Preliminary Hydraulic Analysis and Implications for Restoration of Noyes Slough, Fairbanks, Alaska

Water-Resources Investigations Report 00–4227

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U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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CONVERSION FACTORS and VERTICAL DATUM

Multiply	by	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
gallon per minute (gal/min)	0.06308	liter per second
ton per day (ton/d)	0.9072	megagram per day
ton per year (ton/yr)	0.9072	megagram per year

In this report, temperature is reported in degrees Fahrenheit (°F), which can be converted to degrees Celsius (°C) by the equation

$$°C = (°F - 32) / 1.8$$

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929, formerly called "Sea-Level Datum of 1929"), which is derived from a general adjustment of the first-order leveling networks of the United States and Canada.

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Abstract

The present-day channels of the Chena River and Noyes Slough in downtown Fairbanks, Alaska, were formed as sloughs of the Tanana River, and part of the flow of the Tanana River occupied these waterways. Flow in these channels was reduced after the completion of Moose Creek Dike in 1945, and flow in the Chena River was affected by regulation from the Chena River Lakes Flood Control Project, which was completed in 1980. In 1981, flow in the Chena River was regulated for the first time by Moose Creek Dam, located about 20 miles upstream from Fairbanks. Constructed as part of the Chena River Lakes Flood Control Project, the dam was designed to reduce maximum flows to 12,000 cubic feet per second in downtown Fairbanks.

Cross-section measurements made near the entrance to Noyes Slough show that the channel bed of the Chena River has been downcutting, thereby reducing the magnitude and duration of flow in the slough. Consequently the slough slowly is drying up. The slough provides habitat for wildlife such as ducks, beaver, and muskrat and is a fishery for anadromous and other resident species. Beavers have built 10 dams in the slough. Declining flow in the slough may endanger the remaining habitat.

Residents of the community wish to restore flow in Noyes Slough to create a clean, flowing waterway during normal summer flows. The desire is to enhance the slough as a fishery and habitat for other wildlife and for recreational boating.

During this study, existing and new data were compiled to determine past and present hydraulic interaction between the Chena River and Noyes Slough. The U.S. Army Corps of Engineers Hydrologic Engineering Center River Analysis System (HECRAS) computer program was used to construct a model to use in evaluating alternatives for increasing flow in the slough. Under present conditions, the Chena must flow at about 2,400 cubic feet per second or more for flow to enter Noyes Slough. In an average year, water flows in Noyes Slough for 106 days during the open-water season, and maximum flow is about 1,050 cubic feet per second.

The model was used to test a single method of increasing flow in Noyes Slough. A modified channel 40 feet wide and about 2 feet deeper within the existing slough channel was simulated by changing the cross-section geometry in the HECRAS model. The resulting model showed that flow in such a modified slough channel would begin at a flow of about 830 cubic feet per second in the Chena River and would increase to a maximum flow of about 1,440 cubic feet per second. In an average year, flow would continue for 158 days during the open-water season.

Theoretically, enlarging the slough channel by lowering its bed could increase flow, but other solutions are possible. Possible obstacles to

excavating the channel, such as bridges and utility crossings, and the destruction of desirable features such as beaver dams were not considered in the study. Further engineering and economic analyses would be needed to assess the cost of excavation and future maintenance of the modified channel. A computer-modeling program such as HECRAS may provide a means for testing other solutions.

INTRODUCTION

Noyes Slough is a 5.5-mi-long waterway connected to the Chena River in Fairbanks, Alaska (fig. 1). The slough is located north of the river and is surrounded by mixed urban and suburban developments. Several small tributaries flow southward into the slough from the Creamers Field Migratory Waterfowl Refuge, which is one of the adjacent wetland areas that provide additional wildlife habitat. The State of Alaska (1999) classified the slough as an anadromous stream, providing rearing areas for juvenile salmon and habitat for grayling and other fish species. Local residents have been concerned for years that the slough is deteriorating from being a flowing, clean waterway. In spite of intermittent cleanup efforts, some reaches of the slough have become dumps for solid waste. Also, flow in the slough has been declining during the past 50 years. A hydraulic assessment of present conditions and the effect on the hydraulic interaction between the Chena River and Noyes Slough was performed to evaluate possible means to increase flow in the slough.

Community Interest

In the past, the Noyes Slough has been a valuable resource to the community. The slough is still a fisheries habitat for anadromous and other species; in a reconnaissance report concerning the Chena River watershed, the U.S. Army Corps of Engineers (1997) recommended that further investigations address the need to “provide restoration of fisheries habitat on Noyes Slough * * *.” Also, the slough and the adjacent wetlands such as the Creamers Field Migratory Waterfowl Refuge provide habitat for waterfowl and other avian and terrestrial wildlife. Teachers at two elementary schools and one middle school that are near the slough consider it to be a natural laboratory where they can take students to observe wildlife and learn about the value of clean waterways as well as the effects of pollution and abuse. At least once a year, each of 20 separate classes at one of the schools visit the slough. A symposium held in 1999 brought together 30 presenters and was attended by 500 students. In addition, students collected bottom sediments for analysis at the University of Alaska.

Although presently the Noyes Slough cannot be floated the entire length without portages except at medium to high flows, the Fairbanks North Star Borough maintains a park that has a small-boat launch along the slough. In the 1980’s, the borough hired a consulting firm to survey the slough (cross sections and bottom profile) and study flow conditions to assess the feasibility of establishing a canoe trail in the slough (Unwin, Scheben, Korynta, and Huettl, Inc., 1982).

Local residents feel that if Noyes Slough were restored, it would provide enhanced educational and recreational resources and would protect and improve the quality of life for Fairbanks residents. Cleanup alone will not restore the slough as a flowing waterway. If restoration and maintenance of flow are objectives, then present hydraulic conditions and options for channel modification must be evaluated.

Purpose and Scope

Based on current conditions, it seems likely that flows in Noyes Slough will continue to decline without some intervention to reverse the process. The rate and duration of flow in the slough must be increased to maintain the channel as an active waterway. Also, sediment regimes in the slough must be understood before future flow maintenance can be evaluated.

To allow adequate evaluation of possible restoration schemes, analyses of the hydraulic relation between the Chena River and Noyes Slough are needed. The purposes of this study were to document past and current conditions on the basis of existing information, supplemented by new data as time and flow conditions allowed, and to construct a hydraulic model useful in evaluating different schemes to increase flow in Noyes Slough. Because of the short duration of the study (spring and summer 2000), only limited new data could be collected.

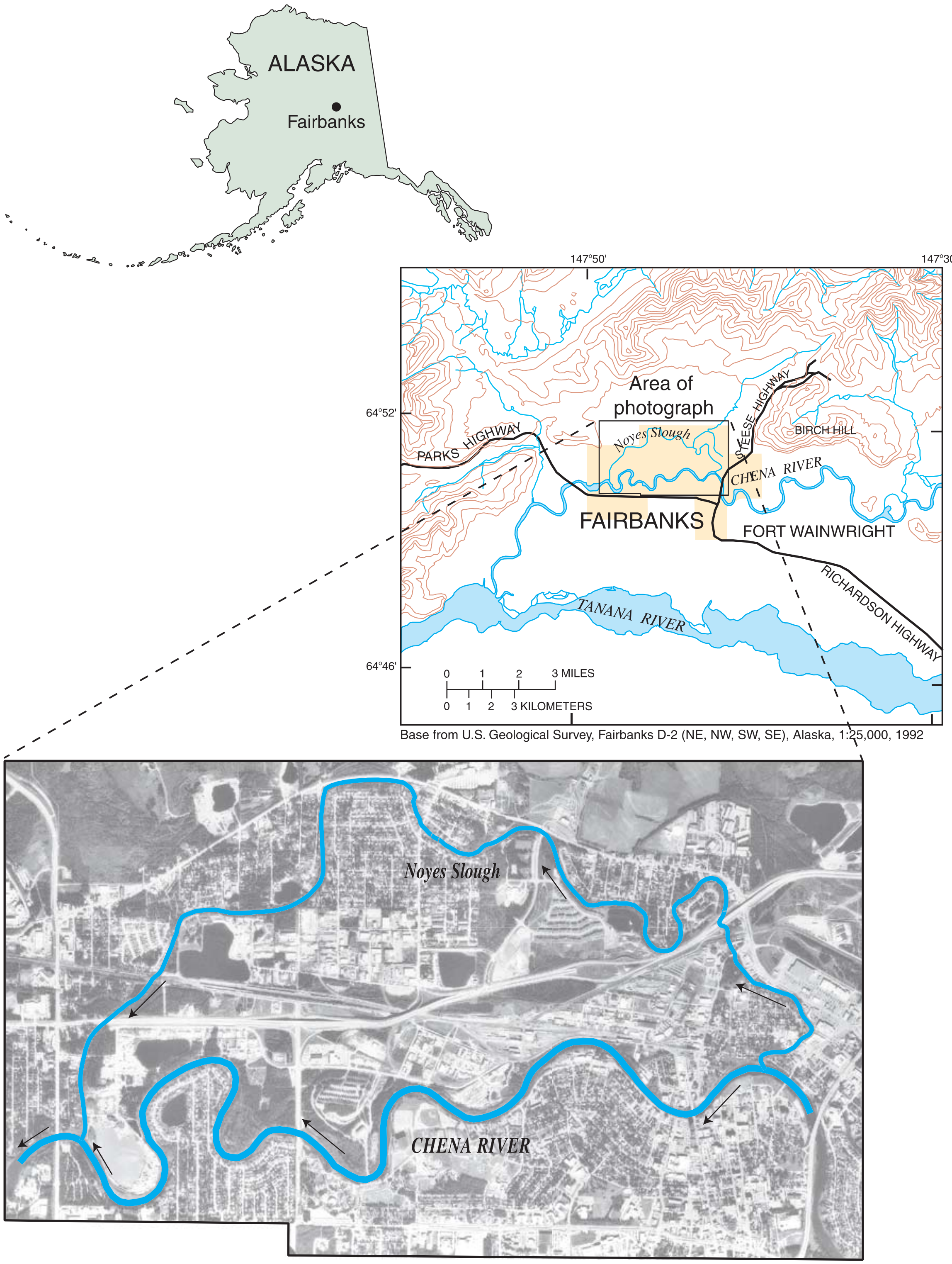

Figure 1. Location and aerial photograph (fig. 14) of study area. Arrows indicate flow directions.

Acknowledgments

The authors wish to thank the Noyes Slough Action Committee, particularly the director John Carlson, for help and enthusiastic support; the Binkley family for sharing their knowledge of the history of the Chena River and Noyes Slough; the Fairbanks North Star Borough for providing information and support; and many local residents for their interest.

DESCRIPTION OF STUDY AREA

In downtown Fairbanks, Alaska, the study area is in the Chena–Tanana alluvial plain (fig. 1). The reach length of the Chena River in the study is 27,300 ft, and Noyes Slough, 29,100 ft. Noyes Slough branches off to the north from the right bank of the Chena River about 500 ft downstream from the Wendell Street bridge and returns to the north bank of the Chena River 450 ft upstream from the University Avenue bridge.

Fairbanks has a continental climate typified by warm, moist summers and cold, dry winters. Mean minimum January temperature is –19°F, and mean maximum July temperature is 72°F. On average, Fairbanks receives about 70 in. of snowfall annually. Mean annual precipitation at Fairbanks International Airport is 11 in. Mean annual flow for the entire period of record for the Chena River at Fairbanks is 1,360 ft^3/s; however, because flow has been regulated by Moose Creek Dam since 1981, no water discharge greater than 12,000 ft^3/s flows through Fairbanks.

