200
1986	7/14	12,700	63,400

Notes:
1. These values are for the discharge at the mouth of the Talkeetna River. The values were computed by adjusting the discharge measured at the USGS Talkeetna River stream gage for the difference in drainage area, as described in Sections D.2 and D.3.
2. These values are the maximum annual mean daily discharge for the Susitna River immediately above the Talkeetna River. The values were computed by adjusting the discharges measured at the USGS stream gage stations for the differences in drainage area, and summing the results, as described in Sections D.2 and D.3.

Table D.5: Regression Analysis To Predict Talkeetna River Discharge

The regression equation is

Talkeetna $(\log_{10})$Q = - 2.07 + 1.29 Susitna $(\log_{10})$Q

Predictor	Coef	SE Coef	T	P
Constant	-2.075	1.318	-1.57	0.138
Susitna $(\log_{10})$Q	1.2883	0.2664	4.84	0.000

S = 0.1328 R-Sq = 62.5% R-Sq(adj) = 59.9%

PRESS = 0.368721 R-Sq(pred) = 44.08%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	0.41240	0.41240	23.38	0.000
Residual Error	14	0.24695	0.01764		
Total	15	0.65936			

Figure D.3: Susitna River Discharge Versus Talkeetna River Discharge

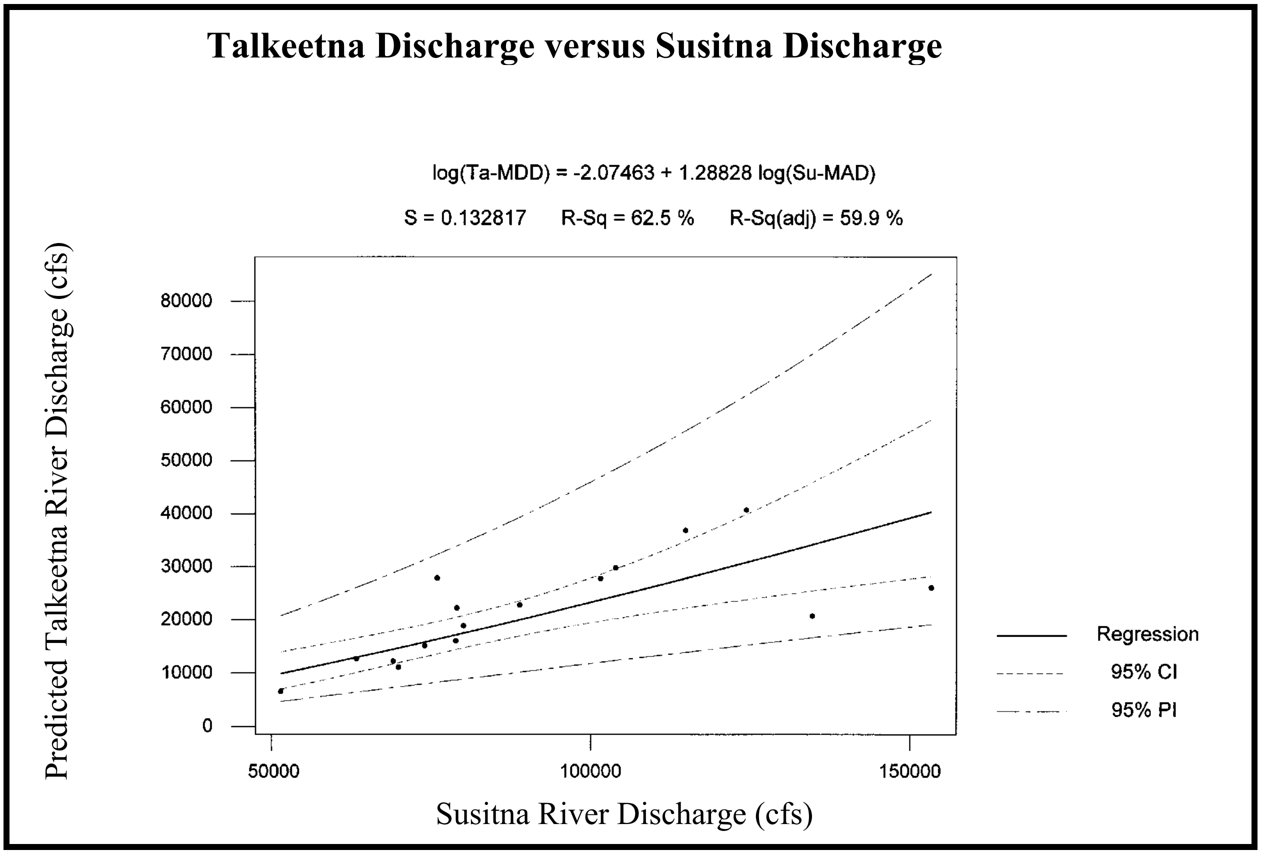

Table D.6: Predicted Talkeetna River Discharge During Specified Susitna River Discharge

Susitna River below the Talkeetna River		Discharge (cfs) [2]	
Return Period (years)	Instantaneous Flood-Peak Discharge (cfs) [1]	Susitna River above Talkeetna	Talkeetna River at its mouth [3]
2	110,000	89,300	20,700
5	149,000	119,000	30,000
10	177,000	140,000	37,000
25	217,000	170,000	47,000
50	251,000	194,000	56,000
100	289,000	222,000	67,000
200	333,000	254,000	80,000
500	402,000	302,000	100,000

Notes:
1. The values for the instantaneous flood-peak discharge on the Susitna River below Talkeetna were calculated by single-station flood-frequency analysis, as presented in Appendix B, Section B.4.2.
2. The discharge values for the Susitna River above Talkeetna and the Talkeetna River at its mouth were estimated as described in Section D.4.
3. A regression equation was developed, based on the data presented in Table D.4, to predict the discharge at the mouth of the Talkeetna River, given the discharge in the Susitna River immediately above the Talkeetna River. The equation is as follows: $Q_{ta} = 0.00851(Q_{su})^{1.29}$.

APPENDIX E

TWO-DIMENSIONAL SURFACE-WATER MODEL

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E.1 INTRODUCTION

A two-dimensional surface-water model was developed to estimate the water surface elevations and velocities near the Talkeetna Airport during a 100-year flood event. A two-dimensional surface-water model was chosen instead of a one-dimensional surface water model for two reasons. First, a preliminary estimate of the 100-year water surface profile on the Talkeetna River suggested that the banks of the Talkeetna River would be overtopped and that the water in the floodplain would not always move parallel to the Talkeetna River channels. Second, a preliminary assessment suggested that water in the floodplain might move toward Twister Creek from several different directions. If a one-dimensional model had been used, it would have been necessary to assume flow directions within the floodplain, to identify individual flow paths within the floodplain based on additional assumptions, and to model the different flow paths as split channels. By using a two-dimensional model it was not necessary to assume flow directions within the floodplain, nor was it necessary to identify individual flow paths. Thus, the two-dimensional model provided a superior approximation of the flow conditions during the 100-year flood.

E.2 MODEL DEVELOPMENT

The two-dimensional surface-water model developed for the confluence of the Talkeetna and Susitna Rivers is the product of two computer programs and a considerable data collection effort. The computer program *Surface Water Modeling System* (SMS) (Brigham Young University, 2002) was used as a pre- and post-processor to develop the finite element mesh and analyze the results of the numerical computations. The computer program *Finite Element Surface-Water Modeling System* (FESWMS) (Froehlich, 2002) performed the numerical computations that describe two-dimensional depth-averaged surface-water flow in a horizontal plane.

E.2.1 Topographic Data

The ground elevations used to represent the floodplain and the channels above the water surface were taken from three sources. The first source was the surface data points used to create the contour map of the project area (McClintock Land Associates 2002b). Most of the ground and water surface elevations used to develop the finite element mesh were obtained from this source. The second source consisted of surface data points obtained from the aerial photography of the

Susitna River floodplain, outside of the area for which the contour map was developed (McClintock 2002). The third source was surveyed cross sections within the Susitna and Talkeetna Rivers (McClintock Land Associates 2002a). Additional information concerning the topographic data is presented in Appendix A.

The ground elevations below the water surface on the Talkeetna and Susitna Rivers were estimated based on the surveyed cross sections. Inspection of the surveyed cross sections suggested that a triangular cross-sectional shape gave a reasonable representation of the geometry below the water surface. Thus, all of the channels in the model are represented as being triangular.

On the Susitna River, the cross-sectional area below the water surface on the May 2001 aerial photography was calculated for each of the major channels, at each of the three surveyed cross sections located within the area represented by the model (Figure A.1, Appendix A). The thalweg elevation of the equivalent triangular cross section was then computed for each of the major channels (Table E.1), and extrapolated from the cross sections to the junctions of the major channels. It was assumed that the thalweg elevation was uniform between the junctions of the major channels.

On the Talkeetna River, the cross-sectional area below the water surface on the contour map was calculated for each of the Talkeetna River cross sections (Figure A.1, Appendix A and Table E.2). Using this data, the following regression equation (Table E.3) was developed to predict the cross-sectional area below the water surface from the water surface width on the contour map (Adjusted R^2 = 89 percent).

$$\text{Cross-Sectional Area} = 0.1769 * (\text{Width})^{1.5438}$$

Using the regression equation and the water surface width on the contour map, the thalweg elevation was computed at each 2-foot contour based on a triangular channel cross section. Thalweg elevations between the 2-foot contours were linearly interpolated from the elevations at the 2-foot contours.

E.2.2 Finite Element Mesh

E.2.2.1 Mesh Creation

The upstream boundary of the Susitna River portion of the two-dimensional surface water model was set approximately 1600 feet upstream from the mouth of Billion Slough. The upstream boundary of the Talkeetna River portion of the model was set approximately 1300 feet upstream from the U.S. Geological Survey (USGS) stream gage. The downstream boundary of the model was set approximately 300 feet downstream from the mouth of Twister Creek.

The elements were sized and located so that changes in hydraulic roughness, significant channels and islands, the general floodplain, and significant embankments on the floodplain are represented in the model. The elements are composed of 6 node triangles and 9 node quadrangles.

The mesh was designed to model the 100-year flood event. Thus, the elements were sized to provide a representation of the topography adequate for predicting water surface elevations and velocities during large flood events. The completed mesh contains 31,355 nodes and 9,337 elements, and is presented in Figure E.1.

E.2.2.2 Element Geometry

The size and shape of the elements are important considerations during mesh generation. The accuracy of the model improves as the size of the elements decreases. However, as element size decreases, the number of elements increases and the computational time needed to run the model increases exponentially. With a model that covers as large an area as the confluence of the Talkeetna and Susitna Rivers, it is necessary to manage the number of elements so that the accuracy of the model remains acceptable and the run times remain practical.

Smaller element sizes were used within the channels and near the Talkeetna Airport. Larger element sizes were used in relatively uniform areas of the floodplain. However, the transition between small and large elements must be gradual. For this reason, the ratio of the surface areas associated with adjoining elements was generally kept to 3 and not allowed to exceed 5.

Where water surface and velocity gradients could be estimated in advance, quadrangular elements were generally used, and aligned with the longest side parallel to the smallest gradient. For example, in the river channels where the change in depth and velocity is much greater across the channel than along the channel, the longest sides of the elements were aligned in the direction of flow. This helped reduce the number of elements needed to describe the geometry of the channels. However, extremely long elements are not desirable because they can cause numerical instability. For this reason, the aspect ratio (the ratio of element length to width) was generally kept below 8.

The size of the internal angles on the individual elements was also controlled. The interior angles on triangular elements were generally kept greater than 20 degrees. Less than 1 percent of the elements had an angle of less than 20 degrees. The size of the interior angles on quadrangular elements was generally kept smaller than 130 degrees. Less than 0.1 percent of the elements had an angle that exceeded 130 degrees. No interior angles were allowed to be smaller than 5 degrees or greater than 140 degrees.

E.2.2.3 Nodal Elevations

After the locations of the elements had been defined and the element geometry checked, the vertical elevation of each corner node was set. First, the horizontal and vertical coordinates of the surface data points from all of the sources described in Section E.2.1 were combined into a single data file. Next, the ground surface elevation at each corner node was interpolated from the surface data points. Finally, the elevations of the mid-side nodes were computed as the average of the adjacent corner nodes.

After an elevation had been assigned to each node, the ground surface was contoured and compared with the contour map of the project area. The node elevations were manually edited where the interpolated elevations did not give an accurate representation of the topography. This was most often necessary at the bridge openings and at the road and railroad embankments.

E.2.2.4 Element Wetting and Drying Parameter

From one iteration of the computations to the next, some elements turn "on" and some elements turn "off." Elements that are turned off are not included in the computations. In general, elements that are turned off are elements that are not completely covered by water. However, large numbers of elements turning on and off from one iteration to the next can cause the model to become numerically unstable. Therefore, a tolerance limit is used to allow the model to determine if the status of an element should be changed (turned on or off).

If the tolerance limit is set at zero, an element will turn on as soon as the water surface elevation is above the elevation of the highest node in the element. The element will turn off as soon as the water surface elevation is below the elevation of the highest node in the element.

For this model, the tolerance limit was set at 0.5 feet. Thus, if an element was already turned on, it would not be turned off unless the water surface elevation on the next iteration was below the node with the highest elevation. If an element was already turned off, it would not be turned on unless the water surface elevation on the next iteration was more than 0.5 feet above the node with the highest elevation.

E.2.3 Material Types

Every element was assigned a FESWMS "material type". A material type describes the hydraulic roughness of the ground surface being represented by an element. Each material type also describes the magnitude of the eddy viscosity coefficient at an element. The locations of the various material types within the project area are presented in Figure E.1.

E.2.3.1 Hydraulic Roughness[1]

E.2.3.1.1 Hydraulic Roughness – Floodplains

The Talkeetna River floodplain was divided into areas of similar vegetation using the aerial photography. Each area that had a distinct vegetative cover was assigned a distinct material type. Vegetation density surveys were performed for each material type in the Talkeetna River floodplain and the hydraulic roughness values were calculated using the method presented in *Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains* by G.J. Arcement and V.R. Schneider (1984).

The Susitna River floodplain was also divided into areas of similar vegetation using the aerial photography, and each of the vegetation types was assigned a distinct material type. Hydraulic roughness values were estimated for each material type from published roughness estimates (Chow 1959) with the aid of photographs taken at the time of the survey (McClintock Land Associates 2002a). Since the Susitna River floodplain has a much higher density of willows than

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[1] Manning's coefficient is used within the model to describe hydraulic roughness.

the Talkeetna River floodplain, the hydraulic roughness values calculated for the Talkeetna River floodplain were not extrapolated to the Susitna River floodplain. Similarly, the Susitna River gravel bars contain significantly more debris than the Talkeetna River gravel bars. So, different hydraulic roughness values were assigned to the Susitna River gravel bars.

E.2.3.1.2 Hydraulic Roughness – Channels

The median hydraulic roughness used in the USGS (2001) HEC-RAS model of the Susitna River Bridge at Sunshine was used as the initial estimate of the hydraulic roughness of the Susitna and Talkeetna River main channels. The hydraulic roughness values for each material type are summarized in Table E.4.

E.2.3.2 Kinematic Eddy Viscosity

Each material type was assigned a value for kinematic eddy viscosity. The eddy viscosity term relates to losses in hydraulic head as a result of lateral shear stresses caused by turbulence. As stated in the User's Manual (Froehlich, 1996):

> *"Eddy viscosity coefficients usually affect a solution much less than roughness coefficients. The influence of the eddy viscosity is greatest in a finite element network where velocity gradients are large. Increasing eddy viscosity coefficients will cause velocity gradients to be reduced, and the horizontal velocity distribution will become more uniform. Reducing eddy viscosity coefficients will cause velocity gradients to increase."*

There are few guidelines in the literature for estimating the kinematic eddy viscosity. For this assessment all material types in the model were assigned an eddy viscosity of 100 ft^2/s.

E.3 CONVERGENCE CRITERIA

FESWMS calculates the water surface elevation and velocity at every node using an iterative solution technique. The results from the previous iteration are used as the initial condition for the next iteration. The iterations are continued until the changes in unit flow and water surface elevation, from one iteration to the next, are acceptable. At this point the model is "converged" for the conditions being evaluated. For this model, the tolerances used to establish convergence were: 0.2 feet for changes in water surface elevation, and 0.5 feet for changes in unit flow.

E.4 MODEL CALIBRATION AND VALIDATION

E.4.1 Calibration

Calibration is the process of "fine tuning" a model to more accurately reproduce events that have previously been measured. If a reasonable procedure is used, the probability that the model will accurately represent an event that has not been measured is increased. For this project, the hydraulic roughness and channel geometry were "fine tuned" so that the predicted water surface elevation would match the measured water surface elevation at a known discharge.

E.4.1.1 Selection Criteria

The criteria used to select the events on which to calibrate the model were as follows.

(1) No more than two events would be used to calibrate the model. One event would be used to calibrate the channel roughness and one event would be used to calibrate the floodplain roughness.

(2) The event used to calibrate the channel roughness should represent the highest discharge contained within the channels of the Talkeetna River and be sufficiently documented to allow calibration of the model. If possible, the discharge on the Susitna River should also be contained within the channels, as near to the bankfull discharge as possible.

(3) The event used to calibrate the floodplain roughness should represent the highest discharge in the Talkeetna River, cover at least a portion of the floodplain, and be sufficiently documented to allow calibration of the model. If possible, the discharge on the Susitna River should also cover at least a portion of the floodplain.

E.4.1.2 Available Data

Unfortunately, the historical data from which the events could be selected are limited. In order to calibrate the model, both discharge and water surface elevation data are required. The discharge data were obtained from the USGS Susitna River at Gold Creek, Chulitna River near Talkeetna, and Talkeetna River near Talkeetna stream gages. The water surface elevation data were obtained from the National Weather Service (NWS) and USGS stream gages located on the Talkeetna River. There are only six years in which data are available for all three USGS stream gages and the NWS stream gage. Additional information concerning the available data is presented in Appendix A.

It should also be noted that measurements are generally made only once a day at the NWS site. Thus, the discharge at the time of the NWS water surface elevation measurement may be somewhat different than the mean daily discharge.

E.4.1.3 Main Channel Calibration Model

In selecting the main channel calibration event, it was necessary to eliminate events where it was likely that instantaneous fluctuations in discharge had influenced the water surface elevation measurements at the NWS wire weight gage. Therefore, only events that showed little variability in mean daily discharge and water surface elevation over a period of three consecutive days were considered.

Based on the considerations discussed above, the 14 July 1980 data were chosen for calibrating the main channel hydraulic roughness and channel geometry. The flow was contained within the channels on the Talkeetna River, and within the channels and gravel bars on the Susitna River. The discharges on the Susitna and Talkeetna Rivers were estimated using the mean daily discharges at the USGS Chulitna River near Talkeetna, Susitna River at Gold Creek, and Talkeetna River near Talkeetna stream gages.

The mean daily discharges were 39,000 and 34,200 cubic feet per second (cfs) at the Chulitna River near Talkeetna and Susitna River at Gold Creek stream gages, respectively. The mean daily discharges were extrapolated to the mouth of the Chulitna River using the coefficients described in Appendix D. The extrapolated discharges were summed to yield an estimated discharge of 75,300 cfs on the Susitna River above the mouth of the Talkeetna River. The mean daily discharge at the Talkeetna River stream gage was 15,400 cfs and was extrapolated to the mouth of the Talkeetna River using the coefficient described in Appendix D. Thus, the estimated discharge at the mouth of the Talkeetna River is 15,600 cfs.

The water surface elevation at the downstream boundary of the two-dimensional surface-water model was estimated to be approximately 332.69 feet from the results of the Susitna River HEC-RAS model. Additional information on the HEC-RAS model is presented in Appendix F.

Because the flow being modeled is contained well within the channels, the mesh within the Talkeetna River channels was refined in order to increase model stability. Thus, each element in each of the channels of the Talkeetna River was divided into four smaller elements. Though the main channel calibration model incorporates more elements in the Talkeetna River channels than do the floodplain calibration or 100-year flood models, the channel shapes, cross-sectional areas and depths were unchanged.

Splitting the elements in the main channels caused the element surface area ratio to exceed the target value of 3 between many of the elements along the channel side of the bank, and the adjacent elements on the floodplain. However, because the floodplain was not inundated, the elements in the floodplain were not used to compute water surface elevations and velocities. Thus, it was not necessary to modify the floodplain elements to satisfy the adjacent element area geometry criterion. The main channel calibration model contains 58,110 nodes and 17,778 elements, and is presented in Figure E.2.

E.4.1.4 Floodplain Calibration Model

The highest recorded discharge on the Talkeetna River occurred on 11 October 1986. Mean daily discharge data are available at the USGS Susitna River at Gold Creek stream gage, and hourly discharge data are available at the USGS Talkeetna River stream gage. Between 10 and 12 October, seven water surface elevations were recorded at the NWS wire weight gage.

From the available data, it appears that the flood-peak discharges on the Talkeetna River and the Susitna River occurred at different times on 11 October 1986. The flood-peak discharge on the Talkeetna River occurred at 0600. However, the highest water surface elevation measurement at the NWS wire weight gage was made at 1800. This suggests that the flood-peak discharge on the Susitna River occurred after the flood-peak discharge on the Talkeetna River. Because a water surface elevation measurement was not made at the NWS gage at 0600, the discharge and water surface elevation data recorded on the Talkeetna River at 1800 were used in the floodplain calibration model.

To estimate the discharge on the Susitna River above the mouth of the Talkeetna River, it was necessary to estimate the volume of water contributed by the Chulitna River, as the Chulitna River stream gage was not in operation on 11 October 1986. The mean daily discharge was estimated by developing a regression equation to estimate the mean daily discharge on the

Chulitna River given a mean daily discharge on the Susitna River at Gold Creek. There are approximately 22 years of concurrent mean daily discharge record for the Chulitna River near Talkeetna and the Susitna River at Gold Creek. In order to estimate the discharge on the Chulitna River during a relatively high intensity rain event on the Susitna River, the following criteria were used to select the peak-discharge data that would be used in developing the regression equation. First, the peak discharge on the Susitna River had to occur between the months of July and October to preclude snowmelt and rain on snow flood events. Second, the peak discharge on the Susitna River had to be at least 30 percent larger than the discharge prior to the flood event. Based on these criteria, 63 discharge events were identified (Table E.5). A linear regression analysis (Table E.6) was then conducted based on the data presented in Table E.4. The mean daily discharge on the Chulitna River at the stream gage is estimated to be 32,000 cfs, given a mean daily discharge of 36,200 cfs on the Susitna River at Gold Creek. The mean daily discharges at the Chulitna River near Talkeetna and Susitna River at Gold Creek stream gages were extrapolated to the mouth of the Chulitna River using the coefficients described in Appendix D. The extrapolated discharges were summed to yield an estimated discharge on the Susitna River above the mouth of the Talkeetna River of 70,150 cfs.

The discharge on the Talkeetna River was estimated to be approximately 58,640 cfs from hourly water surface elevation measurements at the USGS stream gage on the Talkeetna River and the USGS rating curve for the site. The water surface elevation at the downstream boundary of the two-dimensional surface-water model was estimated to be approximately 333.84 feet from the results of the Susitna River HEC-RAS model (Appendix F).

The conditions described above were used to calibrate the floodplains instead of the high water observations made by the Talkeetna residents for the following reasons.

(1) It is possible that some of the high water marks were the result of the Talkeetna River peak discharge while others were the result of the Susitna River peak discharge and still others were the result of flow conditions between the two peaks.

(2) The time at which each of the high water marks was made is not known. Thus, the discharge conditions that produced each of the high water marks could not be estimated.

E.4.2 Calibration Results

E.4.2.1 General

Only two changes were made to the models in order to match the observed and calculated water surface elevations:

(1) The thalweg elevations in the Talkeetna River between the Talkeetna River Bridge and the Susitna River were increased by about 2.1 feet from those initially estimated.

(2) The hydraulic roughness of the main channels of the Talkeetna River was increased by 0.01 from the value initially estimated.

In order to match the water surface elevation at the NWS gage, the hydraulic roughness in the Talkeetna River downstream of the Talkeetna River Bridge would have had to increase beyond a reasonable value. Therefore, the thalweg elevations between the bridge and the Susitna River were raised by an average of 2.1 feet from the elevations initially estimated. The thalweg elevations were originally calculated based on a regression equation, which did not incorporate data from this reach of the river. Even after adjustment, the cross-sectional area of this portion of the channel is greater than the cross-sectional area at one of the surveyed cross sections in the Talkeetna River that had a wider water surface width. After raising the thalweg elevations, the water surface elevations at the NWS and USGS stream gages were fine-tuned to correspond with the observed water surface elevations by raising the hydraulic roughness of the main channels of the Talkeetna River from 0.027 to 0.028.

The greatest difference between the measured and modeled water surface elevation was less than 0.3 feet, which occurred at the NWS wire weight gage during the low flow event. A comparison of the measured and calculated water surface elevations at the NWS and USGS gages is summarized in the following table.

	Main Channel Calibration Water Surface Elevations		Floodplain Calibration Water Surface Elevations	
	Observed (feet NAVD88)	Calculated (feet NAVD88)	Observed (feet NAVD88)	Calculated (feet NAVD88)
NWS Gage	344.54	344.83	350.29	350.24
USGS Gage	386.10	386.11	393.28	393.26

Although the results of the calibration were very good, it must be remembered that the models were calibrated to just two water surface elevations. A discussion of the convergence and flow continuity associated with each model is presented below.

E.4.2.2 Main Channel Calibration Model

After numerous iterations of the model, a practical solution was achieved prior to the convergence criteria being completely satisfied. Seven nodes exceed the water surface elevation convergence criteria, with a maximum change of 0.62 feet. Twenty-eight nodes exceed the x-unit flow convergence criteria with a maximum change of 2.82 ft^2/s. Twenty-three nodes exceed the y-unit flow convergence criteria with a maximum change of 1.15 ft^2/s. While it would have been possible to modify the model to achieve convergence at every node, the nodes that exceed the convergence criteria are at the edges of the model and do not affect the water surface elevations and velocities at the surrounding elements. The water surface elevations and velocities calculated for the 14 July 1980 event are presented in Figures E.3 and E.4, respectively.

The flow continuity in the main channel calibration model was checked to verify that the amount of water entering the model and leaving the model is essentially the same. Significant net gains or losses of flow can affect the calculated water surface elevations and velocities. The flow continuity of the main channel calibration model was very good with an overall net gain in flow of 1.9 percent. The results of the flow continuity checks are summarized in the following table.

Location	Expected Discharge (cfs)	Discharge Reported by Model (cfs)	Error
Upstream Boundary of the Susitna River	75,300	75,300	-
Upstream Boundary of the Talkeetna River	15,600	15,600	-
Downstream Boundary of the Susitna River	90,900	92,645	+1.9%
Billion Slough Bridge	-	1,071	-
Talkeetna River Bridge	-	15,132	-
Subtotal:	15600	16,203	+3.8%

E.4.2.3 Floodplain Calibration Model

The water surface elevations and velocities calculated for the 11 October 1986 event are presented in Figures E.5 and E.6, respectively. The flow continuity was very good with an overall net gain in flow of only 0.5 percent. The results of the flow continuity check are summarized in the following table.

Location	Expected Discharge (cfs)	Discharge Reported by Model (cfs)	Error
Upstream Boundary of the Susitna River	70,150	70,285	+0.2%
Upstream Boundary of the Talkeetna River	58,640	58,730	+0.2%
Downstream Boundary of the Susitna River	128,790	129,402	+0.5%
Billion Slough Bridge	-	4,568	-
Talkeetna River Bridge	-	54,612	-
Subtotal:	58,640	59,180	+0.9%

E.4.3 Validation

Validation is the process of determining if the input parameters and output of the model are reasonable. Froehlich (1996) states:

> *"Although model parameters [during calibration] can be adjusted to obtain close agreement between computed and measured values, an adjustment may not be extended beyond physically reasonable values. For example, if good agreement can be obtained only by using Manning roughness coefficients three times as large as estimated initially, the finite element network probably is a poor representation of the physical region being modeled."*

One means of checking the likely reasonableness of the model is to consider how much the hydraulic roughness and channel geometry had to be changed in order to calibrate the model to the known flow conditions. The only hydraulic roughness value that was changed during the calibration procedure was that of the Talkeetna River main channel. The value was increased from 0.027 to 0.028.

The only other change made to the model was the adjustment of the bed elevations in the Talkeetna River downstream of the Talkeetna River Bridge. The thalweg elevations were raised approximately 2.1 feet to decrease the cross-sectional area of the channel. The cross-sectional area that resulted from the revised thalweg elevations is approximately 28 percent smaller than the area predicted using the regression equation. However, the cross-sectional area within this reach of the channel is still larger than the cross-sectional area at one of the surveyed cross sections having a larger water surface width and used to develop the regression equation. Thus, both the change in hydraulic roughness and the change in channel geometry are well within the natural variability one would expect within the Susitna and Talkeetna Rivers.

E.5 100-YEAR FLOOD MODEL

E.5.1 100-Year Flood Event

Two 100-year flood-peak discharge scenarios were considered: a 100-year flood on the Talkeetna River and a 100-year flood on the Susitna River below the mouth of the Talkeetna River (Appendix D). A HEC-RAS model (Appendix F) was used to assess which scenario produced the higher water surface elevation on the upstream side of the Talkeetna River Bridge.

Based on the HEC-RAS model, the higher water surface elevation results from a 100-year flood-peak discharge on the Talkeetna River. Thus, only the 100-year flood on the Talkeetna River was analyzed using the two-dimensional surface-water model. The discharges used in the two-dimensional model are 90,200 cfs and 178,000 cfs on the Talkeetna and Susitna Rivers, respectively.

The HEC-RAS model was also used to estimate a water surface elevation at the downstream boundary of the two-dimensional surface-water model. The water surface elevation at the downstream boundary was set at 337.38 feet. The water surface elevations, velocities, and flow vectors estimated using the two-dimensional surface-water model are presented in Figures E.7, E.8, and E.9, respectively.

The flow continuity of the 100-year flood model was checked to verify that the net change in flow is small enough that the calculated water surface elevations and velocities are not significantly affected. The overall continuity error is less than 0.1 percent. The results of the flow continuity check are summarized in the following table.

Location	Expected Discharge (cfs)	Discharge Reported by Model (cfs)	Error
Upstream Boundary of the Susitna River	90,200	90,380	+0.2%
Upstream Boundary of the Talkeetna River	178,000	178,076	+0.04 %
Downstream Boundary of the Susitna River	268,200 [1]	268,029	-0.06%
Billion Slough Bridge	-	7,692	-
Talkeetna River Bridge	-	75,987	-
Flow Over Spur Road and Railroad Embankments	-	6,880	-
Subtotal:	90,200	90,563	+0.4%
Flow Past the East Side of the Airport	-	2,344 [2]	-
Flow Past the West Side of the Airport	-	4,528 [3]	-
Flow Moving Towards Twister Creek	6,880	6,871	-0.1%

Notes:

1. Calculated as the sum of the discharge at the upstream boundary of the Susitna River and the discharge at the upstream boundary of the Talkeetna River.
2. Calculated as the average of two discharge estimates on the east side of the airport. Discharge estimates are made within the model at flux strings. Two flux strings were used to estimate the discharge along the east side of the airport because it was not possible to locate a single flux string that was perpendicular to the flow. Flux strings that are not perpendicular to the flow may over or under estimate the discharge.
3. Calculated by subtracting the flow past the east side of the airport from the total estimated flow moving towards Twister Creek.

E.5.2 Special Considerations

The road and railroad embankments located on the southwest side of the airport affect the water surface elevations and velocities near the airport during the 100-year flood on the Talkeetna River. During the 100-year flood, approximately 6,900 cfs flows past the airport towards Twister Creek. However, the three Talkeetna Spur Road culverts located near Twister Creek can only pass about 150 cfs. Thus, water overtops the embankments near the level crossing: approximately 1100 feet of the Alaska Railroad (ARR) embankment on the north side of the crossing and approximately 800 feet of the Talkeetna Spur Road on the south side of the crossing. Since the culverts pass an insignificant amount of the total flow, the culverts were not represented in the 100-year flood model.

After water overtops the upstream embankments, it passes over the portion of the Talkeetna Spur Road located north of the level crossing and the portion of the ARR embankment located south of the level crossing. The water surface elevations at the downstream embankments are low enough that they do not submerge the upstream embankments. Since the water surface elevations on the downstream embankments do not influence the water surface elevations on the upstream embankments, the downstream embankments were excluded from the two-dimensional surface-water model.

It was not possible to obtain a stable solution in a practical amount of time with the upstream embankments represented exclusively as weirs. Thus, a portion of the embankment approximately 270 feet wide is modeled as an overflow channel composed of finite elements that connect the upstream side of the Talkeetna Spur Road directly to the Susitna River. The bed elevations and hydraulic roughness of the overflow channel were adjusted so that at a given water surface elevation the total discharge passing through the overflow channel is approximately the same as would be expected to flow over the road. A solution was obtained in which approximately 1250 feet of the upstream embankment was modeled using weirs and 650 feet was represented by the overflow channel. The final water surface elevations on the upstream side of the embankments are approximately 0.04 feet higher than would be expected based on unsubmerged weir flow over the embankments. However, sensitivity tests suggested that this magnitude of difference in the water surface elevation at the embankments would not affect the water surface elevations or velocities near the Talkeetna Airport.

Table E.1: Thalweg Elevations Based on a Triangular Channel Shape and the Surveyed Cross Sections in the Susitna River

Cross Section	Channel Number	Water Surface Elevation [1] (feet NAVD88)	Area [2] (sq. ft.)	Top Width [3] (feet)	Depth [4] (feet)	Thalweg Elevation [5] (feet NAVD88)
X-1	1	336.5	2419	358	13.5	323.0
X-1	2	336.5	3780	582	13.0	323.5
X-1	3	336.5	1210	462	5.3	331.2
X-1	4	336.1	630	205	6.1	330.0
X-2	1	344.9	986	274	7.2	337.7
X-2	2	343.7	2993	843	7.1	336.6
X-3	1	327.7	4353	466	18.7	309.0
X-3	2	327.5	766	725	2.1	325.4
X-3	3	328.3	246	553	0.9	327.4

Notes:
1. Water surface elevation at the time of the aerial photography.
2. Channel area below the water surface at the time of the May 2001 aerial photography, computed from the surveyed cross sections.
3. Top width at the time of the aerial photography.
4. Maximum depth based on a triangular cross section (Depth = (Area x 2)/Top Width).
5. Thalweg elevation based on a triangular cross section (Thalweg Elevation = Water Surface Elevation – Depth).
6. The locations of the cross sections are shown on Figure A.1.

Table E.2: Summary of Widths and Areas at the Talkeetna River Surveyed Cross-Sections

Cross Section [1]	Cross Sectional Area (sq. ft.) [2]	Water Surface Width (feet) [3]
T-1	892	207
T-2	3	11
T-3	103	104
T-4	75	40
T-5	22	47

Notes:
1. Cross sections located on Figure A.1.
2. Area under water surface during the 2001 survey.
3. Water surface width during the 2001 survey.

Table E.3: Regression Analysis to Predict Cross-Sectional Area from Water Surface Width on the Talkeetna River

The regression equation is:

$\log_{10}(\text{area}) = - 0.752 + 1.54 \log_{10}(\text{Width})$

Predictor	Coef	SE Coef	T	P
Constant	-0.7522	0.5371	-1.40	0.256
Width	1.5438	0.2674	5.77	0.010

S = 0.2599   R-Sq = 91.7%   R-Sq(adj) = 89.0%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	2.2511	2.2511	33.33	0.010
Residual Error	3	0.2026	0.0675		
Total	4	2.4537			

Predicted Values for New Observations

New Obs	Fit	SE Fit	95.0% CI	95.0% PI
1	3.026	0.174	(2.471, 3.581)	(2.030, 4.022)

Values of Predictors for New Observations

New Obs	Log_{10}Width
1	2.45

Table E.4: Material Type Summary

Material Type	Hydraulic Roughness 1	Depth 1 (feet) [1]	Hydraulic Roughness 2	Depth 2 (feet) [2]
Bridge	0.028	All Depths	-	-
Channel01	0.028	All Depths	-	-
Channel02	0.045	All Depths	-	-
Cleared Areas	0.030	All Depths	-	-
Floodplain1&7	0.11	All Depths	-	-
Floodplain10	0.10	0-2	0.06	> 6
Floodplain2	0.11	0-2	0.12	> 6
Floodplain3&5	0.13	0-2	0.14	> 6
Floodplain4	0.10	All Depths	-	-
Floodplain6	0.12	0-2	0.11	> 6
Floodplain8	0.18	All Depths	-	-
Pavement	0.015	All Depths	-	-
Sewage Ponds	0.015	All Depths	-	-
Susitna Channel	0.027	All Depths	-	-
Susitna Heavy Brush	0.10	All Depths	-	-
Susitna Light Brush	0.06	All Depths	-	-
Susitna LOB	0.11	0-3	0.05	> 9
Susitna Minor Channels	0.03	All Depths	-	-
Susitna ROB	0.15	0-4	0.055	> 12
Susitna Scattered Brush1	0.035	All Depths	-	-
Susitna Scattered Brush2	0.05	All Depths	-	-
Talkeetna Stub	0.028	All Depths	-	-

Notes:
1. Depth 1 is the range of water depths for which Hydraulic Roughness 1 is applied.
2. Depth 2 is the range of water depths for which Hydraulic Roughness 2 is applied.
3. The hydraulic roughness is linearly interpolated between Depth 1 and Depth 2.
4. Manning's coefficient is used within the model to describe hydraulic roughness.

Table E.5: Mean Daily Discharges in the Susitna and Chulitna Rivers

Date	Susitna Q (cfs)	Chulitna Q (cfs)		Date	Susitna Q (cfs)	Chulitna Q (cfs)
8/3/1958	47800	33800		7/20/1970	29100	29300
8/24/1959	59700	34000		8/2/1970	31600	35600
7/2/1960	30400	24500		8/23/1970	22400	30600
7/31/1960	37500	31700		9/17/1970	11900	10700
9/13/1960	40100	23000		10/2/1970	9000	5000
7/24/1961	30300	32000		7/15/1971	36700	39100
8/27/1961	24800	29500		8/10/1971	77700	40000
9/13/1961	15700	27200		9/3/1971	27000	16300
7/22/1962	30500	34000		8/9/1972	26400	23300
8/3/1962	30600	33000		9/14/1972	26400	25600
9/4/1962	31000	32100		7/29/1980	49700	44800
7/12/1963	44000	34000		9/16/1980	28000	12900
7/18/1963	49000	34000		7/12/1981	60800	43700
7/25/1963	39000	23000		8/2/1981	54100	57500
8/3/1963	35000	16000		8/14/1981	53500	49100
7/12/1964	31900	27000		10/24/1981	10200	5400
7/29/1964	21200	25700		7/13/1982	28400	22500
10/8/1964	9620	15300		7/25/1982	31900	42000
7/13/1965	37700	27000		9/16/1982	32500	37000
8/7/1965	33600	33800		8/10/1983	31900	40600
9/8/1965	30100	34400		9/2/1983	25400	25900
9/27/1965	26000	29200		9/23/1983	17500	10000
7/29/1966	31800	27600		10/2/1983	13500	17600
8/4/1966	33500	37000		10/13/1983	12000	12300
9/14/1966	17300	17000		7/22/1984	34200	28600

Table E.5: (Continued)

7/21/1967	50000	65400		8/26/1984	31700	36000
8/15/1967	76000	73000		9/21/1984	11400	11500
9/3/1967	31800	19700		7/3/1985	38800	37200
7/3/1968	32000	31400		7/21/1985	38400	31300
9/8/1968	13400	10100		8/13/1985	25800	25800
7/16/1969	20900	22100		9/16/1985	26800	24000
8/7/1969	16800	20000				

Notes:
1. Mean daily discharge values selected from the USGS surface water website.

Table E.6: Regression Analysis to Predict Chulitna River Discharge Based on Susitna River Discharge

The regression equation is

Chulitna Q = 6817 + 0.695 Susitna Q

Predictor	Coef	SE Coef	T	P
Constant	6817	2440	2.79	0.007
Susitna	0.69485	0.06953	9.99	0.000

S = 7991 R-Sq = 62.1% R-Sq(adj) = 61.5%

PRESS = 4392466291 R-Sq(pred) = 57.24%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	6378241804	6378241804	99.88	0.000
Residual Error	61	3895262323	63856759		
Total	62	10273504127			

Unusual Observations

Obs	Susitna	Chulitna	Fit	SE Fit	Residual	St Resid
26	50000	65400	41559	1608	23841	3.05R
27	76000	73000	59625	3223	13375	1.83 X
39	77700	40000	60807	3335	-20807	-2.87RX

R denotes an observation with a large standardized residual

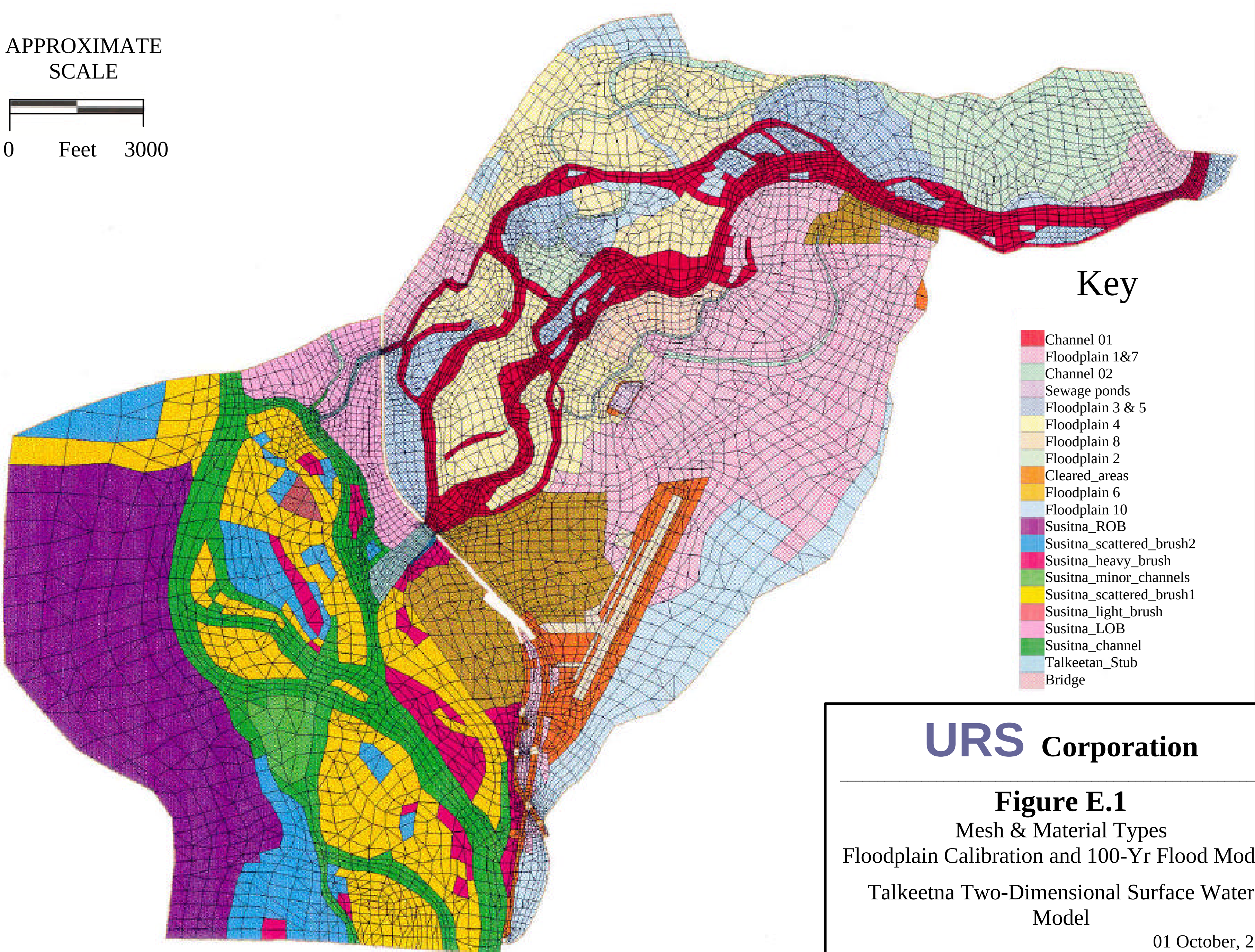
X denotes an observation whose X value gives it large influence.

Predicted Values for New Observations

New Obs	Fit	SE Fit	95.0% CI	95.0% PI
1	31970	1049	(29873, 34068)	(15854, 48087)