RECENT RIVER HISTORY AND BACKGROUND

For the past several years, concern has been expressed by local residents of Fairbanks that Noyes Slough is “drying up.” The reduced flows combined with the abuse of the waterway as a refuse site have depleted the slough's value as aquatic and wildlife habitat. The slough has been a dumping ground for refuse and a catchment for storm runoff that introduces nonpoint-source pollution. Appliances, scrap building materials, concrete, asphalt, and overburden have been discarded in the slough. In many reaches, the slough is stagnant and unsightly, and water flows through its length only intermittently during the open-water season. The local community has a strong desire to restore the slough to a clean, flowing waterway.

Fairbanks is built on the alluvial plain of the Chena and Tanana Rivers. The Tanana River flows from the southeast out of the Alaska Range toward the foothills north of Fairbanks and then turns west along the south side of the hills. The Tanana has been forced into this position along the north edge of its valley by the extensive alluvial outwash from the glacier-fed streams of the Alaska Range.

Before 1945, a channel of the Tanana River, called the Chena Slough, branched off the main river upstream from Moose Creek Bluff. The upper part of this slough also was known as Piledriver Slough, named after a roadhouse on the Old Richardson Trail. Water in this channel flowed northward, then westward through Fairbanks, and back into the Tanana River near Chena Ridge. A smaller subchannel, Noyes Slough, branched off of and back into Chena Slough. According to a 1940 map of Fairbanks (fig. 2), the Chena River actually entered Chena Slough about 7 miles east of Fairbanks.

In the 1930’s, local residents observed and expressed concern that the Tanana River was enlarging the entrance of Chena Slough and that increasing flow from the Tanana was occurring in Chena Slough. These conditions indicated that the Tanana River might be reestablishing its main channel farther to the north, thereby jeopardizing Fairbanks. Also, flow from both the Chena and Tanana Rivers were contributing to flooding in downtown Fairbanks. At that time, no stream-gaging stations had been established on the Tanana River, Chena River, or Chena Slough, so exact streamflows are not known. On August 15, 1933, flow in the Chena Slough at Fairbanks was estimated at 7,000 ft^3/s, of which 5,000 ft^3/s was contributed by the Tanana River. On the basis of present-day knowledge of flow in the Tanana River at Fairbanks, this contribution would be approximately 10 percent of the flow of the Tanana River. (Mean August flow in the Tanana River at Fairbanks has been 48,490 ft^3/s for the period of record, 1973–99). In 1937, a summer flood flow was estimated at 22,000 ft^3/s, half of which was contributed by the Tanana (U.S. Army Corps of Engineers, 1938).

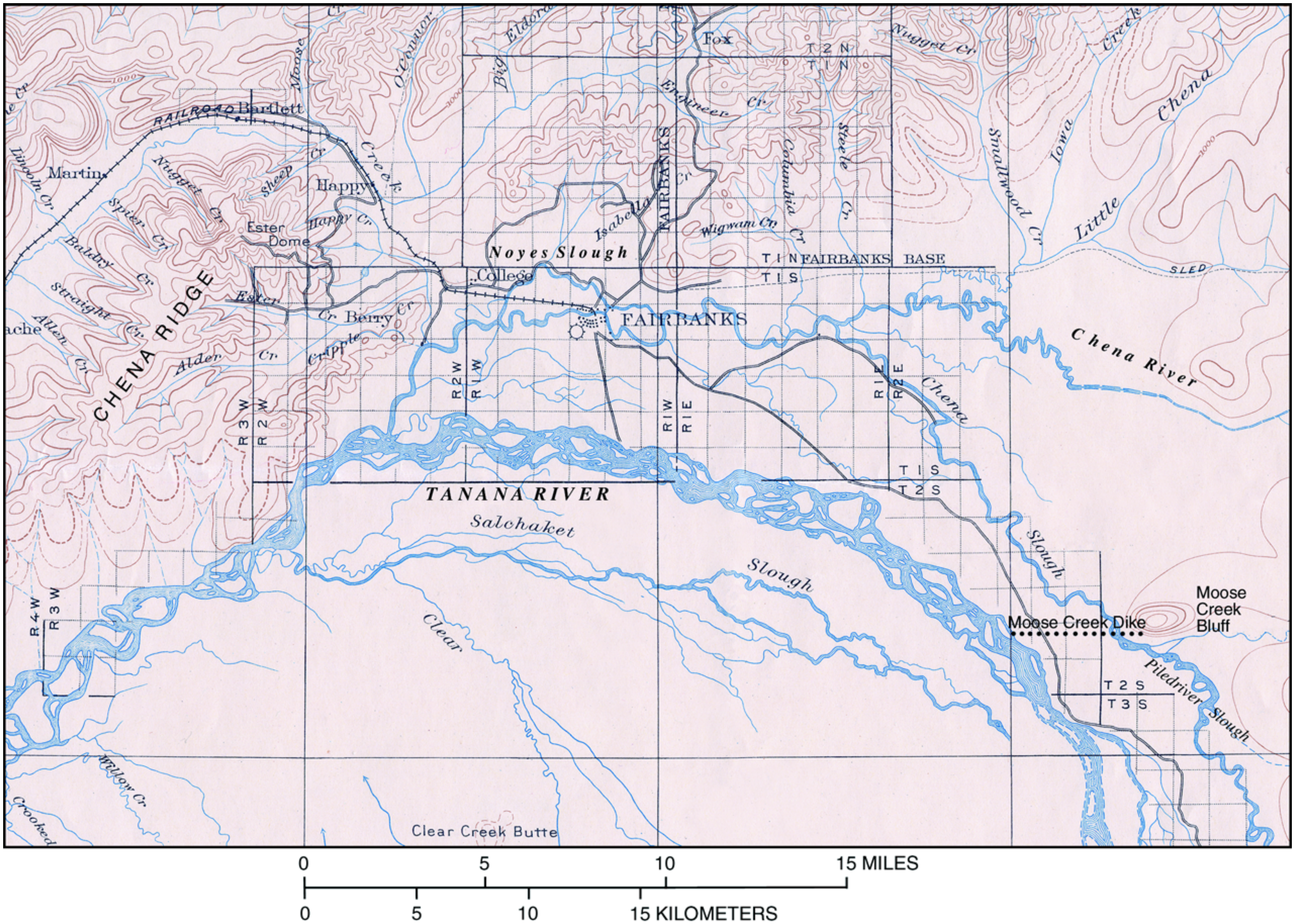

Figure 2. Fairbanks in 1940, showing Tanana and Chena Rivers; Piledriver, Chena, and Noyes Sloughs; and location of Moose Creek Dike, built across Chena Slough during 1940–45. Original topographic surveys (U.S. Geological Survey, 1940) were done in 1902 and 1916.

The proposed solution to reducing the flow contributed to Chena Slough by the Tanana River was to construct an earth-and-rock dike across the slough extending from Moose Creek Bluff westward to the Tanana River (fig. 2). This dike was constructed during the period 1940–45, although additional work on it may have been done as late as 1947. This construction cut off the flow from the Tanana River into the Chena Slough. Considerable seepage through the dike occurred during the years after the dike was constructed. Records from a gaging station that operated during 1948–52 on the upper part of Chena Slough above the old mouth of the Chena River indicate that flows ranged from about 50 to 100 ft^3/s throughout the year. Some seepage still occurs through the dike, and some subsurface flow enters the channel known locally as Badger Slough, which is the reach of the old Chena Slough from the dike downstream to the confluence of the Chena River. (Upstream from the dike, the channel still is called the Piledriver Slough.) Various discharge measurements made by the U.S. Geological Survey (USGS) in the early 1970's indicate an average flow in the slough of about 50 ft^3/s during the open-water season, although it is greater at times of high flow on the Tanana River. Flow was reduced further in Piledriver Slough from some blockages placed in the upper end during the flood-control construction period, 1977–82, and seepage into Badger Slough possibly is even less today. Seepage may have declined as the Tanana River deposited sediment against the upstream side of the dike and as Piledriver Slough shifted away from the dike.

In 1947, the USGS established a gaging station on the Chena Slough at the Cushman Street bridge, downstream from the entrance to Noyes Slough. Although this site initially was called Chena Slough at Fairbanks, after 1952 it was called Chena River at Fairbanks, which is the name used in the permanent records for the whole period. Flow records at this gaging station included Noyes Slough. During 1947–54, separate measurements or estimates of flow were made on Noyes Slough at Illinois Street when flow in the main channel of Chena River was measured at the Cushman Street bridge downstream from the entrance to the slough. The two measurements were added to get total flow for the Chena River. Although discharge measurements begun in 1955 from the newly constructed Wendell Street bridge, upstream from the entrance to the Noyes Slough, included the flow into the slough, only a few separate measurements of flow in Noyes were made since then. In 1957, the gaging station was relocated to the Wendell Street bridge, and in 1967, it was moved 800 ft upstream to its present location on the right bank (station no.[1] 15514000).

On August 14, 1967, a flood of 74,400 ft^3/s occurred on the Chena River at Fairbanks. After this flood, the Chena River Lakes Flood Control Project was designed and built; the project included a diversion dam and control structure on the Chena River upstream from Fairbanks near Moose Creek Bluff, a floodway and spillway leading to the Tanana River, and a raised levee along the north side of the Tanana River (fig. 3). In the event of a major flood on the Chena River, water is impounded behind the Moose Creek Dam and diverted into the Tanana River. During lesser floods, water is impounded behind the dam without spilling into the Tanana River and is regulated down the Chena at levels below flood stage until the impounded floodwater drains. Such regulation of the Chena River was applied for the first time in July 1981; more recent impoundments have been imposed since that time, and in 1992, water was diverted into the Tanana River for the first and only time to date. During impoundment to date, regulated flow down the Chena River to Fairbanks has not exceeded 11,400 ft^3/s at the gaging station; under the present plan, impounded flow will not exceed 12,000 ft^3/s.

What does this mean in relation to Noyes Slough? (1) The Tanana River formed Chena Slough and Noyes Slough (figs. 2 through 4). The mouth of the Chena River was on the Chena Slough at a point east of Fairbanks (figs. 3 and 5). The channel of the Chena River as defined today and the Noyes Slough can convey a higher flow than the flows now occurring through Fairbanks. The greater channel capacity is readily evident when the Chena River upstream from the confluence of Badger Slough is compared to the reach through town. Upstream from Badger Slough, the channel is about 175 ft wide, whereas in town it is about 250 ft wide.

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[1]This and similar numbers (eight or more digits beginning with 15) were assigned by the U.S. Geological Survey and are retained indefinitely to identify surface-water stations on the basis of downstream order. Other station numbers used in this report apply only to this study and were based on stationing (in feet) determined for use in the HECRAS model.