Values of Predictors for New Observations

New Obs Susitna



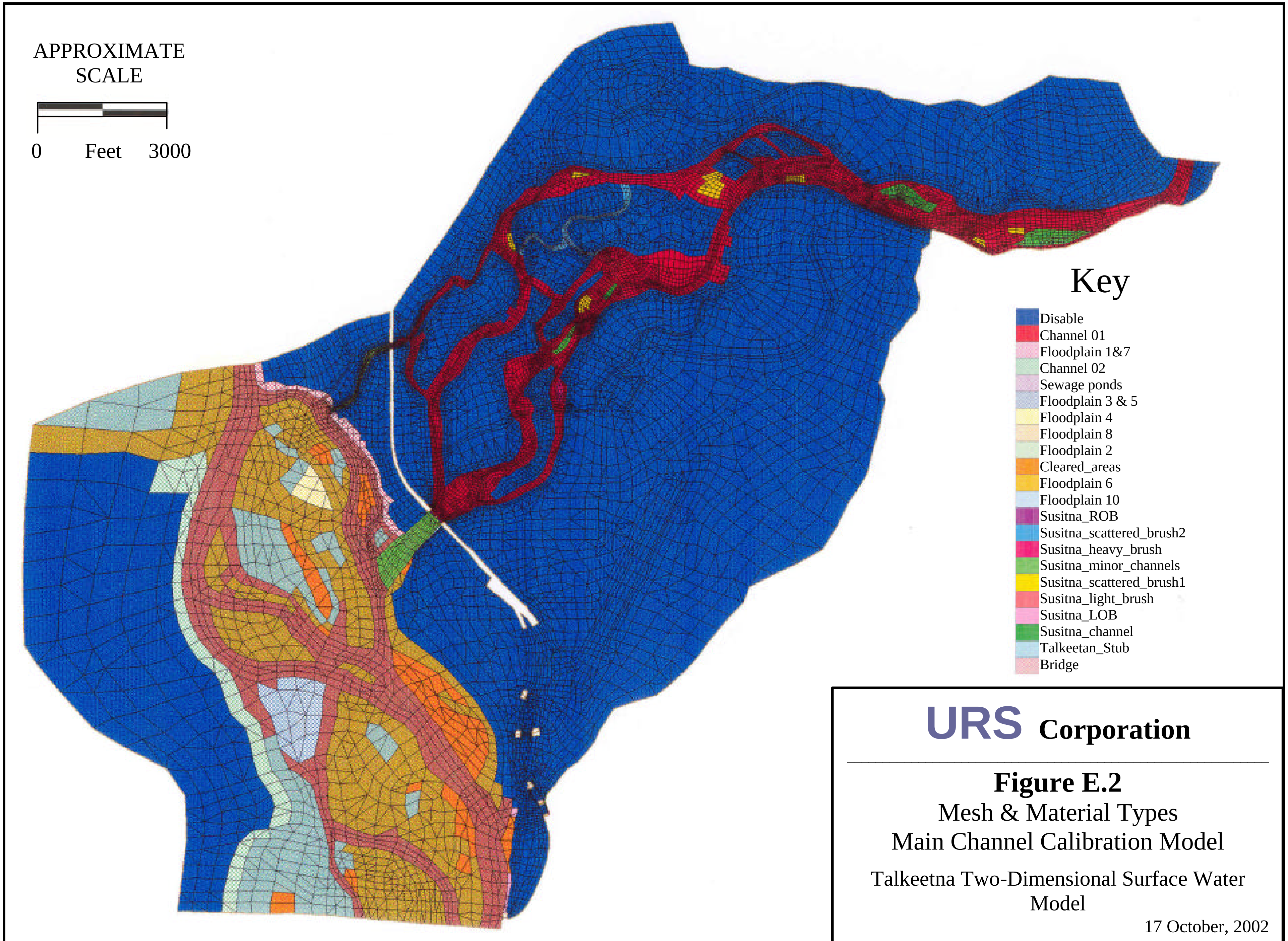
URS Corporation

Figure E.1

Mesh & Material Types
Floodplain Calibration and 100-Yr Flood Models

Talkeetna Two-Dimensional Surface Water Model

01 October, 2002



URS Corporation

Figure E.2
Mesh & Material Types
Main Channel Calibration Model

Talkeetna Two-Dimensional Surface Water Model

17 October, 2002

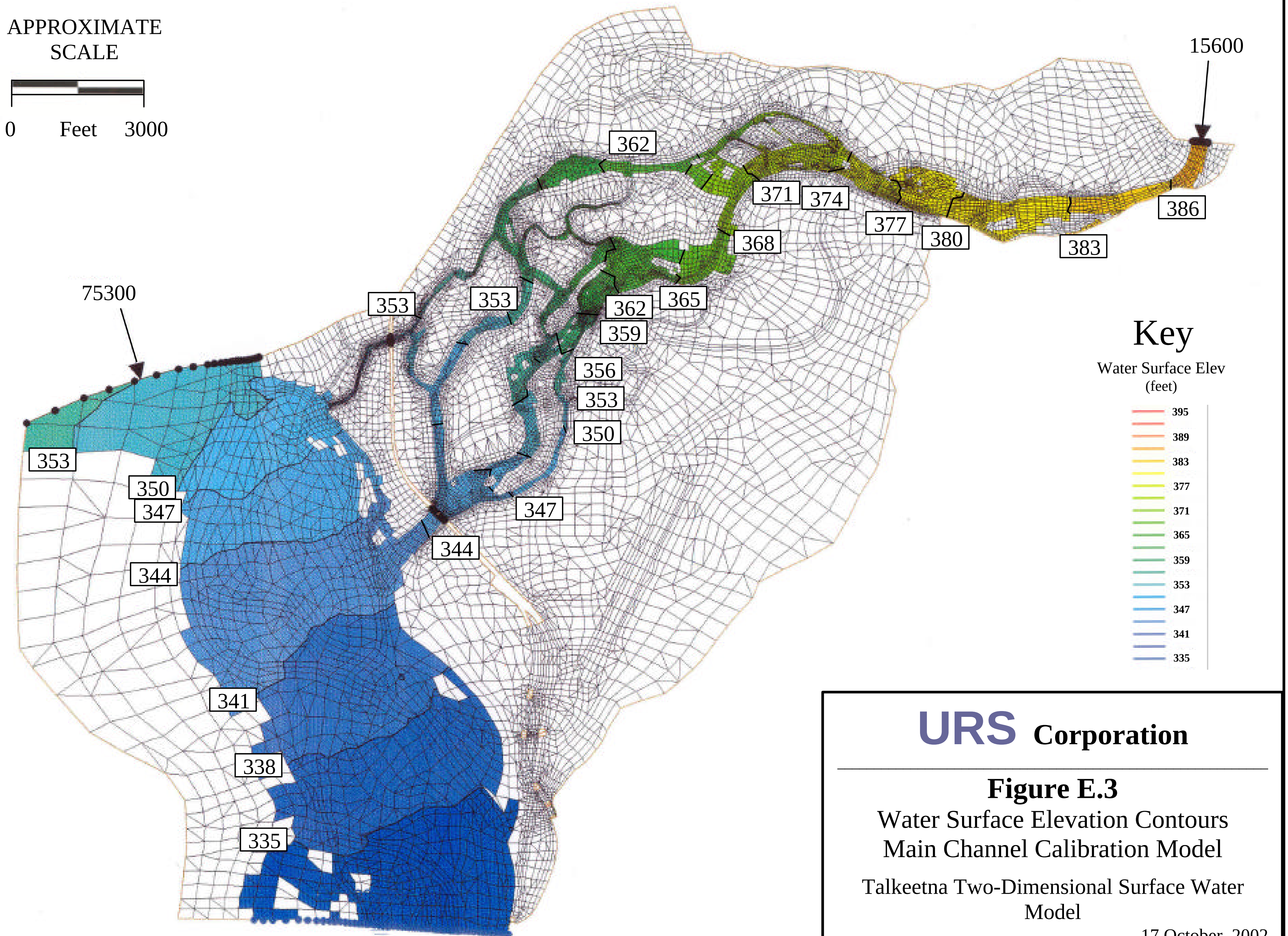


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Figure E.3

Water Surface Elevation Contours
Main Channel Calibration Model

Talkeetna Two-Dimensional Surface Water Model

17 October, 2002

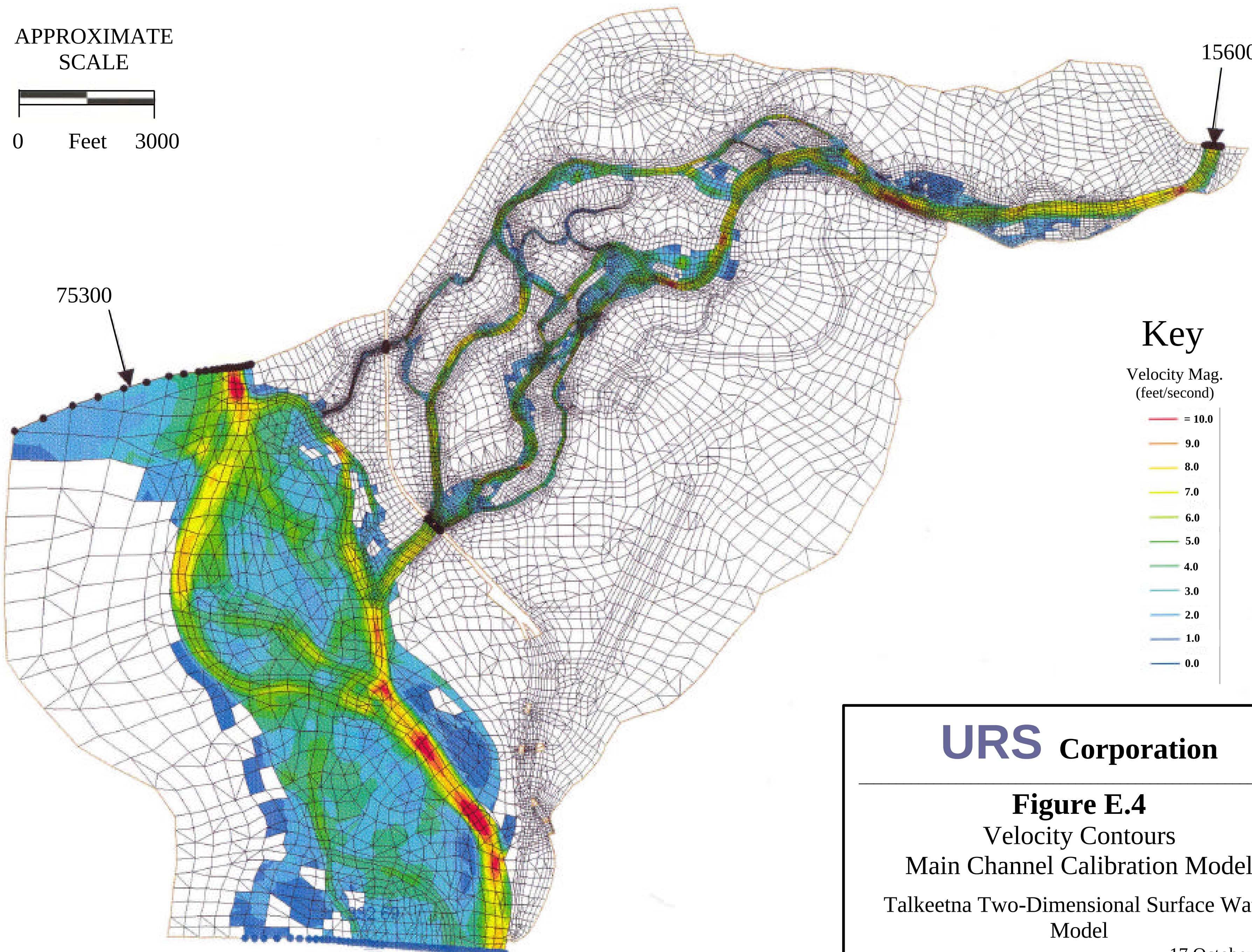

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Figure E.4

Velocity Contours
Main Channel Calibration Model

Talkeetna Two-Dimensional Surface Water Model

17 October, 2002

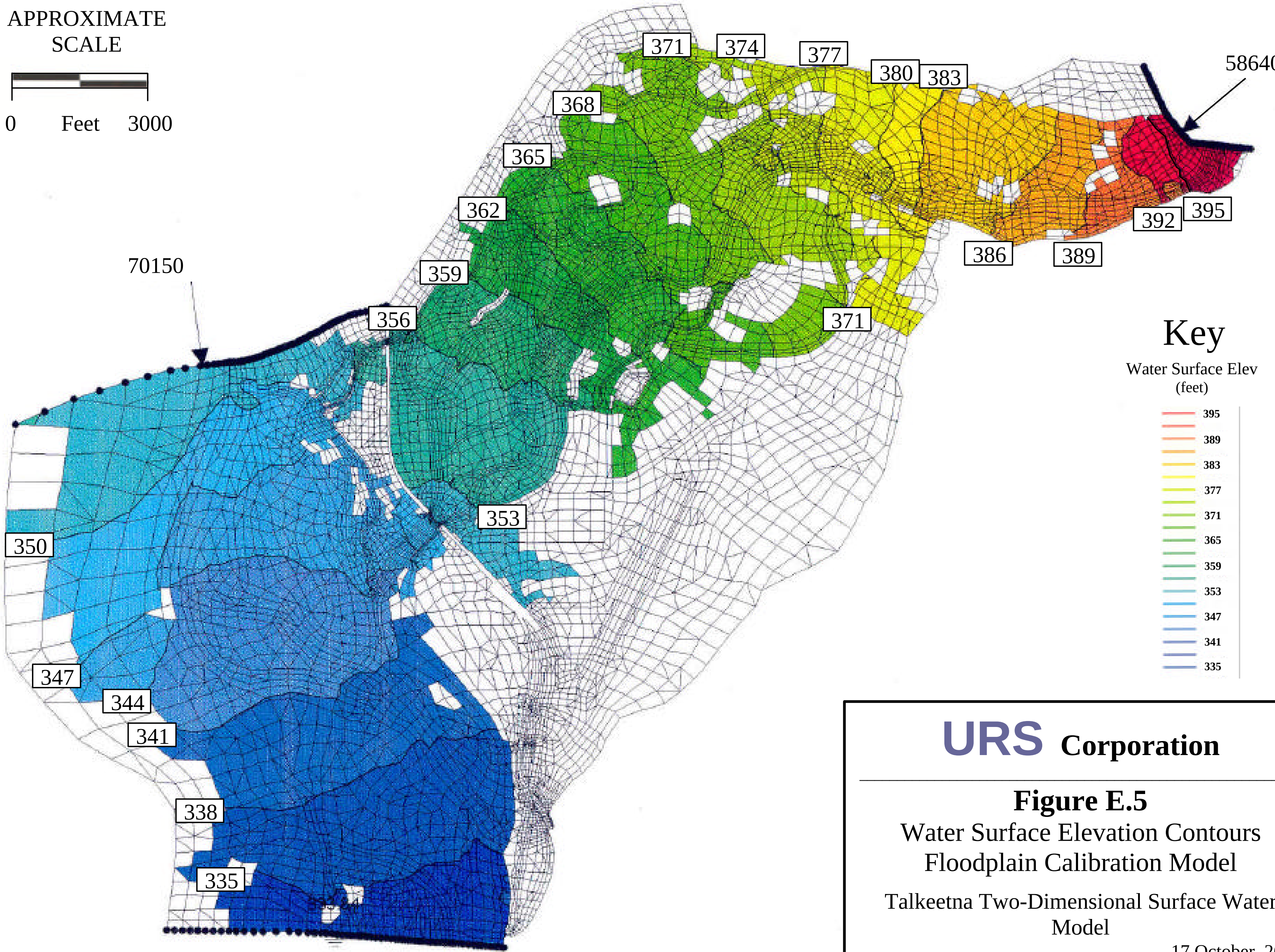

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Figure E.5

Water Surface Elevation Contours
Floodplain Calibration Model

Talkeetna Two-Dimensional Surface Water Model

17 October, 2002

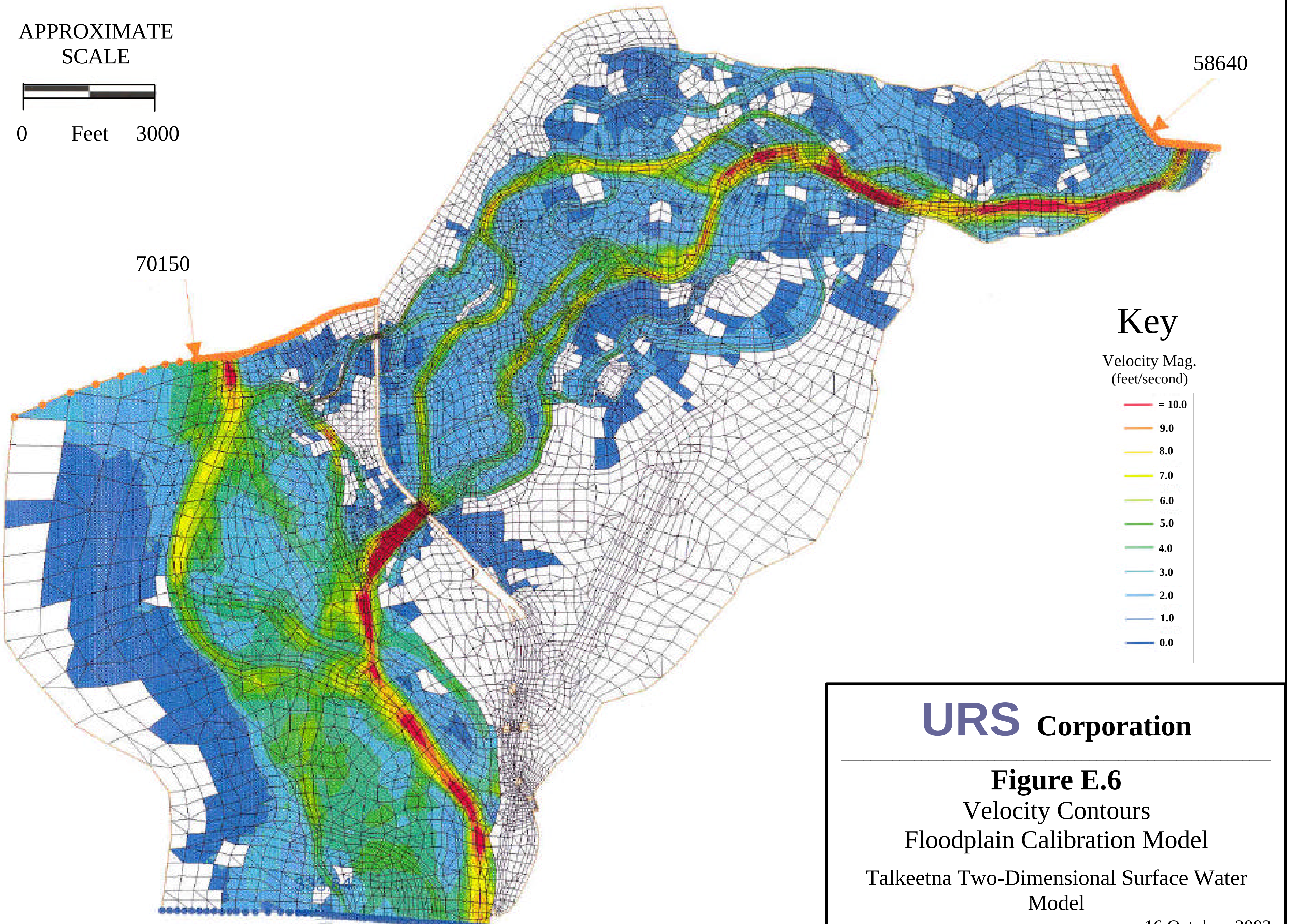

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Figure E.6

Velocity Contours
Floodplain Calibration Model

Talkeetna Two-Dimensional Surface Water Model

16 October, 2002

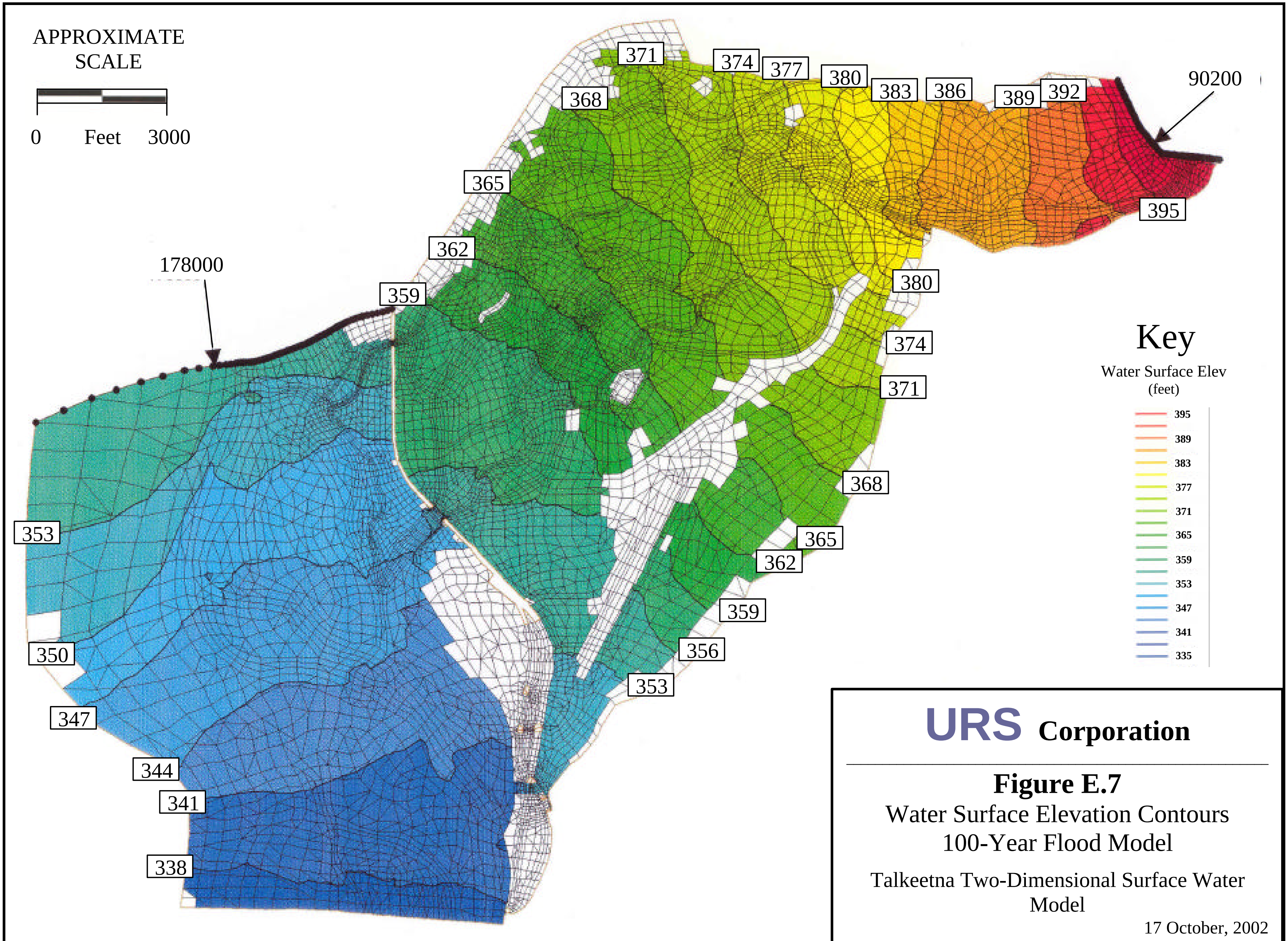

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Figure E.7

Water Surface Elevation Contours
100-Year Flood Model

Talkeetna Two-Dimensional Surface Water Model

17 October, 2002

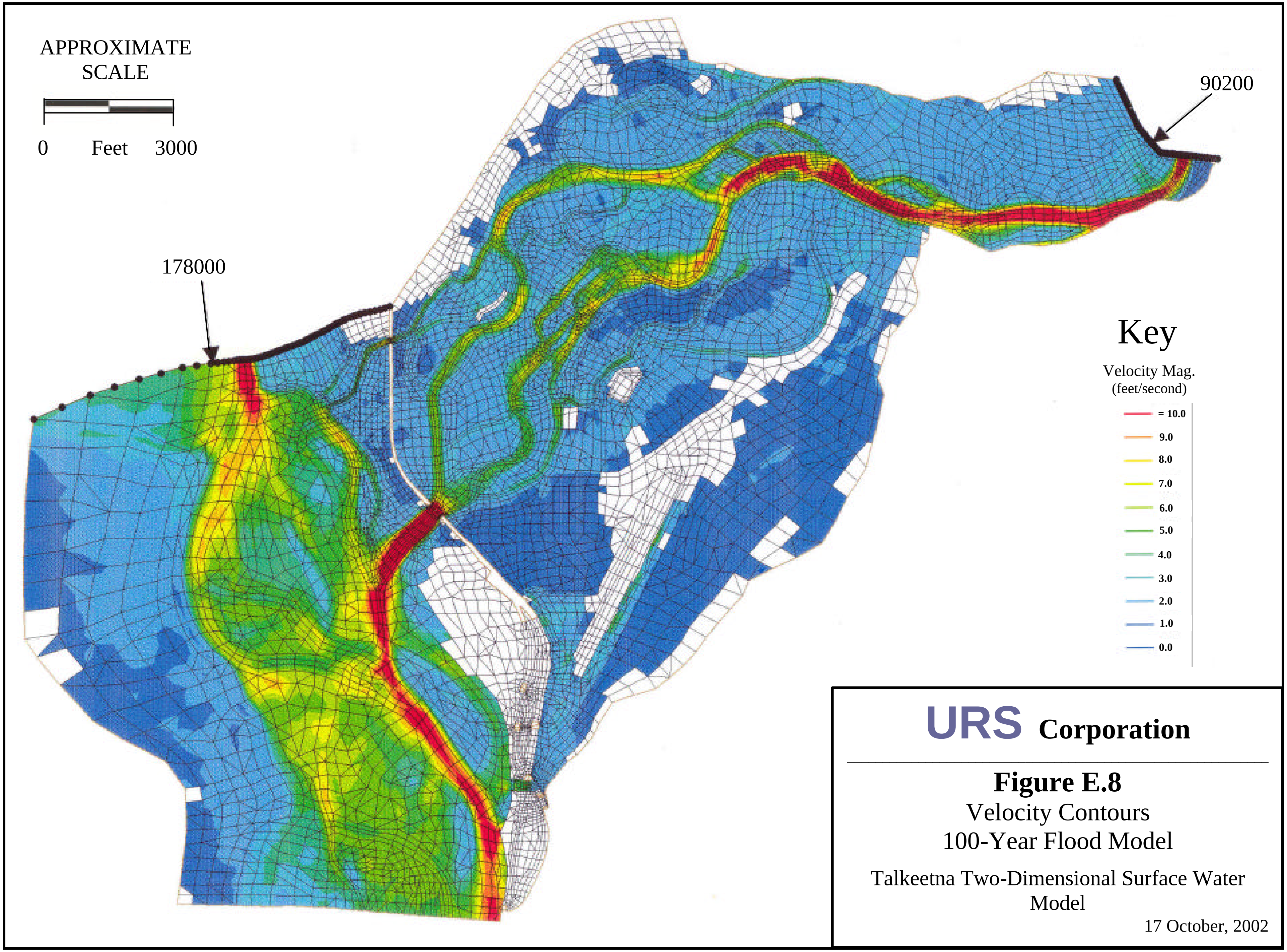
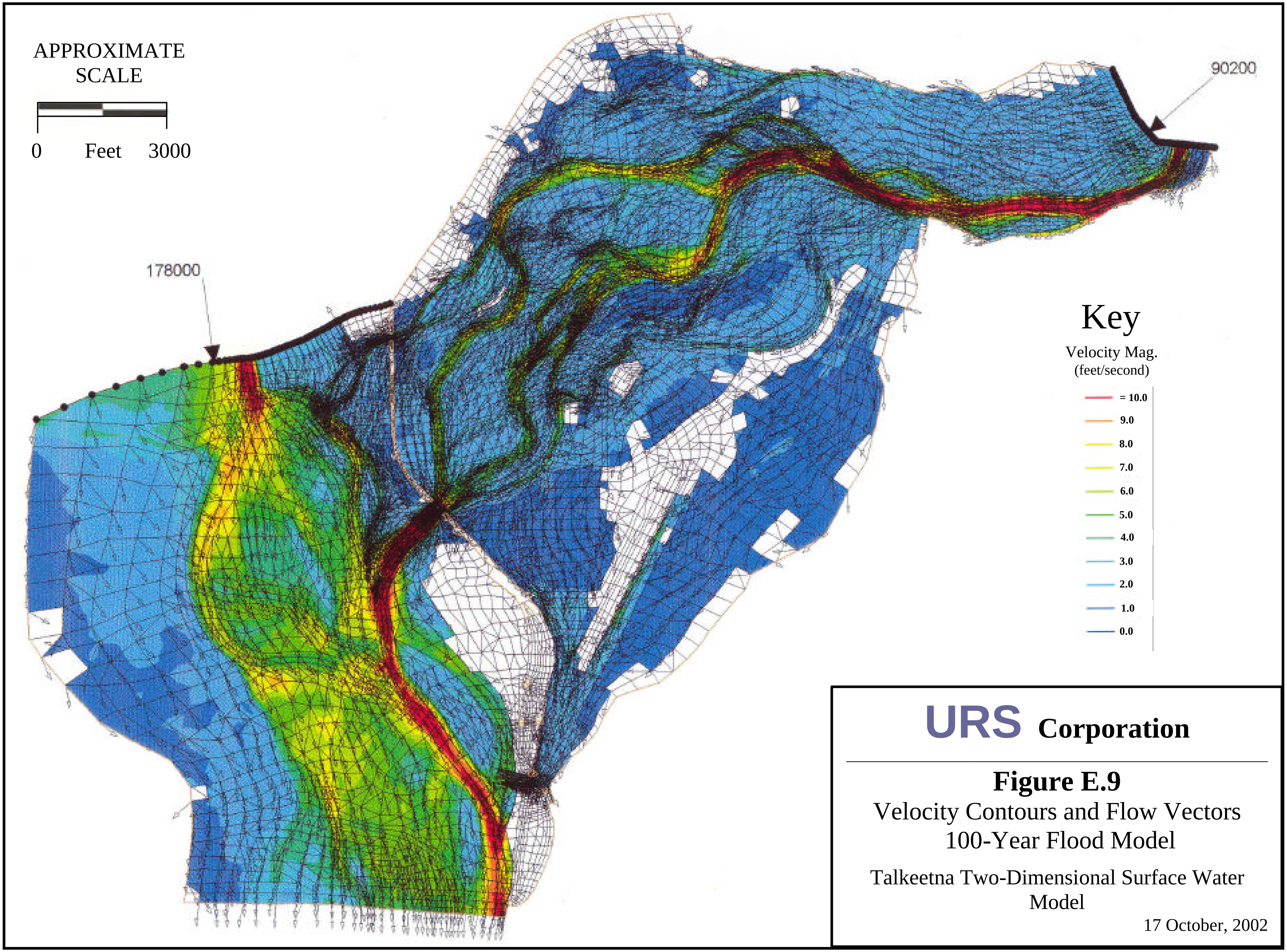


Figure E.8
Velocity Contours
100-Year Flood Model

Talkeetna Two-Dimensional Surface Water Model

17 October, 2002



URS Corporation

Figure E.9
Velocity Contours and Flow Vectors
100-Year Flood Model

Talkeetna Two-Dimensional Surface Water Model

17 October, 2002

APPENDIX F

SUSITNA RIVER HEC-RAS MODEL

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F.1 INTRODUCTION

The U.S. Army Corps of Engineers' (USACE) River Analysis System (HEC-RAS) computer program was used to develop a one-dimensional model of the Susitna River from approximately 10,000 feet downstream of Twister Creek to approximately 400 feet upstream of Billion Slough. The model also includes that portion of the Talkeetna River from its' confluence with the Susitna River to the upstream side of the Talkeetna River Bridge (i.e. the approach section). The model was developed for two reasons.

(1) To estimate which of the two possible 100-year flood scenarios (Section 4) produces the greater water surface elevation on the upstream side of the Talkeetna River Bridge.

(2) To estimate the water surface elevation at the downstream boundary of the two-dimensional surface-water model during each of three events: the 14 July 1980 event used to calibrate the main channels, the 11 October 1986 event used to calibrate the floodplains, and the design 100-year flood event.

F.2 CROSS SECTIONS

McClintock Land Associates surveyed four cross sections on the Susitna River, at River Miles[1]: 8.47, 10.60, 11.61 and 12.65 (Figures F.1, F.2, F.3 and F.4). Additionally, three cross sections were surveyed at the Talkeetna River Bridge: one approximately 70 feet upstream from the upstream face of the bridge (Figure F.5), one in the bridge opening (Figure F.6), and one approximately 150 feet downstream from the downstream face of the bridge (Figure F.7).

To accurately represent the water surface profile, it was necessary to interpolate additional cross sections on the Susitna River. Cords were used to align the coordinates that represent the thalwegs and banks of the main channels in the interpolated cross sections. Thirty-four interpolated cross sections were developed. The maximum spacing between cross sections was 680 feet.

[1] The river miles are measured from the Susitna River Bridge at Sunshine.

F.3 HYDRAULIC ROUGHNESS[2]

Aerial photos of the Susitna and Talkeetna Rivers were used to divide the islands, gravel bars, and floodplains into areas of similar vegetation. Hydraulic roughness values for the floodplain portions of the cross sections were estimated based on published roughness values (Chow 1959). Photographs taken at the time of the cross-section surveys were also used to aid in the selection of roughness values (McClintock Land Associates 2002a). A summary of the hydraulic roughness values used in the model is presented in the following table.

Description	Hydraulic Roughness
Dense Willows	
Water Depth 0 to 1 Times Willow Height	0.150
Water Depth 1 to 2 Times Willow Height	0.110
Water Depth 2 to 3 Times Willow Height	0.080
Water Depth >3 Times Willow Height	0.055
Sparse Willows	
Water Depth 0 to 1 Times Willow Height	0.110
Water Depth 1 to 2 Times Willow Height	0.090
Water Depth 2 to 3 Times Willow Height	0.070
Water Depth >3 Times Willow Height	0.050
Light Scattered Brush	0.035
Heavy Scattered Brush	0.05
Light Brush	0.06
Heavy Brush	0.1
Minor High Water Channels	0.03

The hydraulic roughness of the main channels in the Susitna River was set equal to the median hydraulic roughness used in the U.S. Geological Survey (USGS 2001) HEC-RAS model of the Susitna River Bridge at Sunshine (i.e. 0.027). The main channel of the Talkeetna River was assigned a hydraulic roughness value of 0.028.

[2] Manning's coefficient is used within the model to describe hydraulic roughness.

F.4 DOWNSTREAM BOUNDARY

A normal depth computation and a water surface slope of 0.00159 feet/foot were used to describe the downstream boundary conditions in the one-dimensional model. The water surface slope was computed from the water surface contours shown on the USGS Quadrangle *Talkeetna (B-1) SE* (1987). To reduce the error associated with the normal depth boundary assumption, the minimum distance from the mouth of Twister Creek to the downstream boundary of the one-dimensional model was estimated using the method outlined in *Accuracy of Computed Water Surface Profiles* by the USACE (1986).

F.5 TALKEETNA RIVER VERSUS BILLION SLOUGH DISCHARGE

Since the discharge at the mouth of the Talkeetna River is split between the Talkeetna River and Billion Slough channels, the flow associated with each channel was estimated based on the cross-sectional area under the bridges. The cross-sectional area under the Talkeetna River Bridge is approximately 7,430 square feet, while the cross-sectional area under the Billion Slough Bridge is approximately 920 square feet. Since the cross-sectional area under the Billion Slough Bridge is about 10 percent of the total cross-sectional area, 10 percent of the discharge at the mouth of the Talkeetna River was assumed to pass down Billion Slough, and the remaining 90 percent was assumed to flow under the Talkeetna River Bridge.

F.6 MODEL VALIDATION

By comparing the calculated water surface elevations to the recorded water surface elevations at the National Weather Service (NWS) stream gage, the reasonableness of the results produced with the one-dimensional model was confirmed. Water surface elevations from two events were compared. The first event was the 14 July 1980 event used to calibrate the main channel hydraulic roughness in the two-dimensional model. The second event was the 11 October 1986 event used to calibrate the floodplain hydraulic roughness in the two-dimensional model. A comparison of the measured water surface elevations and the calculated water surface elevations at the NWS stream gage is presented in the following table.

Flood Event	Water Surface Elevation Reported at the NWS Gage (feet NAVD88)	Calculated Water Surface Elevation (feet NAVD88)
14 July 1980, 2-D Model Main Channel Calibration Event	344.54	344.72
11 October 1986, 2-D Model Floodplain Calibration Event	350.29	350.10

Since the calculated water surface elevations are close (within 0.2 feet) to the measured water surface elevations, it was concluded that the one-dimensional model produces reasonable results.

F.7 SUMMARY OF ANALYSES

F.7.1 Selection of Design Flood Event

The one-dimensional model was used to estimate which of the 100-year flood-peak discharge scenarios discussed in Section 4 produces the highest water surface elevation on the upstream side of the Talkeetna River Bridge. The first scenario involves a 100-year flood-peak discharge on the Susitna River immediately below the Talkeetna River. The discharge on the Susitna River immediately below the Talkeetna River is 289,000 cubic feet per second (cfs) and the discharge at the mouth of the Talkeetna River is 67,000 cfs. The second scenario involves a 100-year flood-peak discharge on the Talkeetna River. The discharge at the mouth of the Talkeetna River is 90,200 cfs and the discharge on the Susitna River immediately below the Talkeetna River is 268,000 cfs.

The results of the analysis are presented in Tables F.1, F.2, F.3 and F.4. Based on the results, a 100-year flood-peak discharge on the Talkeetna River produces a water surface elevation on the upstream side of the Talkeetna River Bridge (i.e. the approach section) of approximately 355.7 feet. In contrast, a 100-year flood-peak discharge on the Susitna River below the Talkeetna River produces a water surface elevation of approximately 352.8 feet on the upstream side of the Talkeetna River Bridge (i.e. the approach section). Therefore, the Talkeetna River 100-year flood scenario was used in the two-dimensional surface-water model to estimate conditions at the Talkeetna Airport during a 100-year flood.

F.7.2 Water Surface Elevations at the Downstream Boundary of the 2-D Model

The one-dimensional model was used to estimate the water surface elevations at the downstream boundary of the two-dimensional surface-water model for the two calibration events (Tables F.5, F.6, F.7 and F.8) and the design 100-year flood event (Tables F.3 and F.4). The downstream boundary of the two-dimensional surface-water model is at River Mile 10.46. The following water surface elevations were estimated using the one-dimensional model.

Flood Event	Water Surface Elevation at River Mile 10.46
14 July 1980, 2-D Model Main Channel Calibration Event	332.7
11 October 1986, 2-D Model Floodplain Calibration Event	333.8
Design 100-Year Flood Event	337.4

Table F-1: Susitna River 100-Year Flood Model – HEC-RAS Standard Table 1

River	River Mile [1]	Total Dis-charge (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Critical Water Surface Elevation (ft)	Energy Gradeline Elevation (ft)	Energy Gradeline Slope (ft/ft)	Channel Velocity (ft/s)	Flow Area (sq ft)	Top Width (ft)	Channel Froude Number
Susitna River	12.65	222,000	331.60	351.74		352.41	0.001810	6.75	44,369	10,202	0.46
Susitna River	12.56*	228,700	331.42	350.85		351.53	0.001775	6.74	44,768	10,053	0.45
Susitna River	12.49*	228,700	331.90	350.13		350.80	0.001872	6.71	44,239	9,899	0.45
Susitna River	12.41*	228,700	331.12	349.34		349.99	0.001667	6.60	44,338	9,516	0.44
Susitna River	12.34*	228,700	330.97	348.75		349.35	0.001555	6.33	45,953	9,125	0.42
Susitna River	12.27*	228,700	332.31	348.11		348.70	0.001686	6.33	45,872	8,942	0.42
Susitna River	12.19*	228,700	330.67	347.58		348.11	0.001320	5.98	48,764	8,895	0.39
Susitna River	12.12*	228,700	331.16	347.09		347.59	0.001308	5.82	50,271	8,830	0.38
Susitna River	12.01*	289,000	329.39	345.47	342.89	346.31	0.001799	7.51	49,067	8,689	0.50
Susitna River	11.90*	289,000	328.63	344.84	342.13	345.65	0.001674	7.38	49,774	8,665	0.49
Susitna River	11.83*	289,000	327.78	344.21	341.51	345.03	0.001663	7.45	49,493	8,643	0.50
Susitna River	11.75*	289,000	326.85	343.67	340.89	344.45	0.001439	7.24	51,239	8,637	0.48
Susitna River	11.68*	289,000	326.04	343.17	340.24	343.91	0.001366	7.06	52,566	8,626	0.46
Susitna River	11.61	289,000	325.20	342.71	339.65	343.41	0.001238	6.90	53,981	8,619	0.45
Susitna River	11.50*	289,000	323.86	342.07	338.90	342.75	0.001184	6.73	53,757	8,506	0.44
Susitna River	11.39*	289,000	322.51	341.43	338.08	342.08	0.001182	6.56	53,549	8,400	0.42
Susitna River	11.27*	289,000	321.17	340.84	337.24	341.46	0.001028	6.39	53,731	8,313	0.41
Susitna River	11.16*	289,000	319.82	340.29		340.88	0.001023	6.19	54,273	8,236	0.39
Susitna River	11.04*	289,000	318.48	339.80		340.34	0.000878	5.97	55,306	8,106	0.37
Susitna River	10.94*	289,000	317.13	339.33		339.83	0.000898	5.74	56,570	7,993	0.35
Susitna River	10.82*	289,000	315.79	338.91		339.38	0.000697	5.52	58,322	7,869	0.33
Susitna River	10.71*	289,000	314.44	338.57		338.99	0.000647	5.26	60,574	7,760	0.31
Susitna River	10.60	289,000	313.10	338.22		338.61	0.000675	5.03	62,763	7,693	0.29
Susitna River	10.46*	289,000	311.95	337.83		338.19	0.000538	4.89	65,624	7,671	0.28
Susitna River	10.31*	289,000	310.79	337.27		337.61	0.001548	4.76	67,193	7,653	0.26
Susitna River	10.17*	289,000	309.64	336.50		336.84	0.000839	4.86	67,155	7,631	0.27
Susitna River	10.02*	289,000	308.49	335.78		336.13	0.001350	4.91	67,580	7,639	0.27
Susitna River	9.90*	289,000	307.33	334.75		335.13	0.001555	5.13	65,765	7,622	0.28
Susitna River	9.75*	289,000	306.18	333.62		334.06	0.001553	5.55	63,137	7,605	0.31
Susitna River	9.61*	289,000	305.03	332.65		333.16	0.001119	5.93	61,870	7,591	0.33
Susitna River	9.46*	289,000	303.87	331.86		332.40	0.001092	6.12	62,023	7,546	0.34

Table F-1: (Continued)

River	River Mile [1]	Total Dis-charge (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Critical Water Surface Elevation (ft)	Energy Gradeline Elevation (ft)	Energy Gradeline Slope (ft/ft)	Channel Velocity (ft/s)	Flow Area (sq ft)	Top Width (ft)	Channel Froude Number
Susitna River	9.32*	289,000	302.72	331.13		331.69	0.000999	6.30	62,601	7,517	0.34
Susitna River	9.18*	289,000	301.57	330.39		331.00	0.001005	6.56	63,279	7,735	0.35
Susitna River	9.04*	289,000	300.41	329.60		330.27	0.001092	6.87	63,665	7,930	0.37
Susitna River	8.90*	289,000	299.26	328.79		329.49	0.001162	7.13	63,948	7,917	0.38
Susitna River	8.75*	289,000	298.11	327.91		328.67	0.001225	7.48	63,747	7,888	0.40
Susitna River	8.61*	289,000	296.95	326.96		327.78	0.001331	7.91	63,034	7,859	0.42
Susitna River	8.47	289,000	295.80	325.87	321.66	326.77	0.001592	8.45	61,255	7,830	0.45
Talkeetna River	0.41	60,300	335.50	352.76	344.28	353.15	0.000277	5.14	14,261	1,293	0.24
Talkeetna River	0.40	60,300	335.50	351.34	345.98	352.70	0.001013	9.37	6,434	1,198	0.46
Talkeetna River	0.39	Bridge									
Talkeetna River	0.37	60,300	331.26	350.32	345.81	352.05	0.001348	10.58	5,746	703	0.52
Talkeetna River	0.36	60,300	332.90	349.90	346.05	351.26	0.001240	9.83	7,403	935	0.50
Talkeetna River	0.35	60,300	332.90	349.85	346.05	350.81	0.000970	8.68	9,630	1,495	0.44
Talkeetna River	0.34	60,300	332.90	346.98	346.34	349.85	0.003565	13.93	6,334	1,200	0.81

Notes:
1. The interpolated cross sections are located at river miles marked with and "*".

Table F-2: Susitna River 100-Year Flood Model – HEC-RAS Standard Table 2

River	River Mile [1]	Energy Gradeline Elevation (ft)	Water Surface Elevation (ft)	Velocity Head (ft)	Friction Loss (ft)	Contraction & Expansion Loss (ft)	Discharge Left overbank (cfs)	Discharge Channel (cfs)	Discharge Right overbank (cfs)	Top Width (ft)
Susitna River	12.65	352.41	351.74	0.67	0.89	0.00	1936	211,384	8,680	10,202
Susitna River	12.56*	351.53	350.85	0.68	0.72	0.00	1019	218,981	8,700	10,053
Susitna River	12.49*	350.80	350.13	0.67	0.80	0.01	526	218,870	9,304	9,899
Susitna River	12.41*	349.99	349.34	0.65	0.63	0.02	312	219,501	8,886	9,516
Susitna River	12.34*	349.35	348.75	0.60	0.65	0.00	228	219,339	9,134	9,125
Susitna River	12.27*	348.70	348.11	0.60	0.57	0.02	147	218,719	9,834	8,942
Susitna River	12.19*	348.11	347.58	0.53	0.50	0.01	56	218,594	10,050	8,895
Susitna River	12.12*	347.59	347.09	0.50	1.24	0.03	25	217,549	11,126	8,830
Susitna River	12.01*	346.31	345.47	0.84	0.65	0.01		276,684	12,316	8,689
Susitna River	11.90*	345.65	344.84	0.81	0.62	0.00		276,875	12,125	8,665
Susitna River	11.83*	345.03	344.21	0.83	0.57	0.01		276,581	12,419	8,643
Susitna River	11.75*	344.45	343.67	0.78	0.53	0.01		276,165	12,835	8,637
Susitna River	11.68*	343.91	343.17	0.74	0.48	0.01		275,571	13,429	8,626
Susitna River	11.61	343.41	342.71	0.70	0.66	0.01		274,837	14,163	8,619
Susitna River	11.50*	342.75	342.07	0.68	0.66	0.01		277,478	11,522	8,506
Susitna River	11.39*	342.08	341.43	0.65	0.61	0.01		279,312	9,688	8,400
Susitna River	11.27*	341.46	340.84	0.62	0.57	0.01		281,329	7,671	8,313
Susitna River	11.16*	340.88	340.29	0.58	0.53	0.01		282,558	6,442	8,236
Susitna River	11.04*	340.34	339.80	0.54	0.50	0.01		283,506	5,494	8,106
Susitna River	10.94*	339.83	339.33	0.50	0.44	0.01		283,803	5,197	7,993
Susitna River	10.82*	339.38	338.91	0.47	0.38	0.01		284,621	4,379	7,869
Susitna River	10.71*	338.99	338.57	0.42	0.37	0.01		284,857	4,143	7,760
Susitna River	10.60	338.61	338.22	0.39	0.41	0.01		284,858	4,142	7,693
Susitna River	10.46*	338.19	337.83	0.36	0.58	0.01		281,912	7,088	7,671
Susitna River	10.31*	337.61	337.27	0.33	0.76	0.00		273,261	15,739	7,653
Susitna River	10.17*	336.84	336.50	0.35	0.72	0.00		271,729	17,271	7,631
Susitna River	10.02*	336.13	335.78	0.35	0.99	0.00		267,616	21,384	7,639
Susitna River	9.90*	335.13	334.75	0.38	1.06	0.01		264,620	24,380	7,622
Susitna River	9.75*	334.06	333.62	0.44	0.90	0.01		267,124	21,876	7,605
Susitna River	9.61*	333.16	332.65	0.51	0.76	0.00		269,856	19,144	7,591
Susitna River	9.46*	332.40	331.86	0.54	0.71	0.00		267,369	21,631	7,546
Susitna River	9.32*	331.69	331.13	0.57	0.69	0.00		264,500	24,500	7,517

Table F-2: (Continued)

River	River Mile [1]	Energy Gradeline Elevation (ft)	Water Surface Elevation (ft)	Velocity Head (ft)	Friction Loss (ft)	Contraction & Expansion Loss (ft)	Discharge Left overbank (cfs)	Discharge Channel (cfs)	Discharge Right overbank (cfs)	Top Width (ft)
Susitna River	9.18*	331.00	330.39	0.61	0.72	0.01		263,432	25,568	7,735
Susitna River	9.04*	330.27	329.60	0.67	0.77	0.00		261,725	27,275	7,930
Susitna River	8.90*	329.49	328.79	0.70	0.82	0.01		255,593	33,407	7,917
Susitna River	8.75*	328.67	327.91	0.75	0.88	0.01		249,335	39,665	7,888
Susitna River	8.61*	327.78	326.96	0.82	1.00	0.01		241,822	47,178	7,859
Susitna River	8.47	326.77	325.87	0.90				232,261	56,739	7,830
Talkeetna River	0.41	353.15	352.76	0.39	0.15	0.29	991	58,020	1,289	1,293
Talkeetna River	0.40	352.70	351.34	1.36	0.05	0.24		60,300		1,198
Talkeetna River	0.39	Bridge								
Talkeetna River	0.37	352.05	350.32	1.73	0.60	0.18	416	59,884		703
Talkeetna River	0.36	351.26	349.90	1.36	0.25	0.20	6831	53,137	332	935
Talkeetna River	0.35	350.81	349.85	0.96	0.39	0.57	13039	46,681	581	1,495
Talkeetna River	0.34	349.85	346.98	2.87	2.93	0.61	265	57,415	2,620	1,200

Notes:
1. The interpolated cross sections are located at river miles marked with an “*”.

Table F-3: Talkeetna River 100-Year Flood Model – HEC-RAS Standard Table 1

River	River Mile [1]	Total Dis-charge (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Critical Water Surface Elevation (ft)	Energy Gradeline Elevation (ft)	Energy Gradeline Slope (ft/ft)	Channel Velocity (ft/s)	Flow Area (sq ft)	Top Width (ft)	Channel Froude Number
Susitna River	12.65	178,000	331.60	350.97		351.54	0.001737	6.17	36,834	9,119	0.44
Susitna River	12.56*	187,000	331.42	350.10		350.69	0.001734	6.25	37,438	9,287	0.44
Susitna River	12.49*	187,000	331.90	349.39		349.97	0.001829	6.22	37,206	9,018	0.44
Susitna River	12.41*	187,000	331.12	348.67		349.22	0.001573	6.04	38,266	8,768	0.43
Susitna River	12.34*	187,000	330.97	348.13		348.62	0.001411	5.73	40,385	8,778	0.40
Susitna River	12.27*	187,000	332.31	347.56		348.04	0.001468	5.66	41,104	8,740	0.39
Susitna River	12.19*	187,000	330.67	347.13		347.54	0.001088	5.24	44,813	8,734	0.35
Susitna River	12.12*	187,000	331.16	346.75		347.12	0.001030	5.02	47,225	8,762	0.33
Susitna River	12.01*	268,000	329.39	345.15	342.67	345.95	0.001807	7.32	46,253	8,645	0.50
Susitna River	11.90*	268,000	328.63	344.50	342.01	345.28	0.001692	7.22	46,824	8,624	0.49
Susitna River	11.83*	268,000	327.78	343.85	341.33	344.65	0.001692	7.31	46,407	8,605	0.50
Susitna River	11.75*	268,000	326.85	343.30	340.70	344.05	0.001468	7.10	48,035	8,601	0.48
Susitna River	11.68*	268000	326.04	342.78	339.92	343.50	0.001394	6.94	49,254	8,593	0.47
Susitna River	11.61	268,000	325.20	342.31	339.40	343.00	0.001264	6.79	50,571	8,588	0.46
Susitna River	11.50*	268,000	323.86	341.66	338.64	342.32	0.001204	6.63	50,279	8,472	0.44
Susitna River	11.39*	268,000	322.51	341.01	337.79	341.64	0.001201	6.47	49,999	8,385	0.43
Susitna River	11.27*	268,000	321.17	340.41	336.98	341.01	0.001044	6.30	50,126	8,297	0.41
Susitna River	11.16*	268,000	319.82	339.85		340.42	0.001032	6.09	50,662	8,032	0.39
Susitna River	11.04*	268,000	318.48	339.36		339.88	0.000886	5.87	51,713	7,947	0.37
Susitna River	10.94*	268,000	317.13	338.88		339.37	0.000903	5.64	52,999	7,841	0.35
Susitna River	10.82*	268,000	315.79	338.46		338.91	0.000699	5.41	54,783	7,750	0.33
Susitna River	10.71*	268,000	314.44	338.12		338.52	0.000647	5.15	57,080	7,701	0.31
Susitna River	10.60	268,000	313.10	337.77		338.14	0.000671	4.92	59,295	7,674	0.29
Susitna River	10.46*	268,000	311.95	337.38		337.73	0.000531	4.77	62,205	7,630	0.28
Susitna River	10.31*	268,000	310.79	336.83		337.14	0.001558	4.63	63,801	7,605	0.26
Susitna River	10.17*	268,000	309.64	336.05		336.38	0.000844	4.73	63,751	7,573	0.27
Susitna River	10.02*	268,000	308.49	335.33		335.66	0.001355	4.77	64,152	7,567	0.27
Susitna River	9.90*	268,000	307.33	334.30		334.66	0.001567	5.00	62,308	7,533	0.28
Susitna River	9.75*	268,000	306.18	333.15		333.58	0.001573	5.42	59,627	7,489	0.31
Susitna River	9.61*	268,000	305.03	332.19		332.67	0.001118	5.75	58,406	7,520	0.32
Susitna River	9.46*	268,000	303.87	331.39		331.91	0.001108	5.98	58,464	7,534	0.34

Table F-3: (Continued)

River	River Mile [1]	Total Dis-charge (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Critical Water Surface Elevation (ft)	Energy Gradeline Elevation (ft)	Energy Gradeline Slope (ft/ft)	Channel Velocity (ft/s)	Flow Area (sq ft)	Top Width (ft)	Channel Froude Number
Susitna River	9.32*	268,000	302.72	330.64		331.19	0.001014	6.15	58,979	7,490	0.34
Susitna River	9.18*	268,000	301.57	329.91		330.49	0.001008	6.37	59,646	7,452	0.35
Susitna River	9.04*	268,000	300.41	329.14		329.77	0.001085	6.66	60,093	7,613	0.36
Susitna River	8.90*	268,000	299.26	328.33		329.00	0.001157	6.92	60,356	7,708	0.38
Susitna River	8.75*	268,000	298.11	327.46		328.17	0.001223	7.28	60,163	7,765	0.39
Susitna River	8.61*	268,000	296.95	326.51		327.29	0.001331	7.70	59,480	7,758	0.42
Susitna River	8.47	268,000	295.80	325.42	321.36	326.28	0.001593	8.23	57,751	7,697	0.45
Talkeetna River	0.41	81,200	335.50	355.71	345.49	356.19	0.000261	5.66	17,794	1,293	0.24
Talkeetna River	0.40	81,200	335.50	353.94	347.68	355.66	0.001004	10.53	7,712	1,198	0.47
Talkeetna River	0.39	Bridge									
Talkeetna River	0.37	81,200	331.26	352.47	347.65	354.76	0.001454	12.17	6,725	703	0.55
Talkeetna River	0.36	81,200	332.90	352.23	347.84	353.79	0.001153	10.66	9,583	935	0.49
Talkeetna River	0.35	81,200	332.90	352.31	347.85	353.28	0.000802	8.92	13,305	1,495	0.41
Talkeetna River	0.34	81,200	332.90	347.96	347.96	352.00	0.004457	16.66	7,513	1,202	0.92

Notes:
1. The interpolated cross sections are located at river miles marked with an “*”.