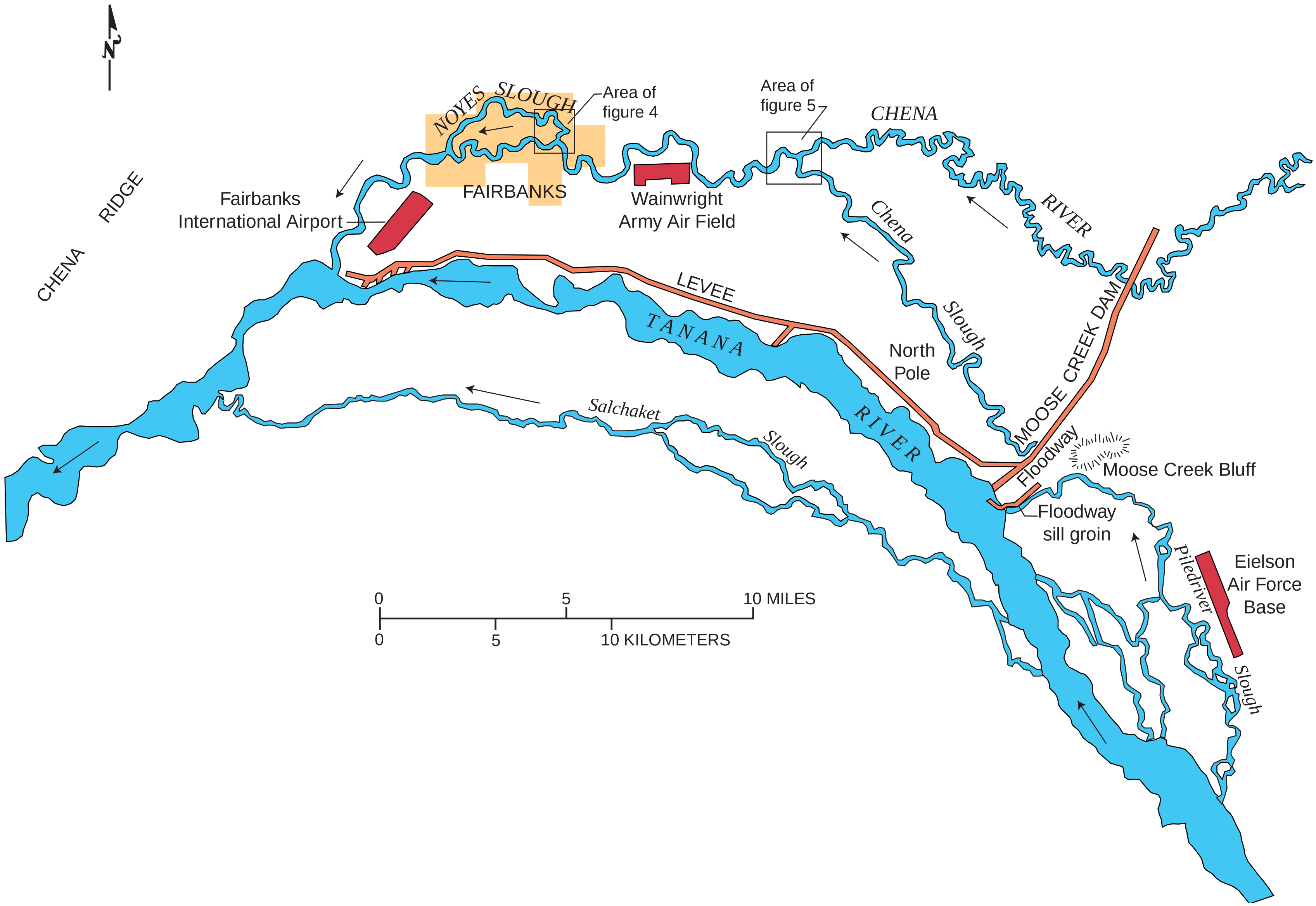


Figure 3. Present-day conditions affecting Chena River and Noyes Slough, showing Chena River Lakes Flood Control Project and other structures in vicinity. Chena Slough is also known locally as Badger Slough. Arrows indicate flow directions. Modified from Burrows and Harrold (1983).

Figure 4. Noyes and Chena Sloughs near entrance to Noyes, also showing Illinois and Cushman Streets, Fairbanks, 1938. Light color of water indicates high suspended-sediment load from Tanana River's contribution to flow. Arrows indicate flow direction in sloughs. See figure 3 for location. Photograph courtesy of U.S. Army Corps of Engineers.

(2) Except for minor seepage through Moose Creek Dike, the absence of flow from the Tanana River means an absence of sediment load from the river. The Tanana River at Fairbanks transports an average of 25,000,000 tons/yr of suspended sediment (Burrows and others, 1981). The reduction in flow and loss of a substantial sediment load in Chena Slough are similar to observed effects of dams on other alluvial rivers. One of the possible downstream effects is channel scour or degradation (Williams and Wolman, 1984). Channel cross sections measured at the Wendell Street bridge on the Chena River (immediately upstream from Noyes Slough) in 1959, 1989, and 2000 are shown in figure 6. Although the flows are about the same for the three years (3,450 ft^3/s, 3,180 ft^3/s, and 3,270 ft^3/s, respectively), the main deep part of the channel broadened

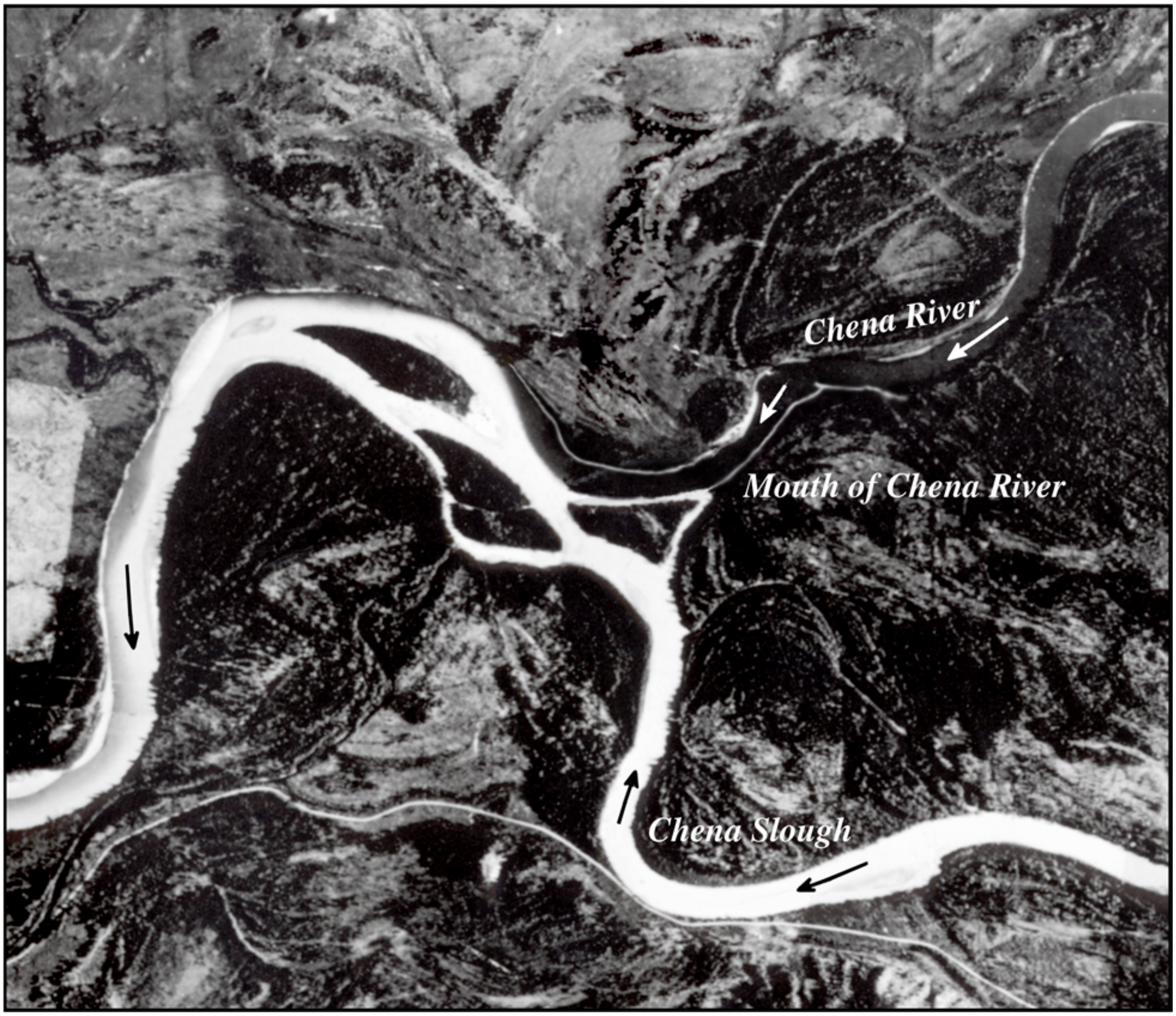


Figure 5. Mouth of Chena River on old Chena Slough about 7 miles east of Fairbanks, 1938. Silt-laden water of slough (light) contrasts notably with clear water of river (dark). Arrows indicate flow direction in slough and river. See figure 3 for location. Photograph courtesy of U.S. Army Corps of Engineers.

and shifted to the left from 1959 to 1989. Further enlargement of the main channel and scouring of the thalweg occurred by 2000. These changes caused a lowering of the mean bed elevation and consequently a decline in water-surface elevation of about 1.8 ft (fig. 6).

(3) The ratings reflect the scouring or lowering of the mean bed elevation of the main channel of the Chena River downstream from the gaging station. A range of discharge measurements at their respective gage heights at different times from 1957 to 2000 (rating numbers 5, 14, 18, and 22) are shown in figure 7. No measured flow data are available for the Chena Slough prior to the construction of Moose Creek Dike. By 1957, the dike had been in place for about 10 years. Rating 5 was in effect during 1957–59. In 1967, the river flooded, and then rating 14 was in effect during 1968–73. Rating 18, in use 1987–89, reflected conditions after the Moose Creek Dam had been in effective operation. Rating 22 is the present-day stage–discharge relation.

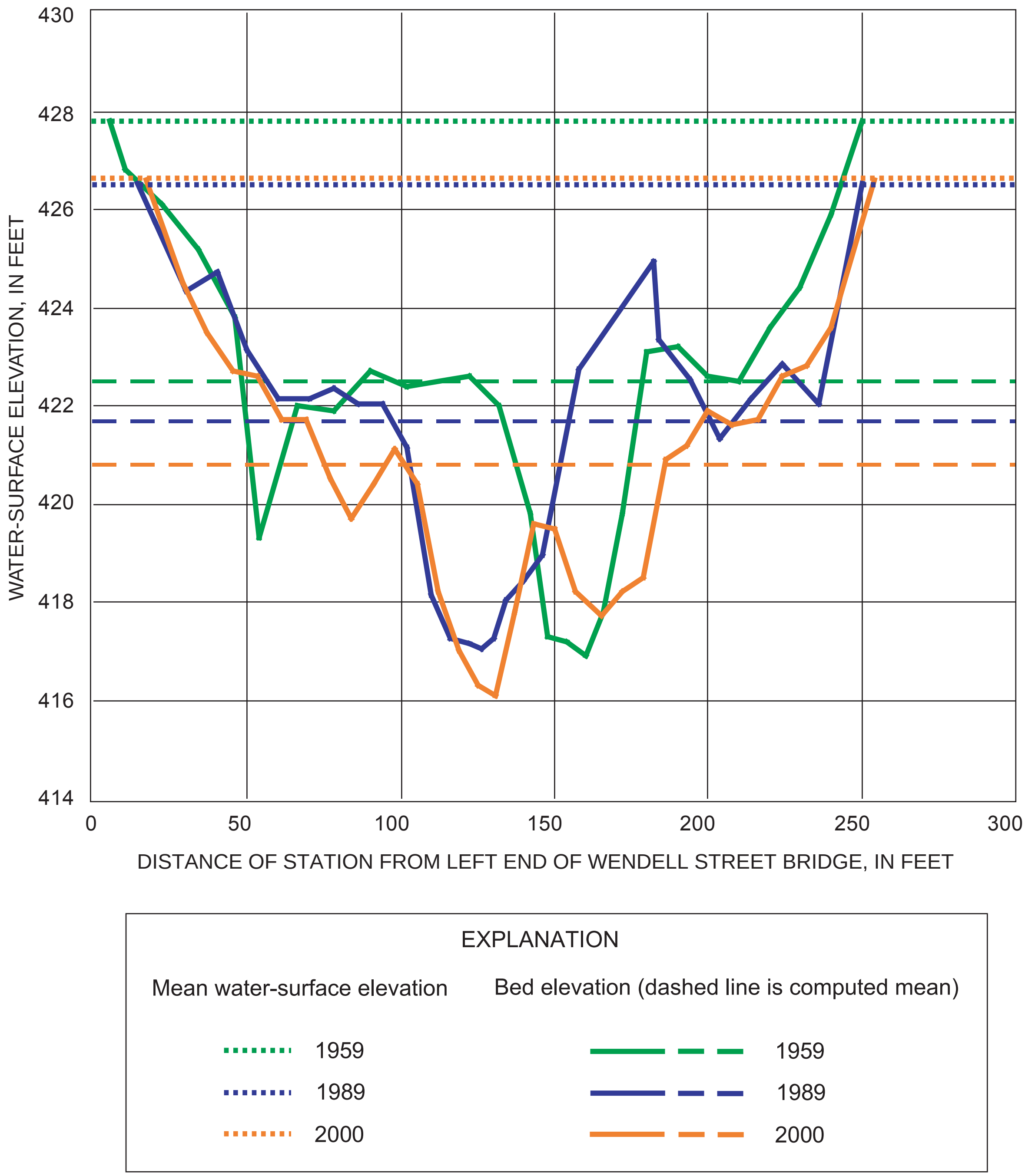


Figure 6. Cross sections for Chena River at Wendell Street bridge, showing mean water-surface and bed elevations on May 13, 1959, at discharge of 3,450 cubic feet per second; April 28, 1989, at discharge of 3,180 cubic feet per second; and May 3, 2000, at discharge of 3,270 cubic feet per second.

(4) Noyes Slough acts as an overflow channel for high flows on the Chena River. Because flows greater than 12,000 ft^3/s no longer occur and the main channel of the Chena River has been lowered, flow into Noyes Slough might be expected to be reduced. Discharge measurements that were made on Noyes Slough during the periods 1947–53, 1967–93, and 1994–2000, plotted against total flow of the Chena River, and the corre-

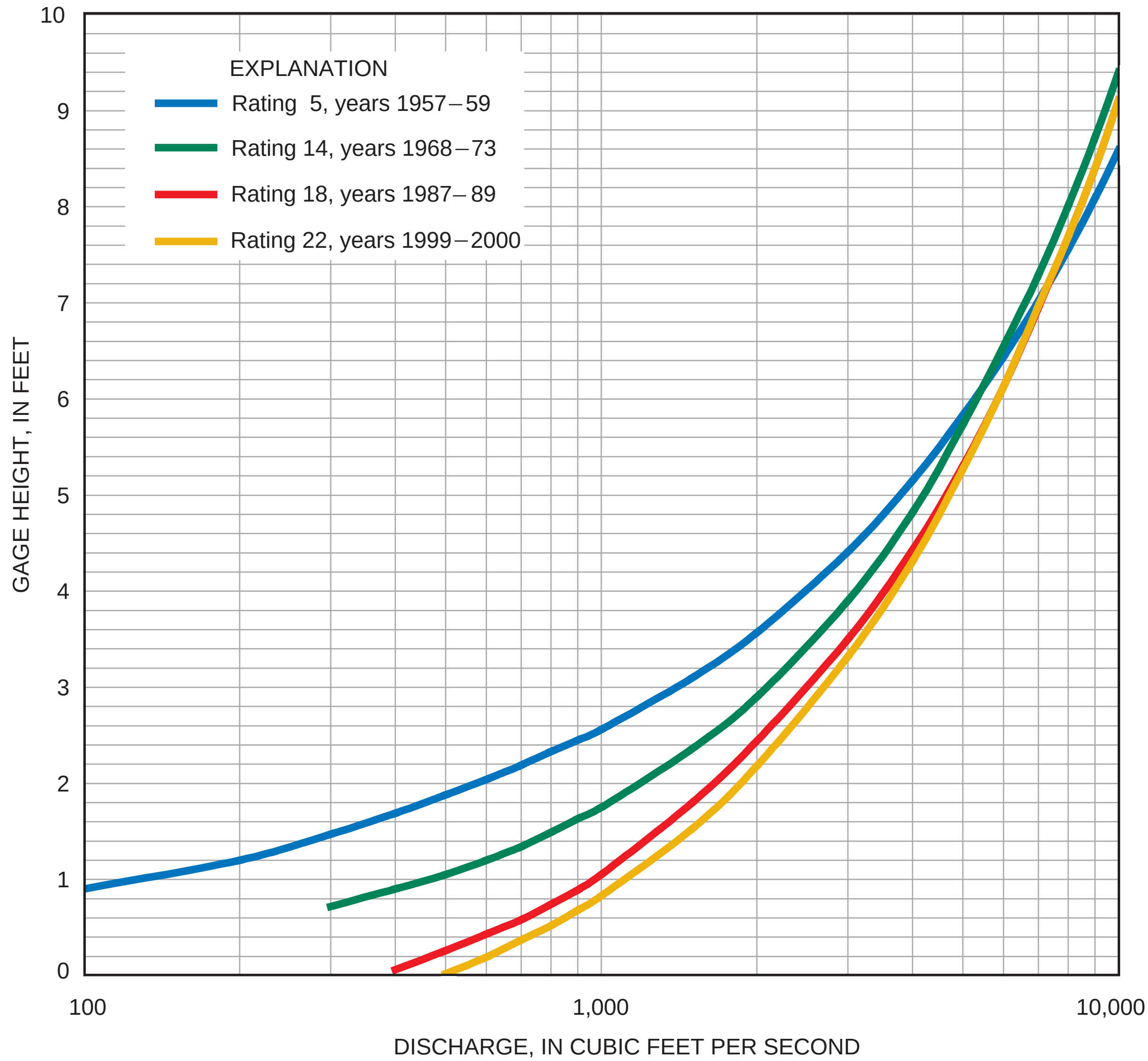


Figure 7. Rating curves for Chena River stream-gaging station, 1957–2000. (Gage datum, 422.92 feet above sea level.)

sponding regression relations are shown in figure 8. During 1947–53, when flow was about 2,400 ft^3/s in the Chena River, flow in Noyes Slough was about 100 ft^3/s, and when the flow in the river was about 1,600 ft^3/s, the slough had almost no flow. During 1967–93, the same flow of about 2,400 ft^3/s in the Chena River corresponded to a flow in Noyes Slough of only about 40 ft^3/s, and when the flow in the river was about 2,000 ft^3/s, the slough had almost no flow. To reach 100 ft^3/s in Noyes Slough under present conditions, the Chena River must be flowing at about 3,800 ft^3/s; when flow in the river drops below about 3,000 ft^3/s, the slough has no flow. Because of regulation, flow cannot exceed 12,000 ft^3/s in the Chena River; at that level, maximum flow into Noyes Slough would be about 1,100 ft^3/s. In winter, no water flows in the slough, and the channel is filled with ice and snow.

Studies done by the USGS (Nelson, 1978; Glass and others, 1996) show that, in general, the flow of subsurface water (or ground water) is from the Tanana River toward the northwest in the alluvial plain (fig. 9). A section of the alluvial plain from Noyes Slough to the Tanana River is shown in figure 10. During high flows on the Tanana River and low flows on the Chena River, ground-water flow is contributed to the Chena. Conversely, when the Chena River is at higher flows,

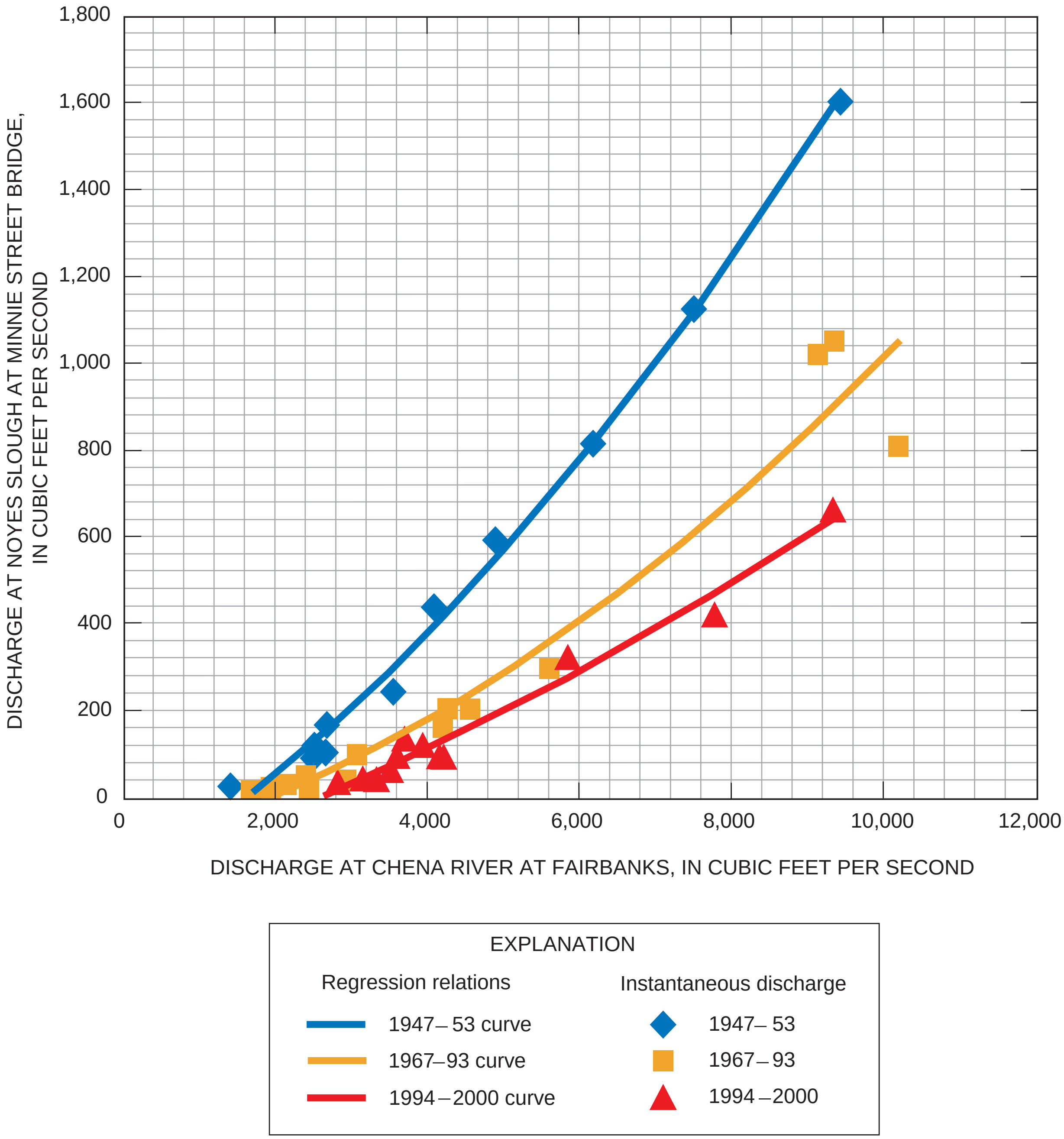


Figure 8. Relations between flows in Noyes Slough and Chena River for three periods during 1947–2000.

it contributes water to the aquifer, thereby raising the ground-water levels near the river. Farther from the river, ground-water levels rise as long as high flow continues. At times of no surface-water flow from the Chena River into the entrance of Noyes Slough, pools of water in the deeper parts of the slough correspond to local ground-water levels. Depending on whether flow in the Chena River is rising or falling, Noyes Slough may lose flow along its reach or gain flow from sustained high ground-water levels.