Table F-4: Talkeetna River 100-Year Flood Model – HEC-RAS Standard Table 2

River	River Mile [1]	Energy Gradeline Elevation (ft)	Water Surface Elevation (ft)	Velocity Head (ft)	Friction Loss (ft)	Contraction & Expansion Loss (ft)	Discharge Left overbank (cfs)	Discharge Channel (cfs)	Discharge Right overbank (cfs)	Top Width (ft)
Susitna River	12.65	351.54	350.97	0.57	0.86	0.00	971	171,467	5,562	9,119
Susitna River	12.56*	350.69	350.10	0.59	0.70	0.00	398	180,923	5,679	9,287
Susitna River	12.49*	349.97	349.39	0.58	0.74	0.01	297	180,902	5,802	9,018
Susitna River	12.41*	349.22	348.67	0.55	0.58	0.02	203	181,329	5,468	8,768
Susitna River	12.34*	348.62	348.13	0.49	0.57	0.00	131	181,028	5,841	8,778
Susitna River	12.27*	348.04	347.56	0.48	0.49	0.02	85	180,297	6,618	8,740
Susitna River	12.19*	347.54	347.13	0.41	0.40	0.01	31	179,793	7,176	8,734
Susitna River	12.12*	347.12	346.75	0.37	1.13	0.04	12	178,651	8,337	8,762
Susitna River	12.01*	345.95	345.15	0.80	0.66	0.01		257,458	10,542	8,645
Susitna River	11.90*	345.28	344.50	0.78	0.63	0.00		257,630	10,370	8,624
Susitna River	11.83*	344.65	343.85	0.80	0.58	0.01		257,375	10,625	8,605
Susitna River	11.75*	344.05	343.30	0.75	0.54	0.01		256,936	11,064	8,601
Susitna River	11.68*	343.50	342.78	0.72	0.49	0.01		256,378	11,622	8,593
Susitna River	11.61	343.00	342.31	0.68	0.68	0.01		255,671	12,329	8,588
Susitna River	11.50*	342.32	341.66	0.66	0.67	0.01		258,143	9,857	8,472
Susitna River	11.39*	341.64	341.01	0.63	0.62	0.01		259,877	8,123	8,385
Susitna River	11.27*	341.01	340.41	0.60	0.58	0.01		261,680	6,320	8,297
Susitna River	11.16*	340.42	339.85	0.57	0.54	0.01		262,617	5,383	8,032
Susitna River	11.04*	339.88	339.36	0.53	0.50	0.01		263,526	4,474	7,947
Susitna River	10.94*	339.37	338.88	0.49	0.44	0.01		263,755	4,245	7,841
Susitna River	10.82*	338.91	338.46	0.45	0.38	0.01		264,417	3,583	7,750
Susitna River	10.71*	338.52	338.12	0.41	0.37	0.01		264,584	3,416	7,701
Susitna River	10.60	338.14	337.77	0.37	0.41	0.01		264,572	3,428	7,674
Susitna River	10.46*	337.73	337.38	0.35	0.58	0.01		261,983	6,017	7,630
Susitna River	10.31*	337.14	336.83	0.32	0.77	0.00		254,315	13,685	7,605
Susitna River	10.17*	336.38	336.05	0.33	0.72	0.00		252,907	15,093	7,573
Susitna River	10.02*	335.66	335.33	0.33	1.00	0.00		249,208	18,792	7,567
Susitna River	9.90*	334.66	334.30	0.36	1.07	0.01		246,551	21,450	7,533
Susitna River	9.75*	333.58	333.15	0.43	0.90	0.01		248,787	19,213	7,489
Susitna River	9.61*	332.67	332.19	0.48	0.76	0.00		249,874	18,126	7,520
Susitna River	9.46*	331.91	331.39	0.52	0.72	0.00		249,173	18,827	7,534
Susitna River	9.32*	331.19	330.64	0.54	0.69	0.00		246,503	21,497	7,490

Table F-4: Talkeetna River 100-Year Flood Model – HEC-RAS Standard Table 2 (Continued)

River	River Mile [1]	Energy Gradeline Elevation (ft)	Water Surface Elevation (ft)	Velocity Head (ft)	Friction Loss (ft)	Contraction & Expansion Loss (ft)	Discharge Left overbank (cfs)	Discharge Channel (cfs)	Discharge Right overbank (cfs)	Top Width (ft)
Susitna River	9.18*	330.49	329.91	0.58	0.72	0.00		244,591	23,409	7,452
Susitna River	9.04*	329.77	329.14	0.63	0.77	0.00		242,989	25,011	7,613
Susitna River	8.90*	329.00	328.33	0.66	0.82	0.01		237,813	30,187	7,708
Susitna River	8.75*	328.17	327.46	0.72	0.88	0.01		232,462	35,538	7,765
Susitna River	8.61*	327.29	326.51	0.78	1.00	0.01		225,721	42,279	7,758
Susitna River	8.47	326.28	325.42	0.86				216,871	51,130	7,697
Talkeetna River	0.41	356.19	355.71	0.48	0.15	0.37	1,826	77,407	1,967	1,293
Talkeetna River	0.40	355.66	353.94	1.72	0.05	0.36		81,200		1,198
Talkeetna River	0.39	Bridge								
Talkeetna River	0.37	354.76	352.47	2.29	0.60	0.36	737	80,463		703
Talkeetna River	0.36	353.79	352.23	1.56	0.22	0.29	11,522	68,654	1,024	935
Talkeetna River	0.35	353.28	352.31	0.97	0.36	0.92	21,645	57,751	1,804	1,495
Talkeetna River	0.34	352.00	347.96	4.04	3.17	0.97	574	75,921	4,704	1,202

Notes:
1. The interpolated cross sections are located at river miles marked with an "*".

Table F-5: Two-Dimensional Model Main Channel Calibration Event – HEC-RAS Standard Table 1

River	River Mile [1]	Total Dis-charge (cfs))	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Critical Water Surface Elevation (ft)	Energy Gradeline Elevation (ft)	Energy Gradeline Slope (ft/ft)	Channel Velocity (ft/s)	Flow Area (sq ft)	Top Width (ft)	Channel Froude Number
Susitna River	12.65	75,300	331.60	347.71		348.18	0.001728	5.54	14,505	4,173	0.51
Susitna River	12.56*	76,860	331.42	346.90		347.33	0.001616	5.32	15,278	4,624	0.50
Susitna River	12.49*	76,860	331.90	346.24		346.67	0.001858	5.30	15,246	4,717	0.50
Susitna River	12.41*	76,860	331.12	345.60		345.98	0.001569	4.97	16,224	5,211	0.47
Susitna River	12.34*	76,860	330.97	345.06		345.38	0.001426	4.56	17,765	5,551	0.42
Susitna River	12.27*	76,860	332.31	344.43		344.76	0.001823	4.63	17,557	5,683	0.44
Susitna River	12.19*	76,860	330.67	343.83		344.11	0.001492	4.27	19,152	5,886	0.40
Susitna River	12.12*	76,860	331.16	343.23		343.51	0.001607	4.26	19,300	5,908	0.40
Susitna River	12.01*	90,900	329.39	341.68	340.10	342.09	0.001882	5.18	18,827	5,852	0.49
Susitna River	11.90*	90,900	328.63	340.97	339.45	341.39	0.001854	5.20	18,776	6,006	0.50
Susitna River	11.83*	90,900	327.78	340.18	338.85	340.65	0.002008	5.55	17,669	5,998	0.55
Susitna River	11.75*	90,900	326.85	339.47	337.92	339.94	0.001790	5.53	17,888	6,049	0.55
Susitna River	11.68*	90,900	326.04	338.78	336.78	339.27	0.001749	5.63	17,719	6,011	0.56
Susitna River	11.61	90,900	325.20	338.14	335.94	338.63	0.001596	5.69	17,713	6,027	0.57
Susitna River	11.50*	90,900	323.86	337.24	335.21	337.76	0.001504	5.83	16,626	5,441	0.57
Susitna River	11.39*	90,900	322.51	336.41	334.33	336.93	0.001434	5.78	16,362	5,039	0.56
Susitna River	11.27*	90,900	321.17	335.68	333.61	336.17	0.001244	5.63	16,568	5,086	0.54
Susitna River	11.16*	90,900	319.82	335.03		335.48	0.001141	5.40	17,120	5,181	0.51
Susitna River	11.04*	90,900	318.48	334.47		334.87	0.000974	5.11	18,042	5,334	0.48
Susitna River	10.94*	90,900	317.13	333.97		334.33	0.000898	4.79	19,259	5,390	0.44
Susitna River	10.82*	90,900	315.79	333.57		333.87	0.000683	4.43	20,887	5,537	0.39
Susitna River	10.71*	90,900	314.44	333.25		333.50	0.000582	4.05	22,887	5,713	0.35
Susitna River	10.60	90,900	313.10	332.97		333.18	0.000518	3.70	25,076	5,903	0.31
Susitna River	10.46*	90,900	311.95	332.70		332.87	0.000377	3.32	28,143	6,338	0.27
Susitna River	10.31*	90,900	310.79	332.25		332.39	0.001623	3.11	30,185	6,457	0.24
Susitna River	10.17*	90,900	309.64	331.45		331.61	0.000867	3.15	30,128	6,713	0.24
Susitna River	10.02*	90,900	308.49	330.73		330.88	0.001340	3.16	30,633	6,875	0.24
Susitna River	9.90*	90,900	307.33	329.71		329.89	0.001602	3.35	29,210	6,864	0.25
Susitna River	9.75*	90,900	306.18	328.55		328.76	0.001706	3.68	26,841	6,709	0.29
Susitna River	9.61*	90,900	305.03	327.52		327.76	0.001264	3.95	25,459	6,599	0.31
Susitna River	9.46*	90,900	303.87	326.64		326.90	0.001255	4.11	25,146	6,634	0.32

Table F-5: (Continued)

River	River Mile [1]	Total Dis-charge (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Critical Water Surface Elevation (ft)	Energy Gradeline Elevation (ft)	Energy Gradeline Slope (ft/ft)	Channel Velocity (ft/s)	Flow Area (sq ft)	Top Width (ft)	Channel Froude Number
Susitna River	9.32*	90,900	302.72	325.82		326.09	0.001146	4.24	25,248	6,640	0.33
Susitna River	9.18*	90,900	301.57	325.03		325.31	0.001113	4.36	25,590	6,571	0.33
Susitna River	9.04*	90,900	300.41	324.23		324.54	0.001135	4.50	25,955	6,485	0.34
Susitna River	8.90*	90,900	299.26	323.42		323.73	0.001185	4.66	26,166	6,394	0.34
Susitna River	8.75*	90,900	298.11	322.57		322.91	0.001216	4.87	26,215	6,293	0.36
Susitna River	8.61*	90,900	296.95	321.68		322.05	0.001294	5.13	26,029	6,146	0.37
Susitna River	8.47	90,900	295.80	320.64	317.54	321.06	0.001590	5.55	25,002	5,950	0.41
Talkeetna River	0.41	14,040	335.50	345.11	339.95	345.22	0.000213	2.69	5,626	1,096	0.19
Talkeetna River	0.40	14,040	335.50	344.74	341.21	345.10	0.000697	4.79	2,928	1,089	0.34
Talkeetna River	0.39	Bridge									
Talkeetna River	0.37	14,040	331.26	344.72	339.86	345.02	0.000491	4.39	3,202	447	0.29
Talkeetna River	0.36	14,040	332.90	344.65	340.09	344.97	0.000549	4.55	3,084	445	0.30
Talkeetna River	0.35	14,040	332.90	344.24	340.09	344.60	0.000645	4.84	2,903	425	0.33

Notes:
1. The interpolated cross sections are located at river miles marked with an "*".

Table F-6: Two-Dimensional Model Main Channel Calibration Event – HEC-RAS Standard Table 2

River	River Mile [1]	Energy Gradeline Elevation (ft)	Water Surface Elevation (ft)	Velocity Head (ft)	Friction Loss (ft)	Contraction & Expansion Loss (ft)	Discharge Left overbank (cfs)	Discharge Channel (cfs)	Discharge Right overbank (cfs)	Top Width (ft)
Susitna River	12.65	348.18	347.71	0.47	0.83	0.01	159	74,409	731	4,173
Susitna River	12.56*	347.33	346.90	0.43	0.67	0.00	78	76,177	606	4,624
Susitna River	12.49*	346.67	346.24	0.43	0.68	0.02	39	76,260	560	4,717
Susitna River	12.41*	345.98	345.60	0.38	0.58	0.02	11	76,363	486	5,211
Susitna River	12.34*	345.38	345.06	0.32	0.62	0.00	0	76,366	494	5,551
Susitna River	12.27*	344.76	344.43	0.33	0.63	0.02		76,272	588	5,683
Susitna River	12.19*	344.11	343.83	0.28	0.59	0.00		76,188	672	5,886
Susitna River	12.12*	343.51	343.23	0.28	1.40	0.01		76,053	807	5,908
Susitna River	12.01*	342.09	341.68	0.41	0.71	0.00		89,915	985	5,852
Susitna River	11.90*	341.39	340.97	0.41	0.73	0.01		89,857	1,043	6,006
Susitna River	11.83*	340.65	340.18	0.47	0.71	0.00		89,777	1,123	5,998
Susitna River	11.75*	339.94	339.47	0.47	0.67	0.00		89,616	1,284	6,049
Susitna River	11.68*	339.27	338.78	0.48	0.63	0.00		89,472	1,428	6,011
Susitna River	11.61	338.63	338.14	0.49	0.87	0.00		89,296	1,604	6,027
Susitna River	11.50*	337.76	337.24	0.52	0.83	0.00		90,097	803	5,441
Susitna River	11.39*	336.93	336.41	0.52	0.75	0.01		90,478	422	5,039
Susitna River	11.27*	336.17	335.68	0.49	0.67	0.01		90,689	211	5,086
Susitna River	11.16*	335.48	335.03	0.45	0.60	0.01		90,774	126	5,181
Susitna River	11.04*	334.87	334.47	0.41	0.53	0.01		90,819	81	5,334
Susitna River	10.94*	334.33	333.97	0.36	0.44	0.02		90,809	91	5,390
Susitna River	10.82*	333.87	333.57	0.30	0.36	0.01		90,781	119	5,537
Susitna River	10.71*	333.50	333.25	0.25	0.31	0.01		90,734	166	5,713
Susitna River	10.60	333.18	332.97	0.21	0.30	0.01		90,683	217	5,903
Susitna River	10.46*	332.87	332.70	0.17	0.47	0.01		90,484	416	6,338
Susitna River	10.31*	332.39	332.25	0.15	0.79	0.00		89,603	1,297	6,457
Susitna River	10.17*	331.61	331.45	0.15	0.73	0.00		89,466	1,434	6,713
Susitna River	10.02*	330.88	330.73	0.15	1.00	0.00		89,228	1,672	6,875
Susitna River	9.90*	329.89	329.71	0.17	1.13	0.00		89,030	1,870	6,864
Susitna River	9.75*	328.76	328.55	0.21	0.99	0.00		89,296	1,604	6,709
Susitna River	9.61*	327.76	327.52	0.24	0.86	0.00		89,370	1,530	6,599
Susitna River	9.46*	326.90	326.64	0.26	0.82	0.00		89,024	1,876	6,634
Susitna River	9.32*	326.09	325.82	0.27	0.77	0.00		88,449	2,451	6,640

Table F-6: (Continued)

River	River Mile [1]	Energy Gradeline Elevation (ft)	Water Surface Elevation (ft)	Velocity Head (ft)	Friction Loss (ft)	Contraction & Expansion Loss (ft)	Discharge Left overbank (cfs)	Discharge Channel (cfs)	Discharge Right overbank (cfs)	Top Width (ft)
Susitna River	9.18*	325.31	325.03	0.29	0.77	0.00		87,843	3,057	6,571
Susitna River	9.04*	324.54	324.23	0.30	0.79	0.00		87,097	3,804	6,485
Susitna River	8.90*	323.73	323.42	0.32	0.82	0.00		85,730	5,170	6,394
Susitna River	8.75*	322.91	322.57	0.34	0.86	0.00		84,155	6,745	6,293
Susitna River	8.61*	322.05	321.68	0.37	0.98	0.01		82,193	8,707	6,146
Susitna River	8.47	321.06	320.64	0.42				79,731	11,169	5,950
Talkeetna River	0.41	345.22	345.11	0.11	0.05	0.07	49	13,916	75	1,096
Talkeetna River	0.40	345.10	344.74	0.36	0.02	0.01		14,040		1,089
Talkeetna River	0.39	Bridge								
Talkeetna River	0.37	345.02	344.72	0.30	0.04	0.01	1	14,039		447
Talkeetna River	0.36	344.97	344.65	0.32	0.37	0.00	0	14,040		445
Talkeetna River	0.35	344.60	344.24	0.36	0.15	0.00		14,040		425
Talkeetna River	0.34	344.45	344.06	0.38	2.35	0.00		14,040		423

Notes:
1. The interpolated cross sections are located at river miles marked with an “*”.

Table F-7: Two-Dimensional Model Floodplain Calibration Event – HEC-RAS Standard Table 1

River	River Mile [1]	Total Dis-charge (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Critical Water Surface Elevation (ft)	Energy Gradeline Elevation (ft)	Energy Gradeline Slope (ft/ft)	Channel Velocity (ft/s)	Flow Area (sq ft)	Top Width (ft)	Channel Froude Number
Susitna River	12.65	70,150	331.60	347.71		348.12	0.001497	5.16	14,517	4,175	0.47
Susitna River	12.56*	76,000	331.42	346.95		347.36	0.001531	5.18	15,521	4,654	0.49
Susitna River	12.49*	76,000	331.90	346.33		346.73	0.001730	5.10	15,681	4,809	0.48
Susitna River	12.41*	76,000	331.12	345.75		346.09	0.001428	4.70	17,025	5,446	0.44
Susitna River	12.34*	76,000	330.97	345.27		345.55	0.001249	4.26	18,899	5,689	0.39
Susitna River	12.27*	76,000	332.31	344.76		345.03	0.001389	4.17	19,480	5,807	0.38
Susitna River	12.19*	76,000	330.67	344.37		344.57	0.000955	3.66	22,377	6,239	0.32
Susitna River	12.12*	76,000	331.16	344.04		344.22	0.000848	3.42	24,428	7,084	0.29
Susitna River	12.01*	128,800	329.39	342.59	340.86	343.11	0.001886	5.80	24,710	7,281	0.49
Susitna River	11.90*	128,800	328.63	341.89	340.19	342.40	0.001827	5.76	24,905	7,391	0.49
Susitna River	11.83*	128,800	327.78	341.13	339.61	341.69	0.001916	6.04	23,819	7,187	0.52
Susitna River	11.75*	128,800	326.85	340.47	338.94	341.01	0.001694	5.95	24,484	7,346	0.52
Susitna River	11.68*	128,800	326.04	339.84	338.27	340.37	0.001632	5.93	24,798	7,418	0.52
Susitna River	11.61	128,800	325.20	339.26	337.54	339.79	0.001490	5.89	25,302	7,492	0.51
Susitna River	11.50*	128,800	323.86	338.45	336.67	338.98	0.001388	5.86	24,250	7,108	0.51
Susitna River	11.39*	128,800	322.51	337.69	335.83	338.21	0.001352	5.80	23,709	6,769	0.50
Susitna River	11.27*	128,800	321.17	337.00	335.06	337.49	0.001169	5.64	23,922	6,213	0.48
Susitna River	11.16*	128,800	319.82	336.38		336.83	0.001107	5.41	24,735	6,183	0.45
Susitna River	11.04*	128,800	318.48	335.83		336.24	0.000953	5.16	25,829	6,309	0.43
Susitna River	10.94*	128,800	317.13	335.33		335.70	0.000922	4.89	27,127	6,306	0.40
Susitna River	10.82*	128,800	315.79	334.91		335.23	0.000702	4.60	28,832	6,409	0.37
Susitna River	10.71*	128,800	314.44	334.57		334.86	0.000618	4.28	31,024	6,527	0.33
Susitna River	10.60	128,800	313.10	334.26		334.50	0.000583	4.00	33,255	6,677	0.31
Susitna River	10.46*	128,800	311.95	333.94		334.15	0.000436	3.71	36,377	7,060	0.27
Susitna River	10.31*	128,800	310.79	333.44		333.63	0.001627	3.55	38,464	7,292	0.25
Susitna River	10.17*	128,800	309.64	332.64		332.84	0.000867	3.61	38,490	7,260	0.25
Susitna River	10.02*	128,800	308.49	331.91		332.11	0.001358	3.62	39,021	7,204	0.25
Susitna River	9.90*	128,800	307.33	330.88		331.10	0.001614	3.83	37,416	7,109	0.26
Susitna River	9.75*	128,800	306.18	329.71		329.97	0.001688	4.20	34,886	7,021	0.29
Susitna River	9.61*	128,800	305.03	328.69		328.99	0.001233	4.48	33,490	6,934	0.32
Susitna River	9.46*	128,800	303.87	327.83		328.16	0.001214	4.65	33,260	6,847	0.33

Table F-7: (Continued)

River	River Mile [1]	Total Dis-charge (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Critical Water Surface Elevation (ft)	Energy Gradeline Elevation (ft)	Energy Gradeline Slope (ft/ft)	Channel Velocity (ft/s)	Flow Area (sq ft)	Top Width (ft)	Channel Froude Number
Sustina River	9.32*	128,800	302.72	327.04		327.37	0.001105	4.78	33,450	6,761	0.33
Sustina River	9.18*	128,800	301.57	326.27		326.62	0.001077	4.92	33,849	6,676	0.34
Sustina River	9.04*	128,800	300.41	325.49		325.87	0.001115	5.10	34,187	6,592	0.34
Sustina River	8.90*	128,800	299.26	324.69		325.09	0.001163	5.27	34,413	6,509	0.35
Sustina River	8.75*	128,800	298.11	323.85		324.27	0.001201	5.51	34,378	6,429	0.37
Sustina River	8.61*	128,800	296.95	322.95		323.41	0.001295	5.83	34,021	6,457	0.39
Sustina River	8.47	128,800	295.80	321.89	319.16	322.42	0.001593	6.32	32,740	6,465	0.42
Talkeetna River	0.41	52,800	335.50	352.04	343.78	352.37	0.000249	4.71	14,082	1,350	0.23
Talkeetna River	0.40	52,800	335.50	350.52	345.76	351.90	0.001140	9.44	5,593	1,198	0.48
Talkeetna River	0.39	Bridge									
Talkeetna River	0.37	52,800	331.26	350.10	345.09	351.46	0.001095	9.39	5,673	703	0.47
Talkeetna River	0.36	52,800	332.90	349.23	345.29	350.81	0.001431	10.17	5,763	875	0.53
Talkeetna River	0.35	52,800	332.90	349.00	345.55	350.40	0.001366	9.83	7,909	1,154	0.52
Talkeetna River	0.34	52,800	332.90	345.32	345.32	349.12	0.005764	15.64	3,387	465	0.99

Notes:
1. The interpolated cross sections are located at river miles marked with an “*”.