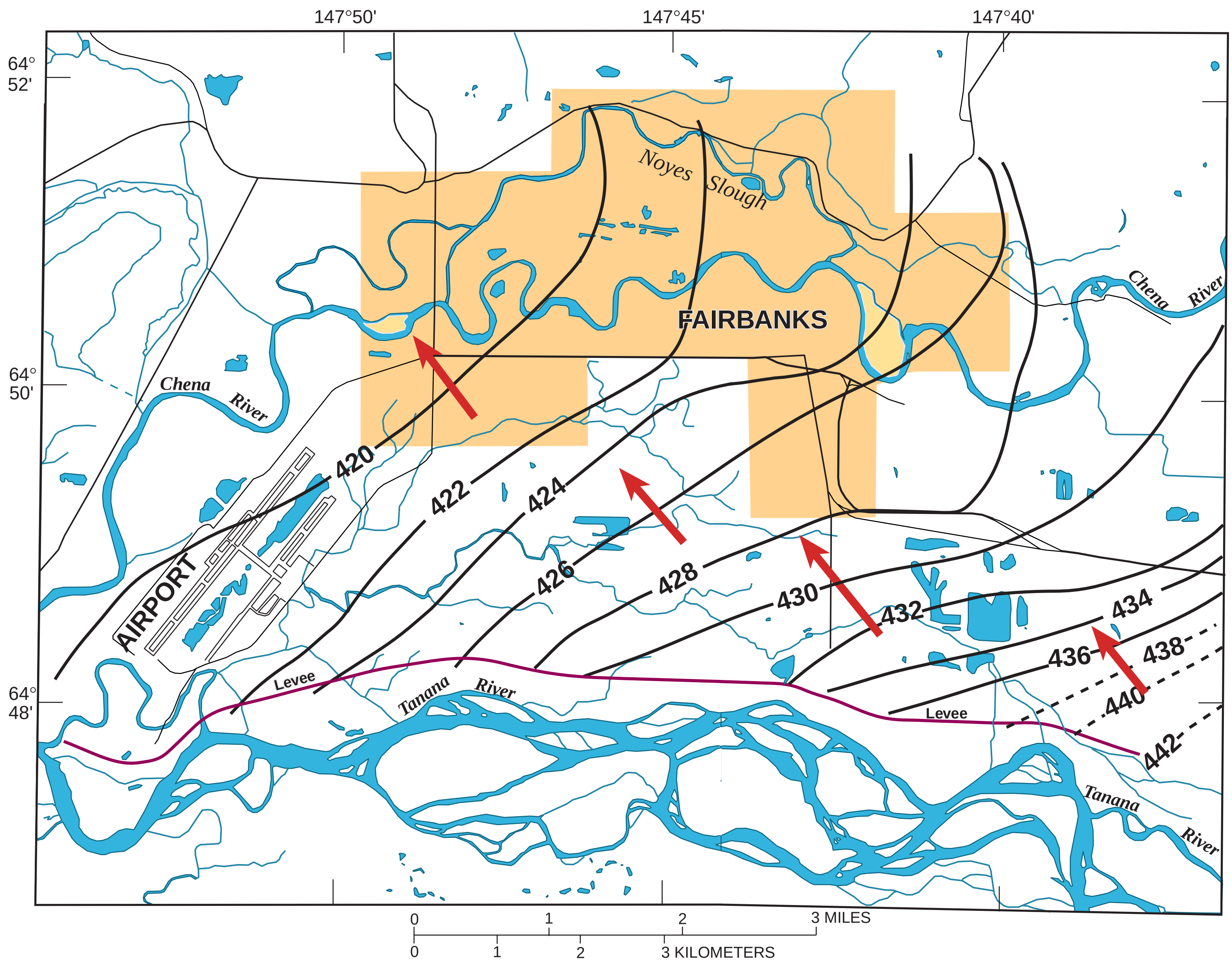


Figure 9. Water-table map of Fairbanks, showing ground-water elevations, in feet above sea level (contour interval, 2 feet), and flow directions (red arrows). Dashed contours indicate uncertainty. Modified after Glass and others (1996).

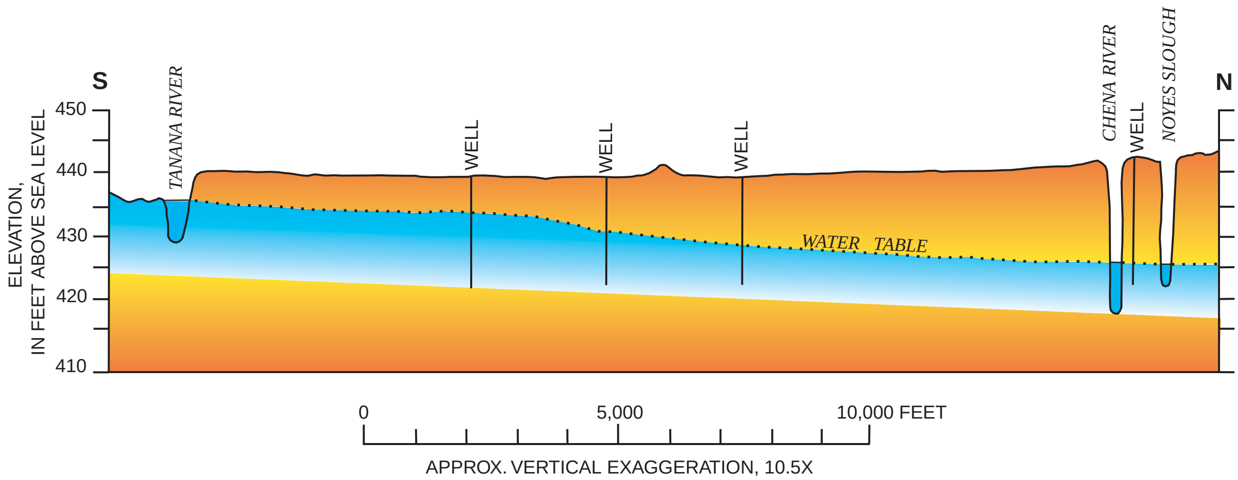


Figure 10. Geohydrologic cross section of Tanana–Chena alluvial plain, showing surface-water–ground-water interaction in vicinity of Tanana River, Chena River, and Noyes Slough. Modified after Nelson (1978).

EVALUATING PRESENT-DAY HYDRAULICS

The approach to establishing present-day hydraulic interaction between the Chena River and Noyes Slough was to build a hydraulic model using the Hydrologic Engineering Center River Analysis System (HECRAS) computer program, a one-dimensional water-surface-profile model developed by the U.S. Army Corps of Engineers (Brunner, 1997). Although model details are not presented herein, basic assumptions used, the source of input data, and graphic presentation of results are given along with some hydraulic information such as roughness coefficients and starting friction slope. The reader should refer to the HECRAS program user manuals (Brunner, 1997) for more explanation.

Most water-discharge measurements made on Noyes Slough near the entrance at Illinois and Minnie Streets were compiled (table 1). Because Chena River spring runoff was sufficiently high in 2000 to cause flow in Noyes Slough, discharge and water-surface elevations were determined at eight sites along Noyes Slough at various flows (table 2). After spring runoff, a construction project discharging water into the slough near the entrance provided an opportunity to measure a very low flow in the slough when no flow was entering Noyes Slough from the Chena River. Additional cross sections of the Noyes Slough were surveyed at seven sites. Cross-section geometry for the Noyes Slough was derived from a combination of discharge data, bridge-scour data (Heinrichs and others, in press), and surveyed bank geometry. Water-surface profiles of Noyes Slough were derived from measurements at the bridge crossings on the slough.

Although water discharge in the Chena River was measured several times in conjunction with the operation of the Chena River at Fairbanks gaging station, reported river flows are generally the mean daily discharge from the gaging station. Discharge measurements are assumed to be the instantaneous flow at the time of measurement, whereas mean flows, derived from gaging-station records, are computed from the recorded stage record for the day and the discharge rating at the gaging station (tables 1 and 2). Water-surface elevations on the Chena River were measured at bridge crossings. An additional cross section was surveyed at the gaging station, upstream from Wendell Street.

Cross-section geometry for the study reach of the Chena River was derived from a combination of the discharge measurements made at several of the bridges; the bridge-scour study (Heinrichs and others, in press); and other cross sections obtained from the U.S. Army Corps of Engineers, the Natural Resources Conservation Service, and the Alaska Department of Transportation and Public Facilities. Water-surface profiles of the Chena River were derived from measurements at the bridge crossings on the river.

Table 1. Discharge and water-surface elevation for Noyes Slough at Illinois Street and Minnie Street bridges and corresponding discharge for Chena River, 1947–2000

[—, no data]

Date		Noyes Slough: Discharge (cubic feet per second)	Noyes Slough: Water-surface elevation (feet)	Chena River: Discharge (cubic feet per second)
Noyes Slough at Illinois Street bridge (station no. 1551400435):				
1947	July 31	25	—	1,430
1948	June 6	1,120	—	7,520
	July 24	592	—	4,890
	September 16	167	—	2,690
1949	July 8	814	—	6,180
	August 12	438	—	4,090
1950	May 15	1,600	—	9,430
1952	June 27	243	—	3,560
	July 25	115	—	2,520
	August 19	101	—	2,670
	September 25	88	—	2,500
Noyes Slough at Minnie Street bridge (station no. 1551400425):				
1967	May 5	205	—	4,180
	May 29	1,020	—	9,130
1971	May 18	1,050	—	9,240
1989	May 14	30.3	—	2,160
1990	September 4	229	—	6,300
1992	May 31	808	—	10,200
1993	April 26	—	425.83	3,720
	April 30	159	427.37	4,130
	May 7	202	426.9	4,570
	May 28	—	—	2,730
	June 1	49.2	424.8	2,420
	June 7	23.1	424.16	1,950
	June 30	11.9	424.17	1,690
	September 9	16.2	425.15	2,450
	September 22	296	427.92	5,610
	September 30	38.7	425.66	2,940
1994	May 20	.2	424.62	1,610
	May 25	—	424.62	1,380
	June 24	651	430.8	9,340
	July 7	129	426.09	3,660
2000	May 3	13.5	425.56	3,300
	May 10	67.2	426.20	3,580
	May 11	34.1	425.72	3,190
	May 19	—	425.40	2,520
	May 20	37.3	426.14	3,330
	May 21	88.0	426.63	4,200
	May 24	311	428.28	5,790
	May 27	431	429.40	7,760
	May 30	89.9	425.99	3,620
	June 6	117	426.24	3,950
	June 15	31.9	425.76	2,870
	June 19	.54	424.84	2,150
	August 12	2.0	425.49	1,350

One set of suspended-sediment samples and one set of bed-load samples were collected on the Chena River, and a single set of suspended-sediment samples was collected on Noyes Slough. A single-point bed-load sample was collected at the entrance to Noyes Slough.

Photographs of the slough under different flow conditions are shown in figures 11 through 13. Also, the locations and dimensions of the 10 beaver dams along the length of the slough were determined and included in the model because they significantly affect water-surface elevations along the slough.

A HECRAS model of the Chena–Noyes hydraulic system was constructed. Initial simulations agreed reasonably well with flows and water-surface profiles in the Chena River and Noyes Slough. The model then was used to present one theoretical means of increasing the magnitude and frequency of flow in Noyes Slough. (HECRAS models used in this report were constructed to mimic flow in the Noyes Sough and Chena River to compare different conditions. One-dimensional, preliminary models, they should not be used for any other purpose without considerable additional data and refinement. Input files for final runs of HECRAS models used in this report are available through Alaska District offices of the U.S. Geological Survey.)

DATA AND ASSUMPTIONS USED IN MODELING

Aerial photography flown in 1996 was provided to the USGS by the Natural Resources Conservation Service. The individual photographs were scanned, composited and cropped to correspond to the study area, and saved as digital files in bitmap format. The composite image (fig. 14) was used as a background in the creation of the model schematic. By comparing measured distances between known features on the composite and USGS 1:25,000-scale topographic maps, the scale of the composite image was determined. Thereafter, all locations were given x-y coordinates relative to a superimposed grid. A digital-display measuring wheel was used to measure reach lengths (in feet) between sections on both channels to establish stationing used in the HECRAS simulations.

Table 2. Discharge and water-surface elevation for Noyes Slough (all sites) and corresponding mean daily discharge and water-surface elevation for Chena River during May, June, and August, 2000

[Number in parentheses after Noyes Slough station name is U.S. Geological Survey station-identification number. —, no data]

Date	Noyes Slough																Chena River	
	Minnie Street (no. 1551400425)		Illinois Street (no. 1551400435)		O'Connor Street (no. 1551400455)		Danby Street (no. 1551400550)		Aurora Drive (no. 1551400650)		West Johansen Expressway (no. 1551401550)		Indiana Street		Goldizen Street		Mean discharge (cubic feet per second)	Mean water-surface elevation based on rating 22 (feet)
	Discharge (cubic feet per second)	Water-surface elevation (feet)	Discharge (cubic feet per second)	Water-surface elevation (feet)	Discharge (cubic feet per second)	Water-surface elevation (feet)	Discharge (cubic feet per second)	Water-surface elevation (feet)	Discharge (cubic feet per second)	Water-surface elevation (feet)	Discharge (cubic feet per second)	Water-surface elevation (feet)	Discharge (cubic feet per second)	Water-surface elevation (feet)	Discharge (cubic feet per second)	Water-surface elevation (feet)		
May 2000																		
3	13.5	425.56	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3,300	426.65
10	67.2	426.20	—	424.88	79.8	424.10	73.8	422.73	—	422.41	—	—	—	—	—	—	3,580	426.95
11	34.1	425.72	—	—	—	423.89	—	422.47	—	—	97.6	420.11	—	—	112	420.54	3,190	426.53
19	—	425.40	—	423.31	—	423.35	—	421.98	—	421.92	—	419.35	—	419.37	—	419.18	2,520	425.78
20	37.3	426.14	—	—	—	—	—	—	—	—	14.2	420.19	—	—	—	—	3,330	426.68
21	88.0	426.63	95.0	424.97	125	424.43	113	423.13	—	—	98.8	420.87	—	—	—	—	4,200	427.57
24	311	428.28	—	—	—	425.78	—	424.35	—	423.81	—	422.36	—	422.33	—	421.88	5,790	429.02
27	431	429.40	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7,760	430.61
30	89.9	425.99	87.9	424.55	—	—	—	—	—	—	145	420.51	—	—	97.2	420.03	3,620	426.99
June 2000																		
6	117	426.24	116	424.90	117	424.06	126	422.79	—	—	115	420.87	—	—	131	420.42	3,950	427.32
15	31.9	425.76	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2,870	426.18
18	—	—	—	—	0	423.52	0	421.56	—	—	—	—	—	—	6.0	419.44	2,380	425.61
19	.54	424.84	—	—	—	—	—	—	—	—	15.8	420.54	—	—	—	—	2,150	425.33
21	—	—	—	—	—	—	—	—	2.2	—	—	—	—	—	—	—	2,010	425.15
22	—	—	—	—	—	—	.93	421.65	1.2	—	3.7	420.43	3.0	—	2.9	—	1,900	425.00
August 2000																		
12	2.0	425.49	.0	423.93	—	—	—	—	—	—	—	—	—	—	—	—	1,350	424.18

Figure 11. Noyes Slough looking upstream during period of flow in spring 2000, showing beaver dam (station 20209, fig. 14)

Cross-section geometry for Noyes Slough was determined from discharge measurements made in 2000 at Minnie, Illinois, O’Connor, Danby, and Goldizen Streets and at West Johansen Expressway. The cross section for the slough at Aurora Drive was from the bridge-scour study (Heinrichs and others, in press). At all measured sections, bank geometry was determined by using a reel and sounding weight referenced to the water-surface elevation at the time of the survey and extending up the dry banks on both sides.

Assuming that no contraction occurs at the highest flows to be modeled, none of the bridges on Noyes Slough were treated as hydraulic structures in the HECRAS model. However, for effective channel modeling, additional cross sections were needed, particularly for the 2.5-mi-long reach between Aurora Drive and West Johansen Expressway. Also, the effects of the 10 beaver dams on channel geometry had to be considered.

At seven locations requiring a survey of channel geometry, including cross sections at the entrance and at the mouth, a survey-grade Global Positioning System (GPS) was used to establish reference marks. Calibrating against known control points yielded a measurement accuracy of about $\pm$0.2 ft vertically, which was sufficient for channel geometry. The vertical control for water-surface elevations had been established already by using levels from benchmarks at other cross-section locations. The reference marks were established at the unknown sections by using GPS, and later the channel was surveyed by using levels. Then these sections were located in the local x-y grid and added to the model.

The slough was floated by canoe and the location of the beaver dams marked on a field copy of the photo image. The relative geometry of each beaver dam was measured by using a tagline and measuring depths and dam height relative to the channel bottom. The locations were established in the local-grid coordinate

Figure 12. Noyes Slough looking downstream after flow ceased in midsummer 2000, at West Johansen Expressway bridge (station 2917, fig. 14).

system used to construct the HECRAS model. The average height of the beaver dams then was used to modify the cross-sectional area at these sections and hence the channel geometry (fig. 15).

In HECRAS, cross sections between established sections can be synthesized by interpolation (Brunner, 1997). This feature of the computer program was used to generate 25 additional intermediate cross sections for a total of 47 (one cross section about every 600 ft or one every 10 channel widths). Cross sections were not subdivided for the first model runs; Manning's roughness coefficient *n* was assumed to be 0.040 for all sections.

Cross sections for the Chena River were from the bridge-scour study (Heinrichs and others, in press) or were derived from discharge measurements. The bridge-scour study was based on a different one-dimensional hydraulic model that required an approach and exit section and sections at the upstream and downstream sides of each bridge. These sections were used in the HECRAS model for the reaches through the bridges at Wendell Street, Cushman Street, Peger Road, and University Avenue.

For the Chena River HECRAS simulations, additional cross sections were required immediately upstream and downstream from the Noyes Slough entrance and mouth to establish junctions. These sections were interpolated or extrapolated from the nearest cross-section geometry and channel slope in HECRAS. This divided the Chena River channel into three reaches: Reach 1 is upstream from the slough, reach 2 is between the slough entrance and mouth, and reach 3 is downstream from the mouth.

The cross section at the Wendell Street bridge shows considerable scour, particularly around the left pier. Because the channel upstream does not reflect this geometry, a section was surveyed at the gaging station and used to template the next section downstream in the reach approaching the bridge. Additional sections were interpolated on the Chena River in the reaches

Figure 13. Noyes Slough looking downstream showing channel filled with snow and ice in late winter, at West Johansen Expressway bridge (station 2917, fig. 14).

between bridges. For the first model runs, the cross sections were not subdivided; Manning's *n* was set at 0.035 for all sections.

Both a flow at the most upstream section and a starting friction slope at the most downstream section of the river reach were required for the initial model run. A slope of 0.0002 ft/ft was computed from the reach distance between the bridges and water-surface elevations measured at the Chena River bridges during spring 2000. The assumed water discharges (Q) were based on measurements made in Noyes Slough and the corresponding flow in the Chena River. For model input, flow had to be split between the two channels. For each model run, a Q value was assigned for each of the three Chena River reaches and a Q value was assigned to Noyes Slough. For example, given a measured flow in Noyes Slough of 117 ft^3/s and corresponding flow in the Chena River of 3,950 ft^3/s, the input to the model would be 3,950 ft^3/s for each of the reaches 1 and 3 of the Chena River; 117 ft^3/s for the Noyes Slough; and the difference between these flow values, or 3,833 ft^3/s, for reach 2 of the river.

MODEL ADJUSTMENT AND CALIBRATION

For this study, the model was calibrated primarily to match observed conditions on Noyes Slough at Minnie Street and at the stream-gaging station on the Chena River upstream from Wendell Street. All the flows that were measured in 2000 were run. For Noyes Slough, Manning's *n* values were adjusted to 0.037 except at Aurora Drive, where a roughness of 0.15 was assigned to part of that section to account for a log jam. With the exception of flows less than about 50 ft^3/s in the slough, the model matched measured water-surface elevations at Minnie Street on the slough reasonably well.

For the Chena River, the model output nearly matched the stage–discharge relation derived from gaging-station records at lower flows but not at higher flows, for which the modeled stage was lower than the rating. The cross sections were subdivided such that the banks at flows greater than about 2,000 ft^3/s were assigned a higher Manning's *n* value. Thus, to adjust