Table F-8: Two-Dimensional Model Floodplain Calibration Event – HEC-RAS Standard Table 2

River	River Mile [1]	Energy Gradeline Elevation (ft)	Water Surface Elevation (ft)	Velocity Head (ft)	Friction Loss (ft)	Contraction & Expansion Loss (ft)	Discharge Left overbank (cfs)	Discharge Channel (cfs)	Discharge Right overbank (cfs)	Top Width (ft)
Susitna River	12.65	348.12	347.71	0.41	0.76	0.00	148	69,320	682	4,175
Susitna River	12.56*	347.36	346.95	0.41	0.63	0.00	78	75,313	609	4,654
Susitna River	12.49*	346.73	346.33	0.40	0.62	0.02	42	75,383	576	4,809
Susitna River	12.41*	346.09	345.75	0.34	0.51	0.02	14	75,463	523	5,446
Susitna River	12.34*	345.55	345.27	0.28	0.51	0.00	1	75,431	568	5,689
Susitna River	12.27*	345.03	344.76	0.27	0.44	0.02		75,280	720	5,807
Susitna River	12.19*	344.57	344.37	0.21	0.35	0.01		75,143	857	6,239
Susitna River	12.12*	344.22	344.04	0.18	1.08	0.03		75,041	959	7,084
Susitna River	12.01*	343.11	342.59	0.52	0.70	0.00		127,126	1,674	7,281
Susitna River	11.90*	342.40	341.89	0.51	0.71	0.01		127,080	1,720	7,391
Susitna River	11.83*	341.69	341.13	0.56	0.68	0.01		127,023	1,777	7,187
Susitna River	11.75*	341.01	340.47	0.54	0.63	0.00		126,771	2,029	7,346
Susitna River	11.68*	340.37	339.84	0.54	0.59	0.00		126,546	2,254	7,418
Susitna River	11.61	339.79	339.26	0.53	0.81	0.00		126,351	2,449	7,492
Susitna River	11.50*	338.98	338.45	0.53	0.77	0.00		127,129	1,671	7,108
Susitna River	11.39*	338.21	337.69	0.52	0.71	0.01		127,778	1,022	6,769
Susitna River	11.27*	337.49	337.00	0.49	0.64	0.01		128,160	640	6,213
Susitna River	11.16*	336.83	336.38	0.45	0.58	0.01		128,335	465	6,183
Susitna River	11.04*	336.24	335.83	0.41	0.53	0.01		128,433	367	6,309
Susitna River	10.94*	335.70	335.33	0.37	0.45	0.01		128,423	377	6,306
Susitna River	10.82*	335.23	334.91	0.33	0.37	0.01		128,419	381	6,409
Susitna River	10.71*	334.86	334.57	0.28	0.34	0.01		128,363	437	6,527
Susitna River	10.60	334.50	334.26	0.25	0.34	0.01		128,289	511	6,677
Susitna River	10.46*	334.15	333.94	0.21	0.52	0.01		127,891	909	7,060
Susitna River	10.31*	333.63	333.44	0.19	0.79	0.00		126,243	2,557	7,292
Susitna River	10.17*	332.84	332.64	0.20	0.73	0.00		125,892	2,908	7,260
Susitna River	10.02*	332.11	331.91	0.20	1.01	0.00		124,692	4,108	7,204
Susitna River	9.90*	331.10	330.88	0.22	1.13	0.00		124,008	4,792	7,109
Susitna River	9.75*	329.97	329.71	0.26	0.98	0.00		124,622	4,179	7,021
Susitna River	9.61*	328.99	328.69	0.30	0.83	0.00		124,779	4,021	6,934
Susitna River	9.46*	328.16	327.83	0.32	0.79	0.00		123,946	4,854	6,847
Susitna River	9.32*	327.37	327.04	0.34	0.74	0.00		122,884	5,916	6,761

Table F-8: (Continued)

River	River Mile [1]	Energy Gradeline Elevation (ft)	Water Surface Elevation (ft)	Velocity Head (ft)	Friction Loss (ft)	Contraction & Expansion Loss (ft)	Discharge Left overbank (cfs)	Discharge Channel (cfs)	Discharge Right overbank (cfs)	Top Width (ft)
Susitna River	9.18*	326.62	326.27	0.36	0.75	0.00		121,953	6,847	6,676
Susitna River	9.04*	325.87	325.49	0.38	0.78	0.00		120,903	7,897	6,592
Susitna River	8.90*	325.09	324.69	0.40	0.81	0.00		118,679	10,122	6,509
Susitna River	8.75*	324.27	323.85	0.43	0.86	0.00		116,343	12,457	6,429
Susitna River	8.61*	323.41	322.95	0.47	0.98	0.01		113,744	15,056	6,457
Susitna River	8.47	322.42	321.89	0.53				110,426	18,374	6,465
Talkeetna River	0.41	352.37	352.04	0.33	0.15	0.32	839	50,521	1,440	1,350
Talkeetna River	0.40	351.90	350.52	1.38	0.04	0.10		52,800		1,198
Talkeetna River	0.39	Bridge								
Talkeetna River	0.37	351.46	350.10	1.36	0.58	0.07	417	52,383		703
Talkeetna River	0.36	350.81	349.23	1.58	0.32	0.09	591	51,948	261	875
Talkeetna River	0.35	350.40	349.00	1.41	0.57	0.72	524	49,335	2,940	1,154
Talkeetna River	0.34	349.12	345.32	3.80	3.62	0.98	26	52,774		465

Notes:
1. The interpolated cross sections are located at river miles marked with an “*”.

Figure F.1: HEC-RAS Cross Section on the Susitna River at River Mile 8.47

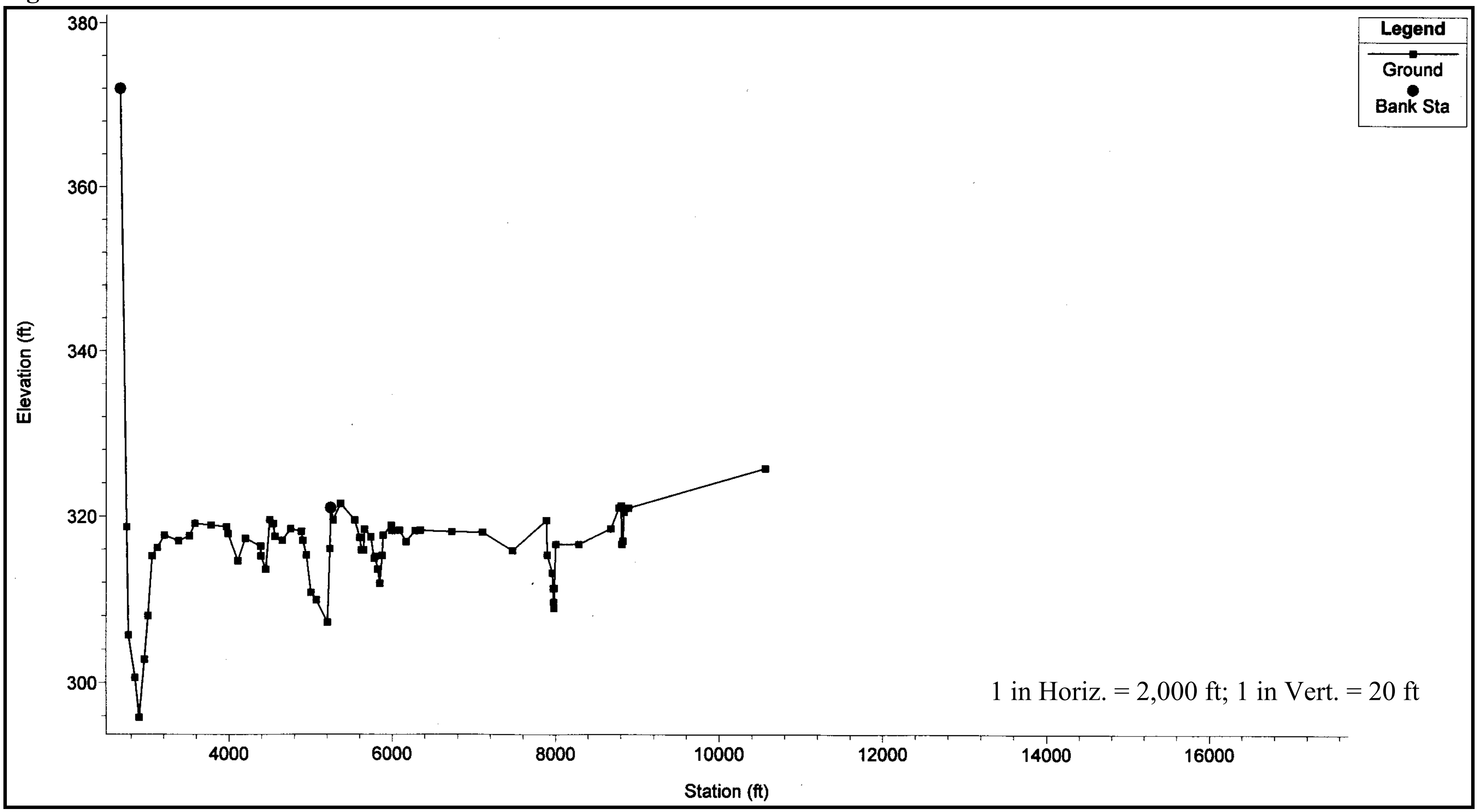


Figure F.2: HEC-RAS Cross Section on the Susitna River at River Mile 10.60

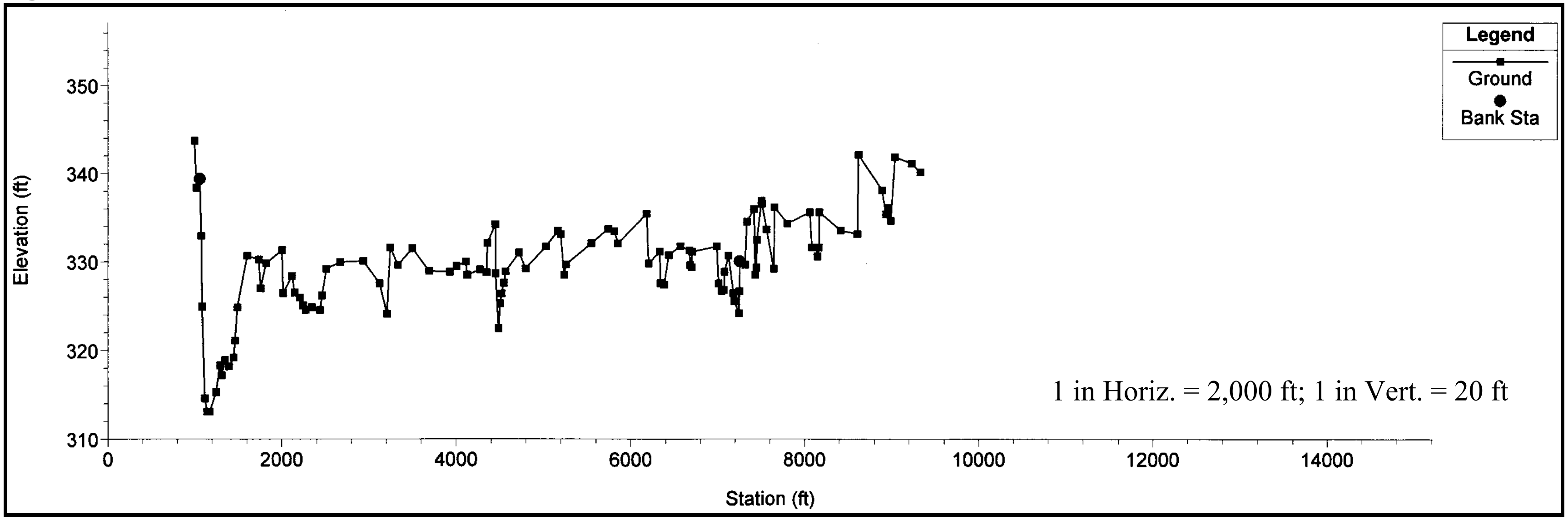


Figure F.3: HEC-RAS Cross Section on the Susitna River at River Mile 11.61

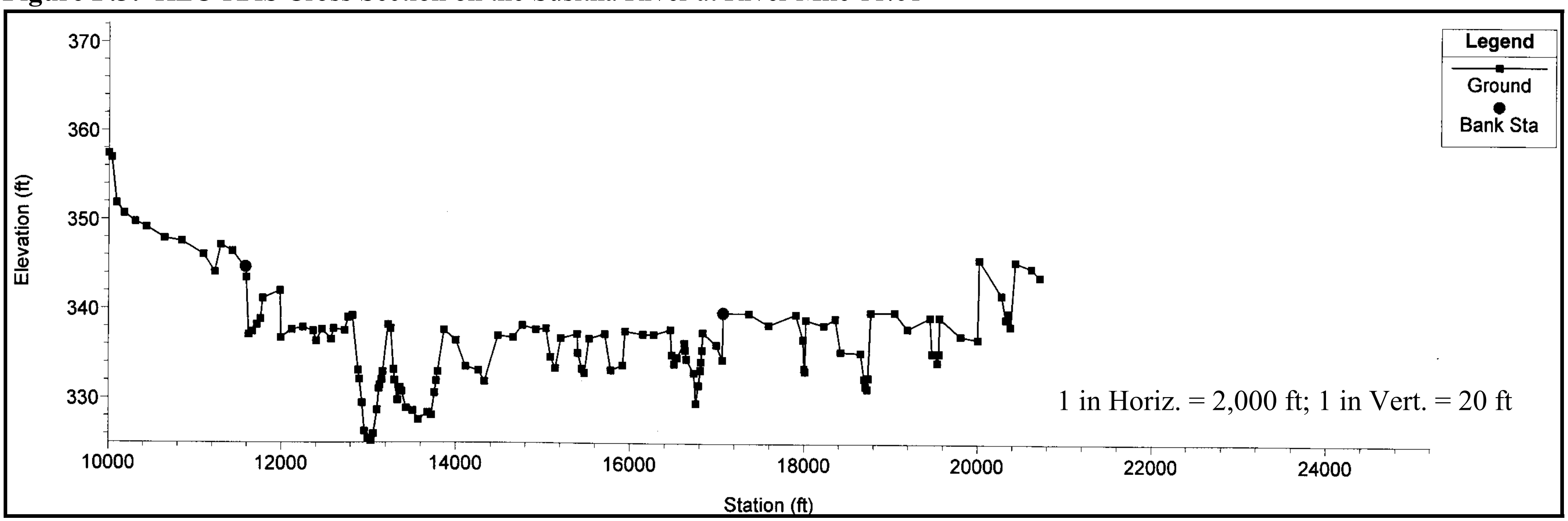


Figure F.4: HEC-RAS Cross Section on the Susitna River at River Mile 12.65

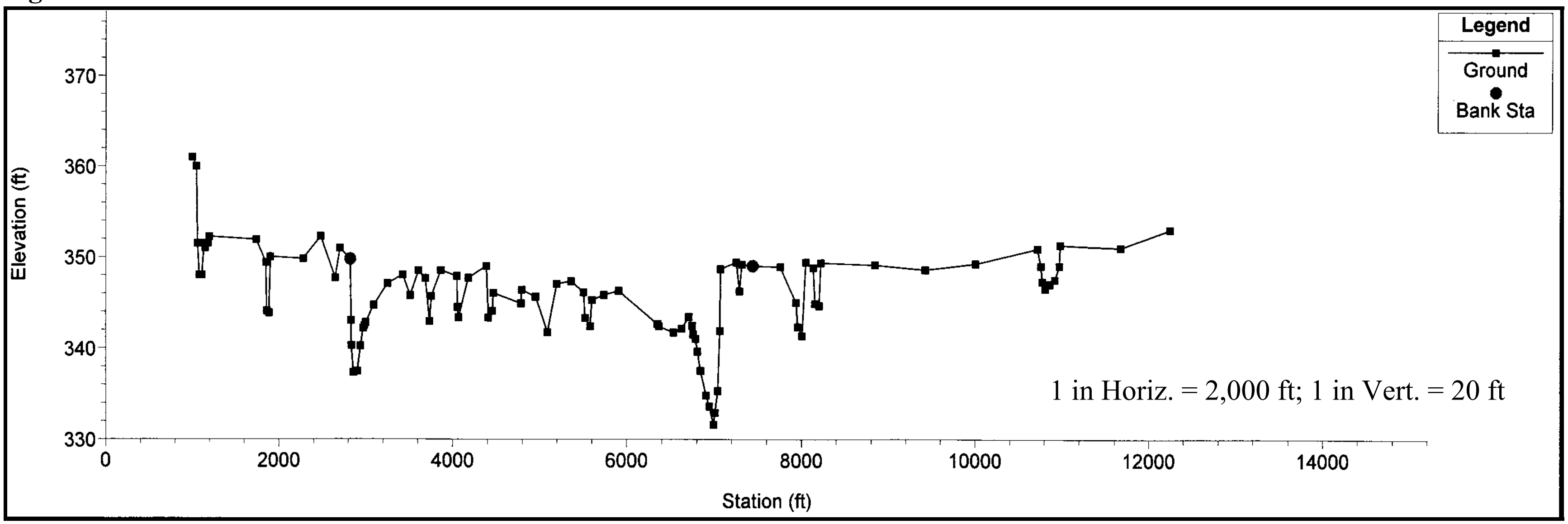


Figure F.5: HEC-RAS Cross Section on the Talkeetna River Approximately 70 Feet Upstream of the Bridge

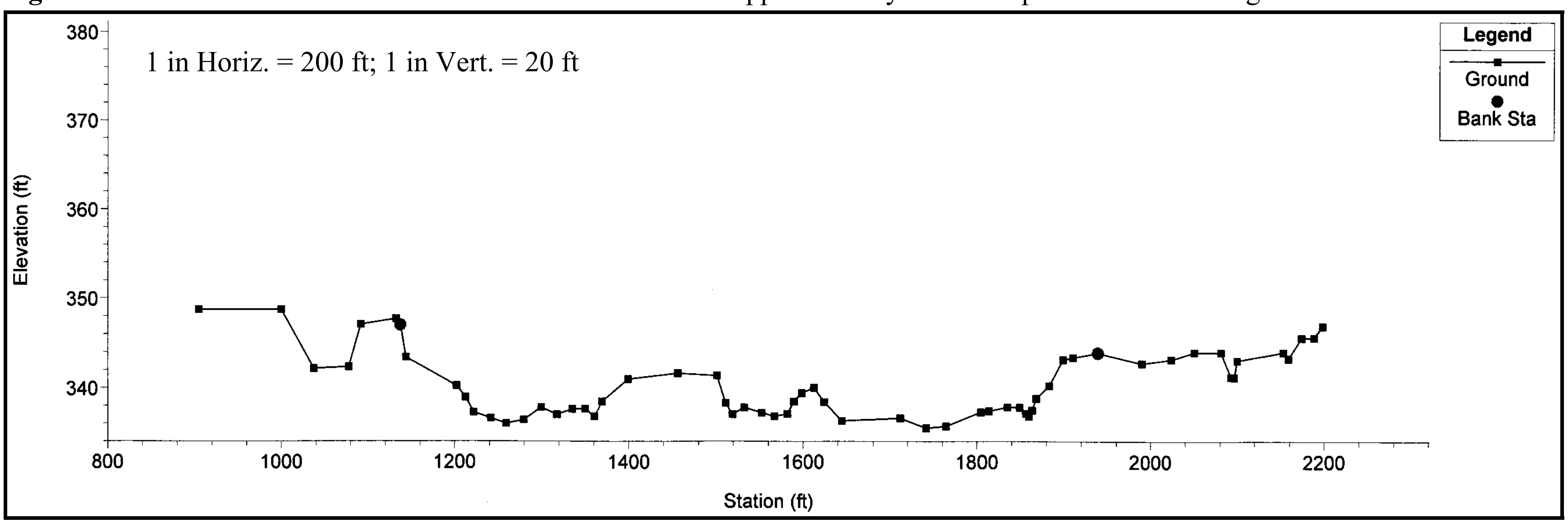


Figure F.6: HEC-RAS Cross Section on the Talkeetna River in the Bridge Opening

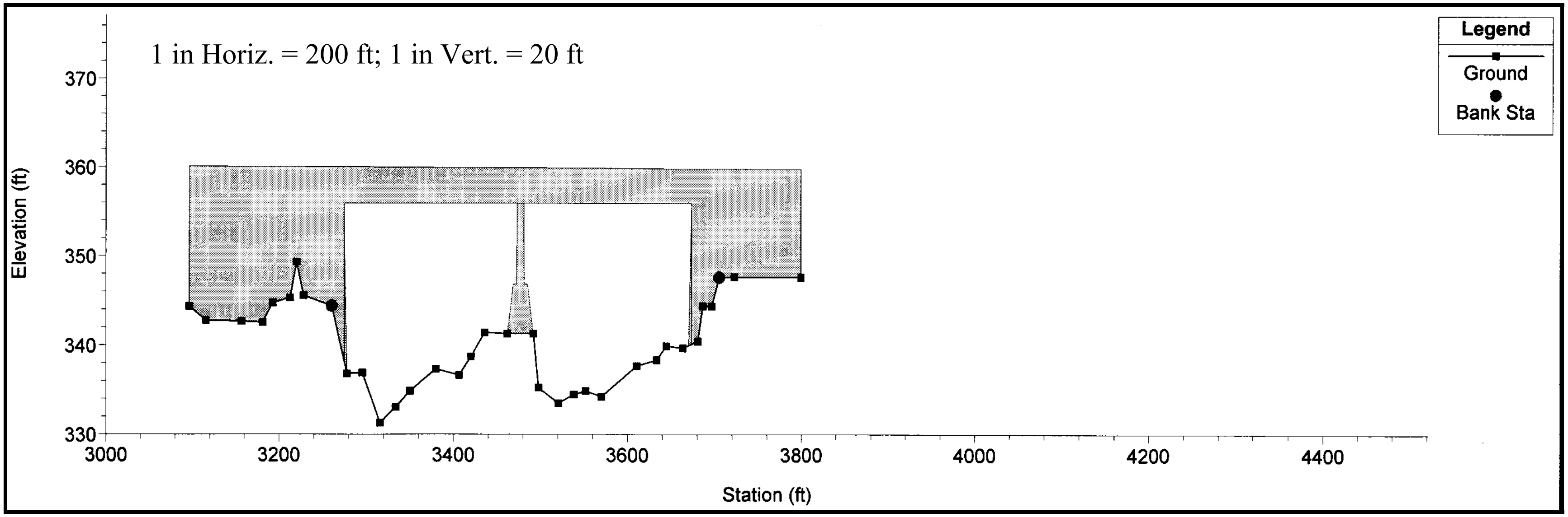
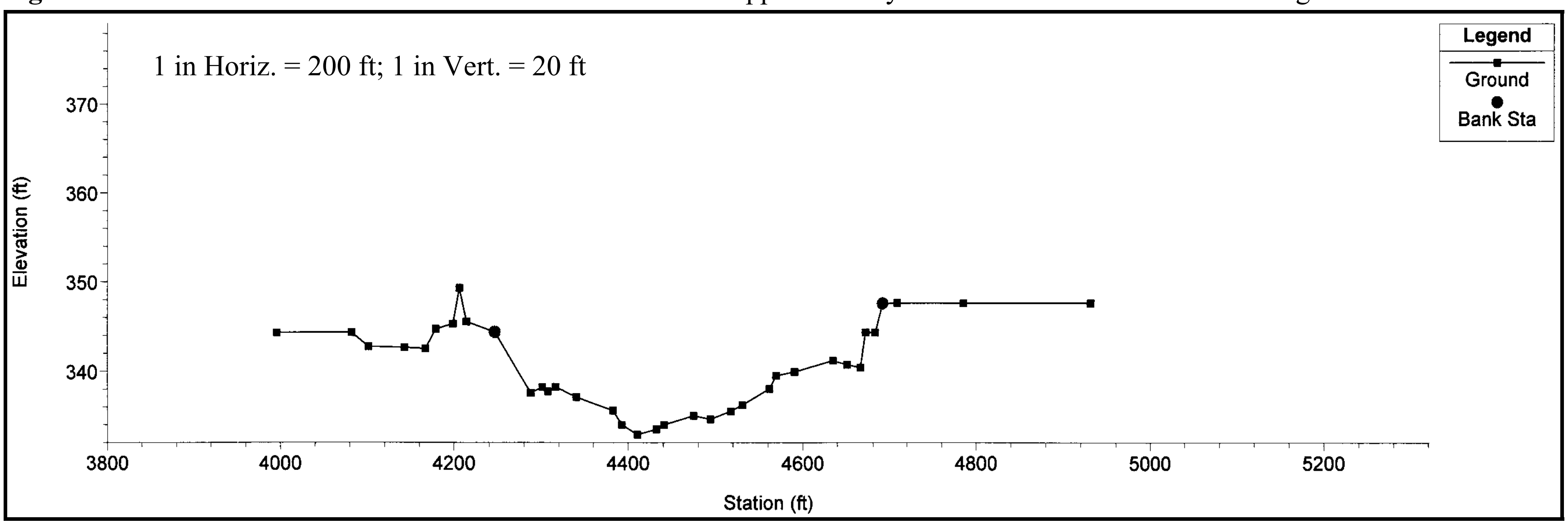


Figure F.7: HEC-RAS Cross Section on the Talkeetna River Approximately 150 Feet Downstream of the Bridge



APPENDIX G

TALKEETNA BANK MIGRATION ASSESSMENT

TECHNICAL MEMORANDUM

Talkeetna Bank Migration Assessment

PREPARED FOR:	Dave Coolidge, P.E. / CH2M HILL
PREPARED BY:	James W. Aldrich, P.E. P.H. and Timothy E. King / URS
PROJECT:	Talkeetna Airport Improvements – Phase II
	URS Project Number 26218895.OB612
DATE:	October 30, 2003
COPIES	File

Executive Summary

To prevent inundation of the airport facilities during a 100-year flood, consideration is being given to constructing a dike to protect the airport from flooding. One of the dike options, Dike Option 2a, is adjacent to the left bank of the Talkeetna River near the intersection of Front and Beaver Streets. To protect the dike from erosion by the river, heavy-duty erosion protection (probably riprap) will be required in the vicinity of the intersection of Front and Beaver Streets. The heavy-duty erosion protection must be placed at this location, and upstream and downstream from this location to a point where the bank of the river is unlikely to undermine the ends of the protection during the economic life of the project.