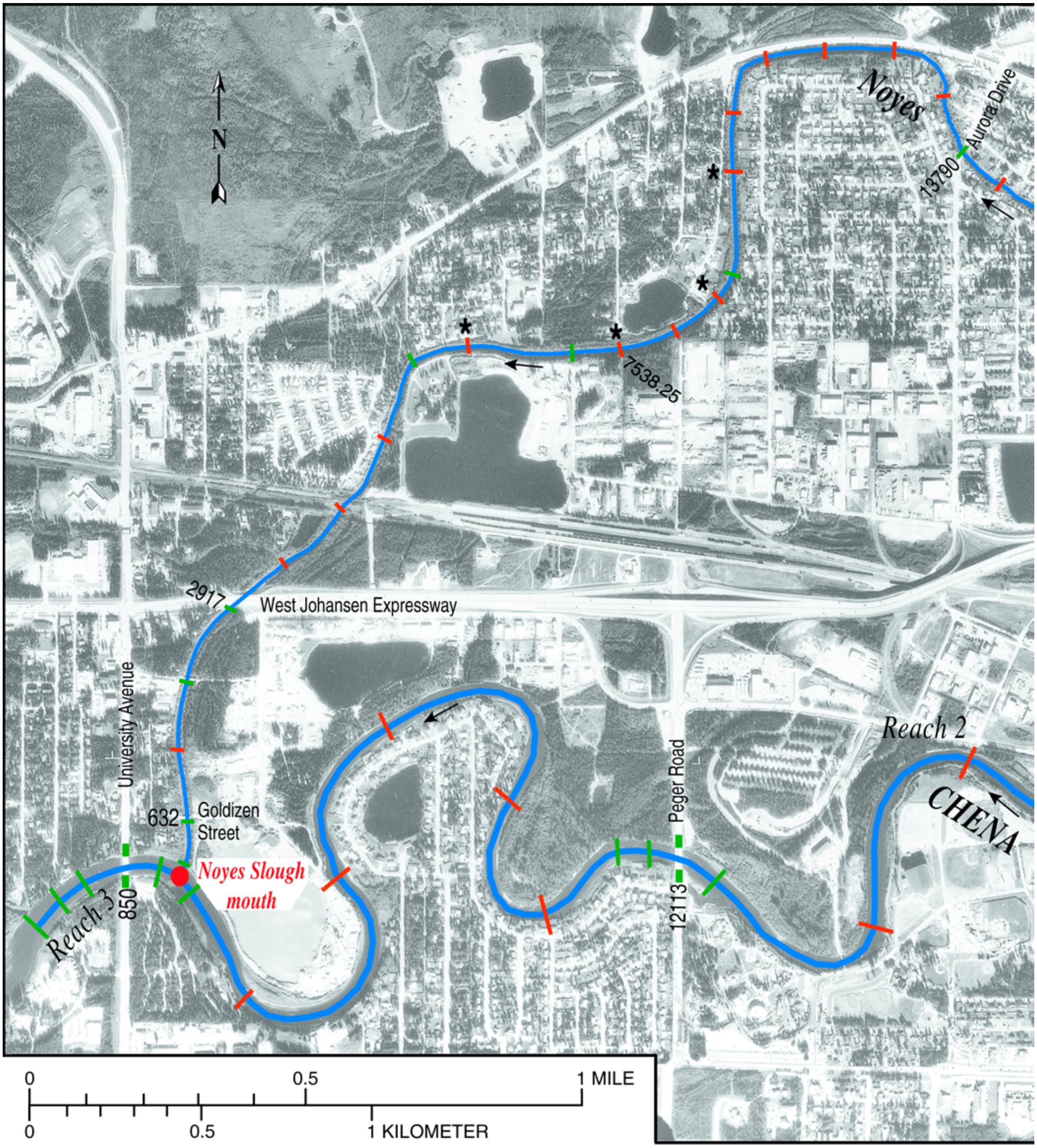
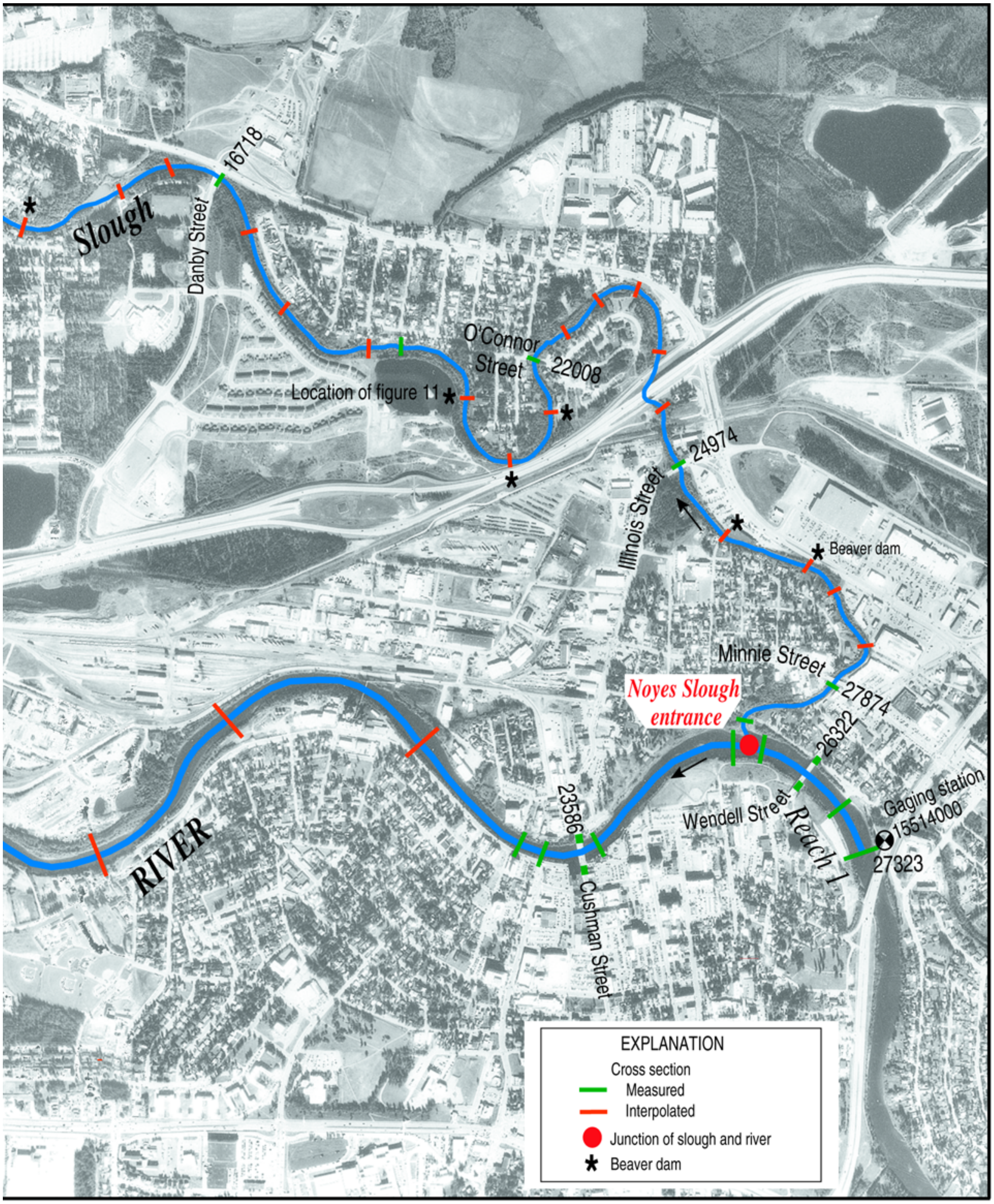


Figure 14. Study reach (fig. 1), showing locations of cross sections used in model, 10 beaver dams, and flow
Aerial photograph courtesy of Natural Resources



directions (arrows). Scale is approximate. Numbers labeling some cross sections refer to stationing, in feet.
Conservation Service; flown in 1996.

the model output to more closely match the rating, Manning's *n* values were changed to 0.029 for the main channel and 0.055 for the banks of the Chena River.

Measured flows in Noyes Slough and measured or gaged flows in the Chena River were used for the initial simulations. If the model accurately calculated water-surface elevations at all measured flows, the water-surface elevations at the entrance to Noyes Slough and at Chena River upstream and downstream from the entrance should be very similar but did not always match, particularly at flows less than about 50 ft^3/s. Discrepancies likely were due to variation in ground-water inflow and outflow on rising or falling stage of the Chena River, which in turn may have caused Noyes Slough to lose flow to the ground-water aquifer during rising stages and to gain flow during falling stages. These variations may amount to as much as 50 ft^3/s (table 2). A one-dimensional, steady-state model such as HECRAS does not adjust automatically for varied flow within a reach.

For the final model, the flow was split between Noyes Slough and the Chena River to make the values for water-surface elevations at the junction of Noyes Slough and Chena River approximately equal. The resulting modeled flows for the slough and river match the measured values reasonably well except at lower flows, for which the model overestimates discharge (fig. 16). Flow in the slough begins at a flow of 2,400 ft^3/s in the Chena River (stage 2.72 ft, elevation 425.64 ft above sea level, rating 22; fig. 7). An example of output from the HECRAS model is shown in figure 17, a perspective view depicting cross sections, the Wendell Street bridge, and the water-surface profile at a flow of 2,000 ft^3/s for Chena River reach 1.

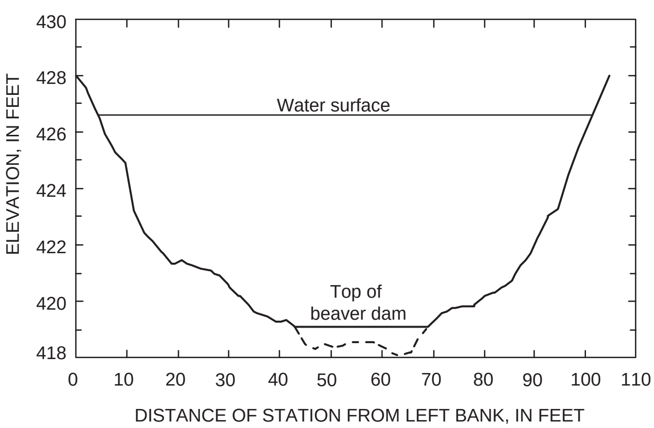


Figure 15. Example of cross section used in HECRAS model, showing channel and beaver dam on Noyes Slough (station 7538.25, fig. 14).

USING MODEL WITH MODIFIED GEOMETRY

Complete restoration of Noyes Slough would require returning flow from the Tanana River to the old Chena Slough. Although this would increase flow in Noyes Slough, it also would increase silt load and hence possibly endanger habitat for wildlife dependent on clearer water and cause potentially serious flooding of much of Fairbanks. Increasing the magnitude and frequency of flow from the present-day Chena River into Noyes Slough by enlarging the slough channel and lowering its bed has been the most commonly suggested means of restoration.

HECRAS may be used to examine the effects of a modified slough-channel geometry. In the model, cross sections may be altered, structures or obstructions may be added, or the channel may be enlarged. The following analysis shows how flow might be increased in Noyes Slough by changing the slough-channel geometry. Basic assumptions in the model were that the entire length of the channel could be excavated and that the 10 beaver dams would be removed. Utility crossings and the possible effects of excavation on bridge foundations were ignored.

The first step of this analysis was to select a desired flow in the Noyes Slough for a given flow in the Chena River. Conditions approximating those a few years after the construction of Moose Creek Dike, were chosen: a flow of 100 ft^3/s in the slough and a flow of 2,000 ft^3/s in the river. Recent discharge measurements show velocities of 1 to 1.5 ft/s at a flow of 100 ft^3/s in the slough; the desired discharge could be achieved by enlarging the slough channel about 80 ft^2 in cross-sectional area.

A channel 40 ft wide at the bottom, 2 ft deeper than at present, and having sides that rise 2 ft for every 1 ft of width would yield the additional area needed. Although such steep sides likely would be unstable, the actual width of Noyes Slough at the channel bottom is constrained to about 40 ft in some parts and thus would require steeper banks to gain the necessary increase in cross-sectional area. Assuming this geometry and a

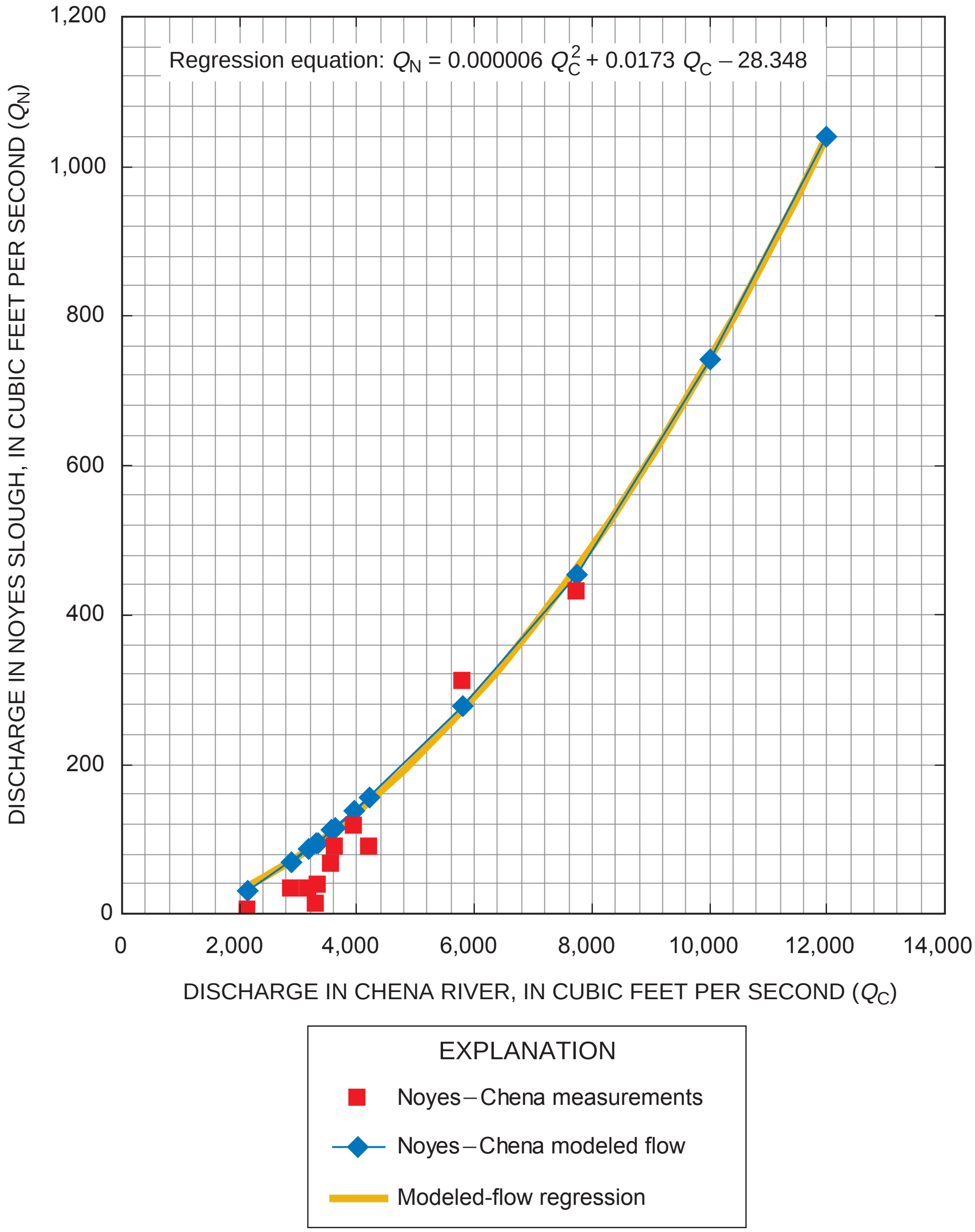


Figure 16. Regression relation between Noyes Slough and Chena River flows for present-day conditions as modeled by HECRAS and measured flows in slough (instantaneous) and river (mean daily).

channel-bottom elevation of 422.35 ft above sea level, the channel-modification option in HECRAS (Brunner, 1997) first was used to model conditions for the most upstream cross section, at the entrance to Noyes Slough (fig. 18). Then this channel geometry was replicated by specifying a slope of 0.0003 ft/ft, about that of the natural channel, at each down-channel cross section.