Aerial photographs taken in 1953, 1974 and 2001 were used to estimate the rate at which the left bank of the Talkeetna River is eroding. The maximum rate of erosion within the reach examined for this task was 17 feet per year between 1953 and 2001, and 4.1 feet per year between 1974 and 2001. The increased rate of erosion between 1953 and 1974 may be due to the construction of a dike. The dike is visible in the 1953 photographs and appears to have been relatively new at the time the photographs were taken. Thus, the erosion rate computed between 1974 and 2001 may be more representative of the long-term natural erosion rate than the value computed for the period 1953 to 2001.

If Dike Option 2a is chosen, it is estimated that construction would begin in 2005 and that the desired economic life would be 20 years. Therefore, based on the maximum rate of erosion observed between 1974 and 2001, it is suggested that the heavy-duty erosion protection be placed along that portion of the dike for which the top river-side shoulder of the dike is within 200 feet of the 2001 bank line. The suggested limits of the heavy-duty erosion protection are shown on Figure 1.

Background

Consideration is being given to the construction of several improvements at the Talkeetna Airport. Some of those improvements would be located within the 100-year floodplain. Therefore, consideration is also being given to constructing a dike that would prevent the airport facilities from being inundated during a 100-year flood.

The proposed dike alignment, Dike Option 2a, is adjacent to the left bank of the Talkeetna River near the intersection of Front and Beaver Streets. At a minimum, the portion of the dike that is close to the river channel will require heavy-duty erosion protection to prevent erosion of the dike by the river channel. To estimate the likely limits of the heavy-duty erosion protection, for the purpose of developing a rough order of magnitude (ROM) construction cost estimate for the dike, an assessment of the magnitude of the erosion along the bank during the last 25 to 50 years was conducted. The results of the bank erosion assessment are reported herein.

Methods

Aerial photographs taken in 1953, 1974 and 2001 were used to estimate the rate at which the left bank of the Talkeetna River is eroding, between the Talkeetna River Bridge and the mouth of the slough near the sewage lagoon. Two periods were considered: 1953 to 2001, and 1974 to 2001.

The 2001 photography had previously been georeferenced by McClintock Land Associates, Inc. and was used as the base for georeferencing the 1953 and 1974 imagery. The 2001 image had been georeferenced to a local control network. The horizontal coordinates were based on "Station G-38", an ADOT&PF GPS control point near the Talkeetna Airport.

Two historic stereo pairs were acquired from AeroMap U.S. Inc. for comparison with the 2001 image. The first photo, a black and white image taken on 26 June 1953, has an approximate scale of 1-inch equals 1670 feet (1:20,040). The second photo, a color image taken on 5 August 1974, has an approximate scale of 1-inch equals 1320 feet (1:15,840). In addition to prints of the stereo pairs, a single scanned image was also obtained from each set. The 1953 photograph was scanned at 833.5 pixels per inch (ppi), producing a pixel resolution of approximately 2 feet. The 1974 photograph was scanned at 660 ppi, also producing a pixel resolution of approximately 2 feet.

The historic images were georeferenced to the 2001 image using ArcGIS ArcInfo software. Four ground control points were identified on each image and used to georeference the images (Table 1).

Table 1: Ground Control Points

Control Point	1953 Photo	1974 Photo
GCP #1	North East corner of Alaska Railroad Bridge on Talkeetna River	North East corner of Alaska Railroad Bridge on Talkeetna River
GCP #2	Southeast Corner of Alaska Railroad Bridge on Talkeetna River	Visible road feature near antenna structure
GCP #3	Small pond with clearly identifiable features between the 1953 and 2001 photos	North edge of Alaska Railroad Bridge on Billion Slough
GCP #4	Identifiable stand of trees in the NW quadrant of the photo	Fire hydrant/electrical box clearly visible on the 1974 and 2001 photos

The Root Mean Square (RMS) error can be used to measure the error associated with a calculated position. In this case, how well the referenced image matches the base image. For this project, the RMS error was calculated in pixels and converted to feet using the resolution associated with the scanned images.

The location of the top of the left bank was identified in each image and transferred to the 2001 image. The distance the top of the left bank had eroded was then computed by measuring the distance between the bank lines in specific years. In general, the measurements were made perpendicular to the 2001 bank line or the left most channel. Measurements were made every 200 feet, between approximately 930 and 3600 feet upstream from the Talkeetna River Bridge.

Results

The RMS error for the 1953 photo was computed to be ± 4.60 pixels, or approximately ±10 feet. The RMS error for the 1974 photo was computed to be ± 0.733 pixels, or approximately ± 1.5 feet. It should be noted that these are estimates and that a variety of factors were not taken into account which could increase the possible error, including: minor terrain variations and image/scanning distortion. Nevertheless, the results are considered more than acceptable for the purposes of this task.

The location of the top of bank in 1953, 1974 and 2001 is shown in Figure 1. The rate of erosion between 1953 and 2001, and between 1974 and 2001 is presented in the following table.

Table 2: Summary of Erosion Rates Along the Left Bank of the Talkeetna River

Dimension	Left Bank Erosion Rate (ft/yr)	
Year	1953 - 2001	1974 - 2001
Average Erosion Rate	10	1.3
Median Erosion Rate	11	0.7
Maximum Erosion Rate	17	4.1

Clearly the rate of erosion was considerably more between 1953 and 1974, than it was between 1974 and 2001. Therefore, an attempt was made to identify the cause of the increased rate of erosion by further comparing the images. A comparison of the 1953 and 2001 images is presented in Figure 2, and a comparison of the 1974 and 2001 images is presented in Figure 3.

After inspecting the 1953 image closely, it was noted that there appears to be a relatively recently constructed dike across a major sub channel of the Talkeetna River. The dike is located in the upper right quadrant of the 1953 image (Figure 2). Based on a comparison of the 1953 and the 1974 images, it appears that the dike was successful in blocking the sub channel. It seems likely that the additional water that was forced toward the left bank contributed to the increased rate of erosion between 1953 and 1974, as the channel adjusted to the new conditions. A comparison of the 1974 and the 2001 images indicates that the sub channel has continued to be abandoned by the river. During both periods, 1953 to 2001 and 1974 to 2001, erosion rates at or very close to the maximum rate occurred near the intersection of Front and Beaver Streets.

Discussion

Consideration is being given to constructing a dike to prevent the airport facilities from being inundated during a 100-year flood. The proposed dike alignment, Dike Option 2a (Figure 1), is adjacent to the left bank of the Talkeetna River near the intersection of Front and Beaver Streets. At a minimum, the portion of the dike that is close to the river channel will require heavy-duty erosion protection (probably riprap) to prevent erosion of the dike by the river channel. The river is closest to the proposed dike at the intersection of Front and Beaver Streets. The heavy-duty erosion protection must be placed at this location, and upstream and downstream from this location to a point where the bank of the river is unlikely to undermine the ends of the protection during the 20-year period following construction[1].

It is anticipated that the proposed dike will be constructed in 2005, if this option is selected. Thus, the results of the bank migration analysis can be used to estimate the distance the bank is likely to move between 2001 and 2025.

Although the maximum rate of erosion within the reach examined for this analysis is significantly greater than the average rate of erosion, the maximum erosion rate will be used to compute the potential magnitude of the bank movement because the maximum rate of erosion (or a rate close to it) occurred near the intersection of Front and Beaver Streets. Based on the erosion rate between 1953 and 2001, a 48-year period, the ends of the heavy-duty erosion protection should be at least 410 feet[2] from the 2001 bank line. Based on the erosion rate between 1974 and 2001, a 27-year period, the ends of the heavy-duty erosion protection should be at least 100 feet from the 2001 bank line.

A preliminary estimate of the riverbed scour in the left channel of the Talkeetna River near the intersection of Front and Beaver Streets suggests that the depth of scour might extend to 16 feet below the peak water surface of the 100-year flood. The top of the dike is anticipated to be 3 feet above the peak water surface of the 100-year flood. The side slope on the dike is anticipated

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[1] Don Baxter. 2003. Personal Communication. Alaska Department of Transportation and Public Facilities.

[2] The setback distance is measured perpendicular to the 2001 bank line.

to be 2 Horizontal to 1 Vertical (2H:1V), the upper limit of the riprap gradation is anticipated to have a median diameter of 1.4 feet and a maximum diameter of 2 feet. The thickness of the riprap layer is anticipated to be 2.8 feet, measured perpendicular to the slope. Based on these assumptions, the distance from the riverside toe of the riprap to the riverside top shoulder of the dike is likely to be on the order of 45 feet[3]. Thus, the top riverside shoulder of the dike must be at least 455 feet from the 2001 bank line, if the 1953 to 2001 erosion rate is to be used to compute the setback, and 145 feet if the 1974 to 2001 erosion rate is to be used. The difference in the setback computed with the two erosion rates will make a significant difference in the length of dike to be protected.

A close inspection of the 1953 image revealed what appears to be a newly constructed dike that might have caused the higher rate of erosion between 1953 and 1974 (Figure 2). Thus, for the purpose of estimating a rough-order-of-magnitude (ROM) cost for the construction of Dike Option 2a, it should be assumed that the 1974 to 2001 erosion rate is more representative of the natural long-term erosion rate at this site. However, due to the uncertainty in the magnitude of the natural long-term erosion rate a safety factor of 50 percent should be added to the estimated erosion rate when computing the limits of the heavy-duty erosion protection. Thus, it is recommended that for ROM cost estimating purposes, the ends of the heavy-duty erosion protection be located such that the top riverside shoulder of the dike is at least 200 feet from the 2001 bank line at the end of the heavy-duty erosion protection. The approximate limits of the heavy-duty erosion protection[4] are presented on Figure 1. During final design it is recommended that the rate of erosion on the left bank be further evaluated by assessing the reach immediately upstream from the reach that was evaluated for this task, and that the final design erosion rate consider both the observations made in the reach immediately adjacent to the proposed dike and in the reach immediately upstream from the project. It is also recommended that during final design consideration be given to the potential impact of the heavy-duty erosion protection on the bank immediately upstream and downstream of the proposed erosion protection.

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[3] The distance from the riverside toe of the riprap to the riverside top shoulder of the dike is computed as 2 times the height of the structure (2 * [16 + 3] feet) plus the horizontal thickness of the riprap (2.3 * 2.8 feet).

[4] From the intersection of Front and Beaver Streets the heavy-duty erosion protection would extend approximately 400 feet down Front Street and 200 feet up Beaver Street.

FIGURE 1: Bank Migration Between 1953 and 2001

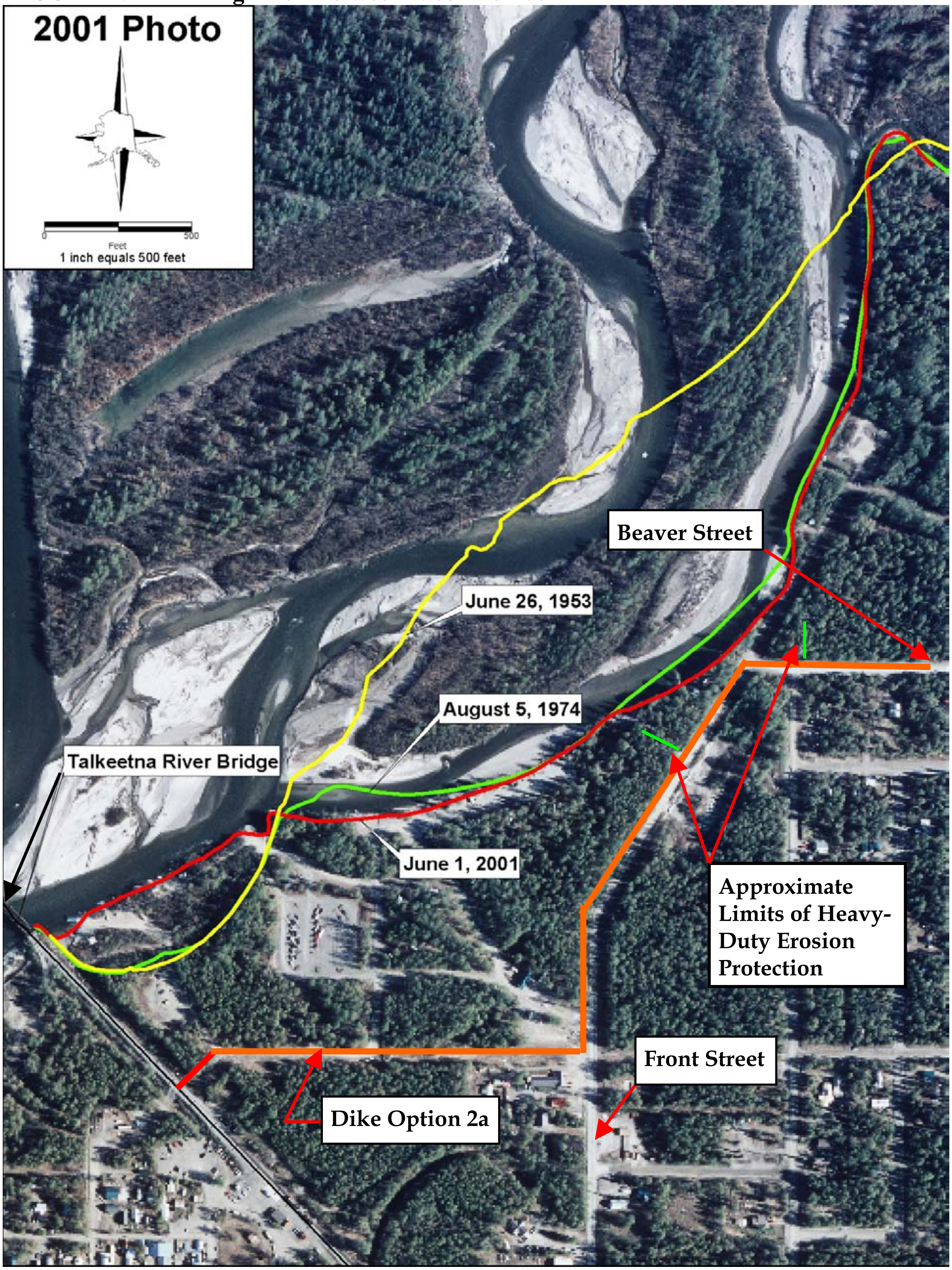


FIGURE 2: Comparison of 1953 and 2001 Aerial Photographs

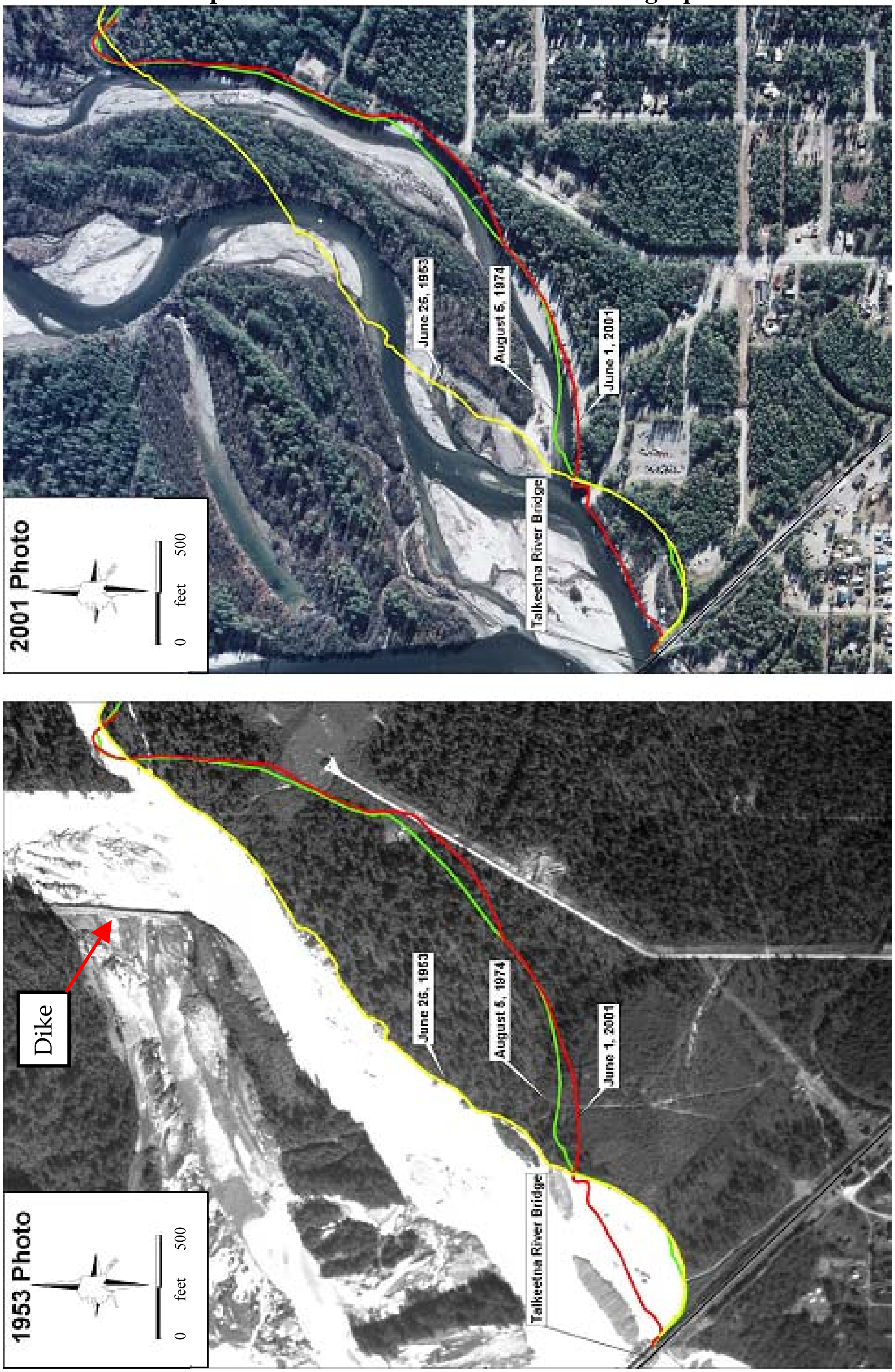
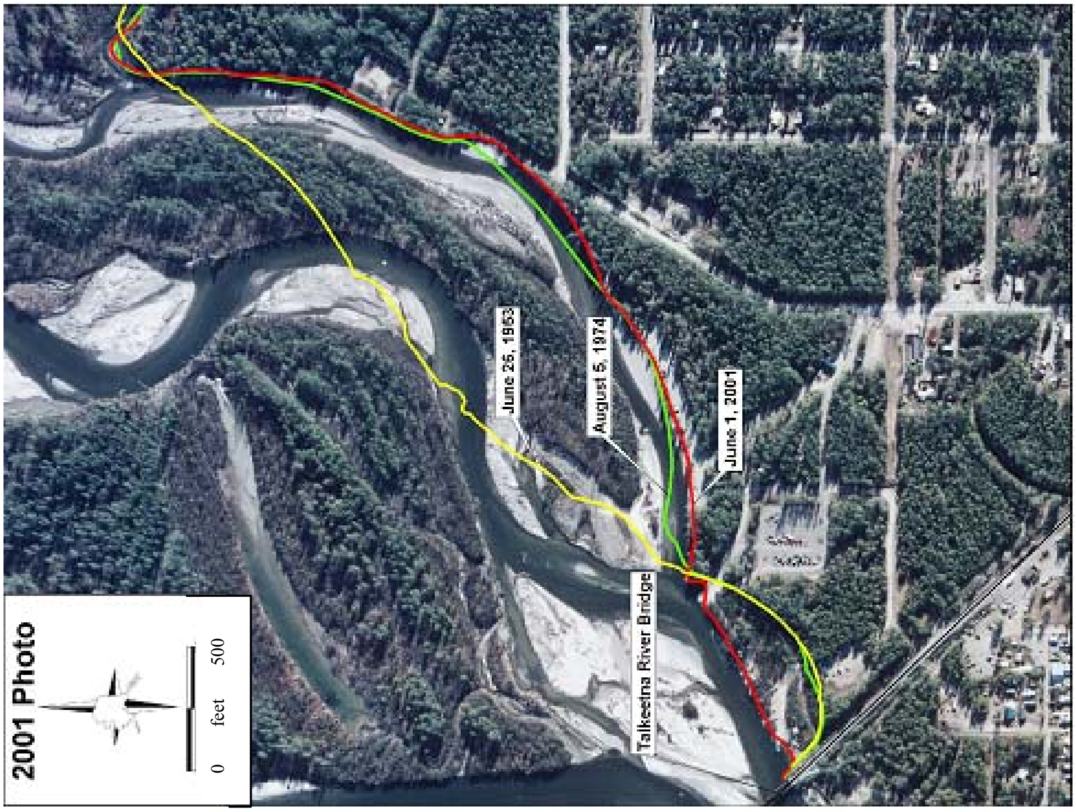
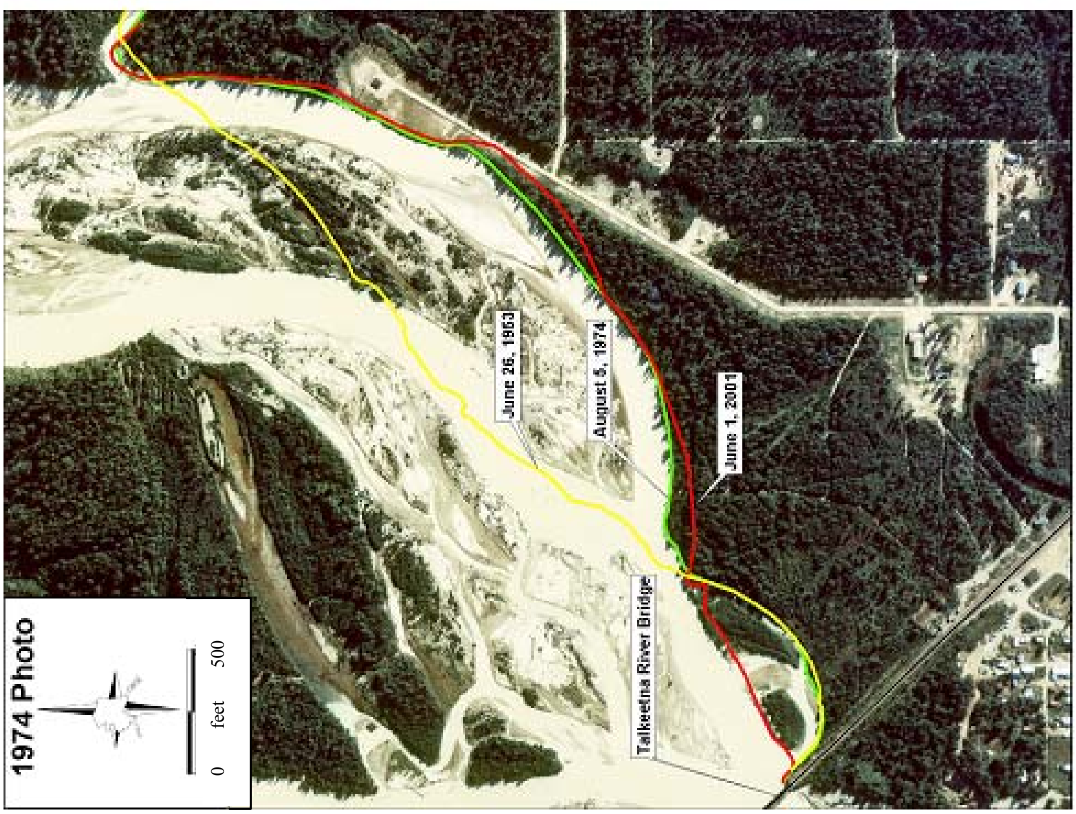


FIGURE 3: Comparison of 1974 and 2001 Aerial Photographs





APPENDIX H

TWISTER CREEK DRAINAGE STRUCTURE ASSESSMENT

TECHNICAL MEMORANDUM

Twister Creek Drainage Structure Assessment

PREPARED FOR:	Dave Coolidge, P.E. / CH2M HILL
PREPARED BY:	James W. Aldrich, P.E. P.H. and Jeff A. Oatley / URS
PROJECT:	Talkeetna Airport Improvements – Phase II
	URS Project Number 26218895.OB612
DATE:	November 14, 2003
COPIES	File

Executive Summary

To prevent inundation of the airport facilities during a 100-year flood, consideration is being given to the construction of a dike to prevent the facilities from flooding. If constructed, the dike would also reduce, from 6900 to 2350 cubic feet per second (cfs), the amount of water expected to pass the Talkeetna Spur Road during a 100-year flood on the Talkeetna River.

To estimate the impact that the reduction in discharge will have on the size of the drainage structure that should be placed in the Talkeetna Spur Road to prevent overtopping of the road at Twister Creek, an estimate was made of the probable size of the drainage structure that would be required both before and after construction of the proposed dike. The preliminary analysis considered two types of structures: a bridge, and a series of culverts.

If a dike is not constructed, a bridge with approximately a 330-foot-long waterway opening will be required to pass the flow expected to occur at the Twister Creek crossing of the Talkeetna Spur Road during a 100-year flood on the Talkeetna River. Alternatively, approximately 83 round culverts projecting through the fill could be used to pass the flow, or approximately 57 round culverts with headwalls.

If Dike Option 2a is constructed, the length of the waterway opening could be reduced to approximately 120 feet. The number of round culverts projecting through the fill could be reduced to approximately 23, and the number of round culverts with headwalls could be reduced to approximately 19.

The estimated length of the bridge and the number of culverts required to pass the design discharge are rather large for the magnitude of the discharge. This is due to the low height of the road embankment.

The length of the bridge or the number of culverts required to pass the design discharge might be reduced if the freeboard requirement is reduced, or the drainage capacity at the Alaska Railroad

is increased. The length of the bridge required to pass the design discharge might also be reduced if the distance between the road surface and the bottom of the low chord could be reduced. Similarly, the number of culverts required to pass the design discharge might also be reduced if arch shaped culverts were used instead of round culverts. However, it is expected that unless large changes are made in these parameters, the bridge length and number of culverts will remain relatively large for the amount of flow.

Background

Consideration is being given to the construction of several improvements at the Talkeetna Airport. Some of those improvements would be located within the 100-year floodplain. Therefore, consideration is also being given to the construction of a dike to prevent the airport facilities from being inundated during a 100-year flood.

At the peak discharge of the 100-year flood on the Talkeetna River, it is anticipated that approximately 6900 cfs will pass the Talkeetna Spur Road at Twister Creek[1]. Almost all of this water will pass over the top of the highway. If the proposed dike is constructed, it is anticipated that the discharge at the highway will be reduced to approximately 2350 cfs[1], but almost all of the water will still pass over the top of the highway. A discharge of even 2350 cfs passing over the top of the highway will probably make the sole road access to Talkeetna impassable.

To estimate the impact that the reduction in discharge will have on the size of the drainage structure that should be placed in the Talkeetna Spur Road at Twister Creek to prevent overtopping of the road, an assessment was conducted to estimate the probable size of the drainage structure required both before and after construction of the proposed dike. The preliminary analysis considered two types of structures: a bridge, and a series of culverts.

The analysis was conducted for the purpose of providing a preliminary estimate of the difference in the size of the drainage structure that might be required so that a rough order of magnitude (ROM) construction cost estimate could be developed by others. The results of the preliminary hydraulic analysis are reported herein. An aerial photograph showing the Talkeetna Spur Road and the Alaska Railroad crossings of Twister Creek is presented in Figure 1.

Methods

To reduce the cost of this analysis several assumptions were specified in the Scope of Services document[2]. These assumptions include:

- If no dike is constructed the discharge in Twister Creek is 6900 cfs.
- If Dike Option 2a is constructed the discharge in Twister Creek is 2350 cfs.
- No additional drainage capacity will be added to the railroad embankment and all of the water will flow over the top of the railroad embankment.
- The water surface slope is zero between the railroad embankment and the Talkeetna Spur Road.

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[1] Aldrich, J.W. and D.J. Helmericks. 2003. Talkeetna Airport, Phase II, Hydrologic/Hydraulic Assessment, Incomplete Draft. Prepared for: CH2M Hill, Anchorage, Alaska. Prepared by: URS Corporation, Fairbanks, Alaska.

[2] CH2M Hill. 2003. Talkeetna Airport Improvements, Phase II, Scope of Services. Prepared for: Alaska Department of Transportation and Public Facilities, Anchorage, Alaska. Anchorage, Alaska.

- The drainage structures will be sized such that the maximum water surface elevation on the upstream side of the road will be two feet below the road surface.
- The length of the bridge required to pass the design discharge will be estimated by representing the bridge as a series of box culverts.
- The distance from the top of the road to the low chord of the bridge will be four feet.
- The analysis to estimate the number and size of culverts required to pass the design discharge will use round culverts.

Using these assumptions to constrain the problem, the process of evaluating the alternative drainage structures was performed in three steps. The first step was to determine the water surface elevation upstream of the railroad embankment for discharges of 6900 and 2350 cfs. The next step was to determine the length of the bridge required to pass 6900 and 2350 cfs under the roadway. The final step was to determine the number and diameter of round culverts required to pass the design discharges.

Water Surface Elevation at Railroad Crossing of Twister Creek

A weir equation was used to calculate the water surface elevation on the upstream side of the railroad embankment during discharges of 6900 and 2350 cfs. The weir equation is as follows:

$$Q = CLH^{2/3}$$

Where: C is the weir coefficient,
L is the length of the weir in feet, and
H is the flow depth in feet, which is equal to the water surface elevation on the upstream side of the weir minus the top of rail elevation.

Figure 24 in *Hydraulics of Bridged Waterways*[3] was used to estimate the weir coefficient, which varied from 2.99 to 3.09. The length of the weir (L) and the top of rail profile were obtained from the two-dimensional surface water model developed for the airport[1]. Since the top of rail elevation changes along its' profile, the flow was broken into discreet sections using the average elevation between nodes in the two-dimensional surface water model to represent the top of rail elevation within the section. The water surface elevation at the design discharge (either 6900 or 2350 cfs), on the upstream side of the track, was then computed by computing the discharge at various water surface elevations until the water surface elevation associated with the design discharge was identified.

The railroad profile slopes slightly downward from North to South. A steep bluff, which is present on the South side of the floodplain upstream from the railroad embankment, intersects the railroad embankment approximately 160 feet south of the existing Twister Creek culvert. For this analysis it was assumed that the bluff represents the southern boundary for the flow over the top of the railroad embankment. The northern limit of the flow was estimated using the water surface elevation and the top of rail profile.

[3] Bradley, J.N. 1978. Hydraulics of Bridged Waterways. Federal Highway Administration. Washington, DC.

Bridge at Highway Crossing of Twister Creek

It was estimated that the bridge span could potentially begin 50 feet south of the intersection of the centerlines of the Talkeetna Spur Road and the Alaska Railroad track. It was also estimated that the bridge span could extend to approximately 820 feet south of the intersection, where a steep bluff along the southern edge of the floodplain, forms a natural barrier to flow. Along this portion of the road, the current road surface elevation varies between 348.0 and 350.6 feet. For this analysis it was assumed that the road surface would be raised to a uniform elevation of 350.5 feet, the elevation of the Talkeetna Spur Road at the railroad crossing.

To improve the accuracy of the bridge length estimate, the length of the potential bridge was divided into discreet sections. The locations of the sections and the ground elevations were obtained from the two-dimensional surface water model developed for the Talkeetna Airport. One representative box culvert was used to compute the hydraulic conditions in each section. The culvert had a span of 10 feet and a height equal to the difference in elevation between the bridge low chord and the ground surface. The ground surface is represented in the computations as the culvert inlet invert elevation and was taken as the average of the two highest toe-of-road elevations associated with the section. Four toe-of-road elevations were available for each section: an elevation on the upstream and downstream toe of the road at both the beginning and ending station. Because of the low height of the road embankment the distance between the low chord and the ground surface varies from approximately 1.8 to 3.3 feet. The box culverts were assumed to be 40 feet long and to have an outlet invert elevation that was 0.01 feet lower than the inlet invert elevation. The entrance loss coefficient (K_e) was assumed to be 0.5. The hydraulic roughness was calculated as a perimeter weighted value assuming a natural channel bottom (Manning's coefficient of 0.035) and concrete sides and top (Manning's coefficient of 0.015).

The discharge passing each section was calculated by first computing the discharge and the unit discharge (discharge divided by culvert width) passing through the representative culvert. The section discharge was then computed by obtaining the product of the unit discharge and the adjusted section width. Because the road is not perpendicular to the flow direction at the proposed bridge, the section width (as measured along the road) had to be adjusted by multiplying it by the cosine of the angle between the road centerline and a line perpendicular to the flow direction. The angle was estimated to be 35 degrees. The length of bridge required to pass each discharge (6900 cfs and 2350 cfs) was then computed based on the total section discharges and the unadjusted width of the sections.

Pipe Culverts at Highway Crossing of Twister Creek

The approach to the pipe culvert analysis was similar to the bridge analysis. The upstream and downstream water surface elevations, the road embankment toe-elevations, the section lengths, and the difference between the inlet invert and the outlet invert elevations were all the same as those used in the bridge analysis. As was done for the bridge analysis, it was also assumed that the road surface would be raised to a uniform elevation of 350.5 feet, the elevation of the Talkeetna Spur Road at the railroad crossing.

This analysis assumes that the location and length of road, through which the culverts might be placed, is the same as identified for the bridge analysis. The culverts were sized to maintain a minimum of one foot of cover between the top of the culvert and the road surface, and a distance of one half the culvert diameter between the culverts[4]. It was also assumed that culverts less than 5 feet in diameter would be constructed of corrugated steel and those 5 feet in diameter or larger would be constructed with structural plate. The hydraulic roughness of the culverts was based on Figure B-3 in *Hydraulic Design of Highway Culverts*[5].

Two analyses were conducted. The first analysis assumes that the culverts are projecting from the fill (i.e. entrance loss coefficient [K_e] equals 0.9) and that the culvert barrels are perpendicular to the road centerline. The barrel length is assumed to be equal to the distance between the upstream and downstream toes of the road embankment. The second analysis assumes that the culverts are 45 feet long, set perpendicular to the road centerline, and have a headwall at both the inlet and outlet of the culvert (i.e. entrance loss coefficient [K_e] equals 0.5). One barrel was analyzed for each section. The total discharge for each section was then calculated by determining the number of barrels that would fit within the section.

Results

Water Surface Elevation on Upstream Side of Railroad Crossing of Twister Creek

The water surface elevation required to pass 6900 cfs over the railroad embankment was calculated to be 346.0 feet. When the discharge is reduced to 2350 cfs the water surface elevation drops to 344.1 feet. A summary of the computations is presented in Tables 1 and 2.

Bridge at Highway Crossing of Twister Creek

To pass 6900 cfs a bridge with a minimum waterway width of approximately 330 feet is required. It is estimated that the northern end of the waterway opening would begin approximately 214 feet south of the railroad crossing on the Talkeetna Spur Road and extend to approximately 544 feet south of the crossing.

To pass 2350 cfs a bridge with a minimum waterway width of approximately 120 feet is required. It is estimated that the northern end of the waterway opening would begin approximately 256 feet south of the railroad crossing on the Talkeetna Spur Road and extend to approximately 376 feet south of the crossing.

The analyses indicate that at flows of 2350 and 6900 cfs the outlet conditions will probably control the amount of water passing through the bridge, but just barely. The analyses also indicate that a change in the tailwater elevation between 344.1 and 346.0 feet does not affect the amount of water that passes through the culverts, if the maximum allowable headwater elevation is 348.5 feet for both conditions. Thus, the results of the analyses are exactly the same for both conditions. A summary of the computations is presented in Table 3.

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4 American Iron and Steel Institute. 1994. Handbook of Steel Drainage & Highway Construction Products. 5th Edition. Washington, D.C.

5 Normann, J.M. R.J. Houghtalen and W.J. Johnson. 1985. Hydraulic Design of Highway Culverts. Federal Highway Administration. McLean, Virginia.

Pipe Culverts at Highway Crossing of Twister Creek
If round culverts projecting through the fill are used, approximately 83 culverts will be required to pass a discharge of 6900 cfs at the Twister Creek crossing of the Talkeetna Spur Road. The quantity and diameter of the culverts would be approximately as follows: 35 72-inch culverts, 19 66-inch culverts, 18 60-inch culverts, and 11 54-inch culverts. For a design discharge of 2350 cfs, approximately 23 72-inch culverts would be required.

If round culverts with headwalls on the upstream and downstream sides of the culverts are used to pass a discharge of 6900 cfs, approximately 57 culverts will be required. The quantity and diameter of the culverts would be approximately as follows: 35 72-inch culverts, 18 66-inch culverts, and 4 60-inch culverts. For a design discharge of 2350 cfs, approximately 19 72-inch culverts would be required.

As with the bridge analysis, tailwater elevations between 344.1 and 346.0 did not affect the amount of water passing through the culverts. Thus, a summary of the computations for round culverts projecting through the fill is presented in Table 4, and a summary of the computation for round culverts with headwalls is presented in Table 5.

Discussion
Consideration is being given to the construction of several improvements at the Talkeetna Airport. Some of those improvements would be located within the 100-year floodplain. Therefore, consideration is also being given to the construction of a dike to prevent the airport facilities from being inundated during 100-year flood.

At the peak discharge of the 100-year flood on the Talkeetna River, it is anticipated that approximately 6900 cfs will pass the Talkeetna Spur Road at Twister Creek. Almost all of this water will pass over the top of the highway. If Dike Option 2a is constructed, it is anticipated that the discharge at the highway will be reduced to approximately 2350 cfs, but almost all of the water will still pass over the top of the highway.

To estimate the impact that the reduction in discharge will have on the size of the drainage structure that should be placed in the Talkeetna Spur Road at Twister Creek to prevent overtopping of the road, an estimate was made of the probable size of the drainage structure that would be required both before and after construction of the proposed dike. The preliminary analysis considered two types of structures: a bridge, and a series of culverts.

If a dike is not constructed, a bridge with approximately a 330-foot-long waterway opening will be required to pass the flow expected to occur at the Twister Creek crossing of the Talkeetna Spur Road during a 100-year flood on the Talkeetna River. Alternatively, approximately 83 round culverts projecting through the fill could be used to pass the flow through the Talkeetna Spur Road. The quantities and sizes of the culverts would be approximately as follows: 35 72-inch culverts, 19 66-inch culverts, 18 60-inch culverts, and 11 54-inch culverts. Another alternative is to use round culverts with headwalls at the inlet and outlet of the culverts. Approximately 57 of these culverts would be required. The quantity and diameter of the culverts would be approximately as follows: 35 72-inch culverts, 18 66-inch culverts, and 4 60-inch culverts.

If Dike Option 2a is constructed, the length of the waterway opening could be reduced to approximately 120 feet. The number of round culverts projecting through the fill could be reduced to approximately 23 72-inch culverts, and the number of round culverts with headwalls could be reduced to approximately 19 72-inch culverts.

The estimated length of the bridge and the number of culverts required to pass the design discharge are rather large for the magnitude of the discharge. This is due to the low height of the road embankment. For this analysis, the road surface was assumed to be at an elevation of 350.5 feet, the elevation of the road at the railroad crossing. The distance from the road surface to the bottom of the low chord was assumed to be 4 feet. It was also assumed that there should be at least 2 feet of freeboard between the water surface elevation on the upstream side of the structure and the road surface, and that the drainage capacity at the Alaska Railroad crossing of Twister Creek would not be increased. The length of the bridge or the number of culverts required to pass the design discharge might be reduced if the freeboard requirement is reduced, or the drainage capacity at the Alaska Railroad is increased. The length of the bridge required to pass the design discharge might also be reduced if the distance between the road surface and the bottom of the low chord could be reduced. Similarly, the number of culverts required to pass the design discharge might also be reduced if arch shaped culverts were used instead of round culverts. However, it is expected that unless large changes are made in these parameters, the bridge length and number of culverts will remain relatively large for the amount of flow.

Attachments

Figure 1: The Twister Creek Crossing of the Talkeetna Spur Road and the Alaska Railroad

Table 1: Summary of the Preliminary Weir Calculations for a Twister Creek Discharge of 6900 cfs at the Alaska Railroad Embankment

Table 2: Summary of the Preliminary Weir Calculations for a Twister Creek Discharge of 2350 cfs at the Alaska Railroad Embankment

Table 3. Summary of the Preliminary Hydraulic Computations for a Bridge at Twister Creek

Table 4. Summary of the Preliminary Hydraulic Computations for Round Pipe Culverts Projecting From the Fill at Twister Creek

Table 5: Summary of the Preliminary Hydraulic Computations for Round Pipe Culverts With Headwalls at Twister Creek

Figure 1: The Twister Creek Crossing of the Talkeetna Spur Road and the Alaska Railroad

Table 1: Summary of the Preliminary Weir Calculations for a Twister Creek Discharge of 6900 cfs at the Alaska Railroad Embankment

Station (ft)	Top of Rail Elevation (ft)	Susitna River WSE[2] (ft)	WSE Upstream of Railroad (ft)	Section Length (ft)	H (ft)	Weir Coefficient	Section Discharge (cfs3)
1698	346.0	338	346				
				156.5	0.0		0
1854	346.0	339	346				
				245.9	0.4	2.994	364
2100	345.3	338.4	346				
				222.6	0.9	3.033	629
2323	344.9	338.9	346				
				317.1	1.7	3.044	1377
2640	343.7	338.3	346				
				141.5	2.4	3.055	777
2782	343.5	338.2	346				
				130.5	2.4	3.055	717
2912	343.7	337.7	346				
				69.3	2.7	3.068	414
2981	342.9	337.5	346				
				88.2	3.4	3.085	618
3070	342.3	337.6	346				
				103.8	3.8	3.088	777
3173[4]	342.2	337.6	346				
				40	3.9	3.089	308
3213	342.0	337.6	346				
				93.1	4.0	3.09	728
3306	342.0	337.6	346				
				26.9	4.0	3.09	210
3333	342.0	337.5	346				
			Inundated Length (ft) =	1635.4		Total Discharge =	6919

Notes:
1. The methods used to conduct this analysis are described in the methods section of this technical. memorandum.
2. Represents the Susitna River water surface elevation at a location adjacent the location where the top of railroad elevation was obtained.
3. Cubic feet per second.
4. Location of existing culvert through the railroad embankment.

Table 2: Summary of the Preliminary Weir Calculations for a Twister Creek Discharge of 2350 cfs at the Alaska Railroad Embankment

Station (ft)	Top of Rail Elevation (ft)	Susitna River WSE[2] (ft)	WSE Upstream of Railroad (ft)	Section Length (ft)	H (ft)	Weir Coefficient	Section Discharge (cfs3)
2640	343.7	338.3	344.12				
				141.5	0.5	3.020	276
2782	343.5	338.2	344.12				
				130.5	0.5	3.020	254
2912	343.7	337.7	344.12				
				69.3	0.8	3.043	185
2981	342.9	337.5	344.12				
				88.2	1.5	3.043	355
3070	342.3	337.6	344.12				
				103.8	1.9	3.043	480
3173[4]	342.2	337.6	344.12				
				40	2.0	3.043	195
3213	342.0	337.6	344.12				
				93.1	2.1	3.048	469
3306	342.0	337.6	344.12				
				26.9	2.1	3.048	136
3333	342.0	337.5	344.12				
			Inundated Length (ft) =	693.3		Total Discharge =	2350

Notes:

1. The methods used to conduct this analysis are described in the methods section of this technical. memorandum.
2. Represents the Susitna River water surface elevation at a location adjacent the location where the top of railroad elevation was obtained.
3. Cubic feet per second.
4. Location of existing culvert through the railroad embankment.

Table 3. Summary of the Preliminary Hydraulic Computations for a Bridge at Twister Creek

Station[2] (ft)	Section Width[3] (ft)	Adjusted Section Width (ft)	Culvert Upstream Invert Elevation (ft)	Culvert Size[4] (ft x ft)	Perimeter Weighted Rough-ness	Represent-ative Culvert Discharge (cfs[5])	Unit Discharge (cfs/ft)	Section Discharge (cfs)
50								
	35.1	28.7	344.0	10 x 2.5	0.0230	197.3	19.73	567
117								
	53.2	43.6	344.7	10 x 1.8	0.0235	132.6	13.26	578
170								
	39.4	32.3	344.0	10 x 2.5	0.0230	197.3	19.73	637
210								
	41.6	34.1	343.5	10 x 3.0	0.0227	246.4	24.64	839
251								
	66.5	54.5	343.5	10 x 3.0	0.0227	246.4	24.64	1342
318								
	66.2	54.2	343.4	10 x 3.1	0.0226	256.6	25.66	1391
384								
	54.7	44.8	343.2	10 x 3.3	0.0225	276.9	27.69	1240
439								
	47.3	38.7	343.2	10 x 3.3	0.0225	276.9	27.69	1073
486								
	53.8	44.1	343.5	10 x 3.0	0.0227	246.4	24.64	1086
540								
	32.6	26.7	344.1	10 x 2.4	0.0231	187.7	18.77	501
572								
	57.4	47.0	343.8	10 x 2.7	0.0229	216.7	21.67	1019
630								
	69.2	56.7	343.7	10 x 2.8	0.0228	226.6	22.66	1284
699								
	76.8	62.9	344.4	10 x 2.1	0.0233	160.1	16.01	1007
776								
	46.6	38.2	344.7	10 x 1.8	0.0235	131.6	13.16	502
822								
	31.3	25.6	344.5	10 x 2.0	0.0233	150.1	15.01	385
861								
					Total Discharge (cfs) =			**13451**

6972 cfs

2631 cfs

Notes:
1. The methods used to conduct this analysis are described in the methods section of this technical memorandum.
2. The Station is the approximate distance along the road centerline, measured in a southerly direction, from the railroad crossing of the Talkeetna Spur Road.
3. The section width is the distance between stations on the road centerline, except for the first and last sections. The section width for the first and last sections was the downstream embankment length rather than the centerline length. This was done to account for the railroad embankment at the North end, and to account for the shape change in topography at the South end.
4. Culvert size is span x height.
5. Cubic feet per second.

Table 4. Summary of the Preliminary Hydraulic Computations for Round Pipe Culverts Projecting From the Fill at Twister Creek

Station[2] (ft)	Section Length[3] (ft)	Culvert Upstream Invert Elevation (ft)	Culvert Diameter (inches)	Culvert Length[4] (ft)	Rough-ness	Number of Barrels	Single Barrel Discharge (cfs[5])	Section Discharge (cfs)
50								
	35.1	344.0	66	101.6	0.0350	4	78.6	314
117								
	53.2	344.7	54	106.4	0.0237	7	54.2	379
170								
	39.4	344.0	66	120.5	0.0350	4	76.0	304
210								
	41.6	343.5	72	129.0	0.0350	4	98.6	394
251								
	66.5	343.5	72	131.2	0.0350	7	98.3	688
318								
	66.2	343.4	72	128.7	0.0350	7	102.3	716
384								
	54.7	343.2	72	124.8	0.0350	6	110.1	661
439								
	47.3	343.2	72	123.6	0.0350	5	110.3	552
486								
	53.8	343.5	72	109.4	0.0350	6	101.8	611
540								
	32.6	344.1	60	104.8	0.035	4	71.1	284
572								
	57.4	343.8	66	113.2	0.035	7	83.3	583
630								
	69.2	343.7	66	105.3	0.035	8	87.8	702
699								
	76.8	344.4	60	99.3	0.035	10	61.0	610
776								
	46.6	344.7	54	102.9	0.0237	7	54.5	382
822								
	31.3	344.5	60	107.6	0.035	4	57.3	229
861								
				Potential Total Discharge (cfs) =				**7410**

7096 cfs

2616 cfs

Notes:
1. The methods used to conduct this analysis are described in the methods section of this technical memorandum.
2. The Station is the approximate distance along the road centerline, measured in a southerly direction, from the railroad crossing of the Talkeetna Spur Road.
3. The section width is the distance between stations on the road centerline, except for the first and last sections. The section width for the first and last sections was the downstream embankment length rather than the centerline length. This was done to account for the railroad embankment at the North end, and to account for the shape change in topography at the South end.
4. For the analysis performed assuming no headwalls, the culvert length is as presented in this table. For the analysis with headwalls, the culvert length is 45 feet.
5. Cubic feet per second.

Table 5: Summary of the Preliminary Hydraulic Computations for Round Pipe Culverts with headwalls at Twister Creek

170										
	39.4	344.0	66	120.5	0.0350	4	94.5	662	7044 cfs	
210										
	41.6	343.5	72	129.0	0.0350	4	123.0	492		
251										
	66.5	343.5	72	131.2	0.0350	7	123.0	861		2573 cfs
318										
	66.2	343.4	72	128.7	0.0350	7	127.5	893		
384										
	54.7	343.2	72	124.8	0.0350	6	136.5	819		
439										
	47.3	343.2	72	123.6	0.0350	5	136.5	683		
486										
	53.8	343.5	72	109.4	0.0350	6	123.0	738		
540										
	32.6	344.1	60	104.8	0.035	4	83.4	334		
572										
	57.4	343.8	66	113.2	0.035	7	102.2	715		
630										
	69.2	343.7	66	105.3	0.035	8	106.1	849		
699										
	76.8	344.4	60	99.3	0.035	10	73.6	736		
776										
	46.6	344.7	54	102.9	0.0237	7	63.9	447		
822										
	31.3	344.5	60	107.6	0.035	4	70.3	281		
861										
				Potential Total Discharge (cfs) =				**9334**		

Notes:
1. The methods used to conduct this analysis are described in the methods section of this technical memorandum.
2. The Station is the approximate distance along the road centerline, measured in a southerly direction, from the railroad crossing of the Talkeetna Spur Road.
3. The section width is the distance between stations on the road centerline, except for the first and last sections. The section width for the first and last sections was the downstream embankment length rather than the centerline length. This was done to account for the railroad embankment at the North end, and to account for the shape change in topography at the South end.
4. For the analysis performed assuming no headwalls, the culvert length is as presented in this table. For the analysis with headwalls, the culvert length is 45 feet.
5. Cubic feet per second.