Rerunning the model using the same modified-channel geometry, flows, and boundary conditions and optimizing the flow split produced a lower water-surface profile throughout the reach. Actual Noyes Slough channel-bed and water-surface profiles compared to modified-channel profiles, assuming a flow of 117 ft^3/s, are shown in figure 19.

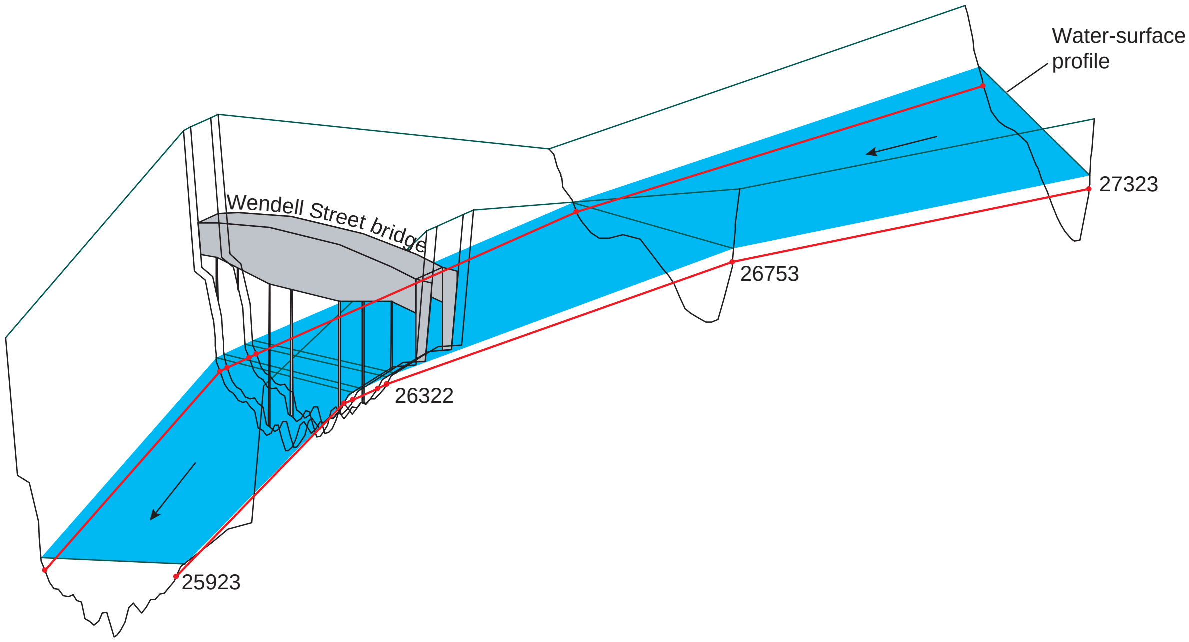


Figure 17. Example of HECRAS model output, showing water-surface profile (at flow of 2,000 cubic feet per second) for reach 1, Chena River through Wendell Street bridge, just upstream from entrance to Noyes Slough. Note differences in cross-section geometry of channel through reach. At points where red lines intersect channel, it was subdivided for different roughness (Manning's *n*) values. Number labels refer to stationing, in feet.

The regression relation between modeled flows in Noyes Slough and Chena River for the modified conditions in the slough are shown in figure 20. Flow in the slough begins at a flow of 1,200 ft^3/s in the Chena River (stage 1.08 ft, elevation 423.30 ft above sea level, rating 22; fig. 7). Hydrographs for the river (based on discharge data) and the slough (based on regression equations; see figs. 16 and 20) for water year 2000 are shown in figure 21. Hydrographs for Noyes

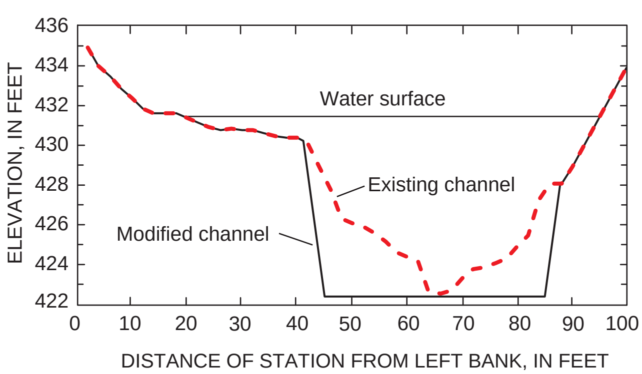


Figure 18. Cross-section geometry at entrance to Noyes Slough and modified channel configuration.

Slough under existing and modified conditions show flow of increased magnitude and duration in the modified channel.

For the period April 1–October 31 of water years 1981–99, the maximum, mean, and minimum of the mean daily flows for the Chena River (table 3) were used to construct three theoretical periods of flow. In turn, these Chena River conditions were used to compute theoretical maximum, mean, and minimum hydrographs for modified Noyes Slough (fig. 22) from regression equations.

If the theoretical mean or maximum hydrographs for Noyes Slough pertained, given present conditions and channel geometry, flow apparently would occur in the slough throughout most of the open-water season; if instead the theoretical minimum hydrograph pertained under present conditions and geometry, the slough would flow for only about 5 days. Noyes Slough flow would be greater for all Chena River flows after modifying the slough channel. Because these hydrographs are theoretical and are unlikely to represent actual flows for any particular water year, the effect of modifying the channel was assessed also in relation to a recent year's hydrograph. Mean flow for the Chena

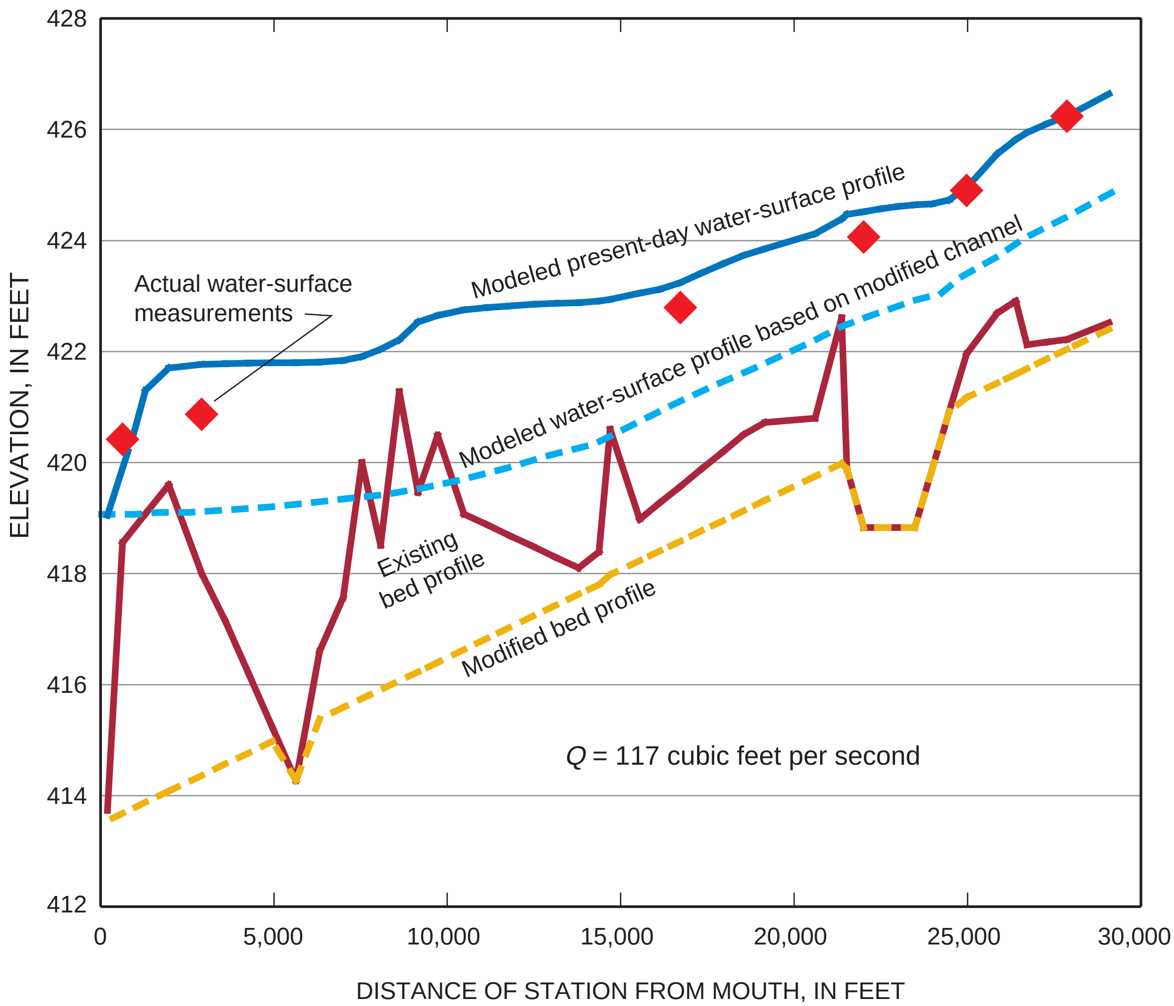


Figure 19. Measured and modeled water-surface and bed profiles at flow of 117 cubic feet per second in Noyes Slough, for present-day conditions and after channel modification.

River at Fairbanks during water year 1999, a relatively low runoff year, was 809 ft^3/s, or only about 60 percent of the mean for the period of record. The computed hydrographs for Noyes Slough for water year 1999 are shown in figure 23. Increasing the channel capacity and lowering of the bed would have increased flow duration from 72 to 131 days.

To compile flow-duration data, mean daily flows for the Chena River during April 1–October 31 of water years 1981–99 were divided into ascending ranges of flow, commonly referred to as flow classes. The number of days flow occurs in each class defines flow duration for the period. The compiled flow durations help in estimating how many days to expect flow in Noyes Slough. The regression relation between Noyes Slough and Chena River flows was applied to derive flow-duration data for Noyes Slough under both present and modified channel geometry for an average year (table 4). The model predicts that flow begins in Noyes Slough at a lower discharge in the Chena River than indicated by flow measurements. Therefore, and because of the varied effects of ground-water–surface-water interaction, flows less than 11 ft^3/s for existing conditions and less than 15 ft^3/s for a modified channel were assumed to be days of no flow.

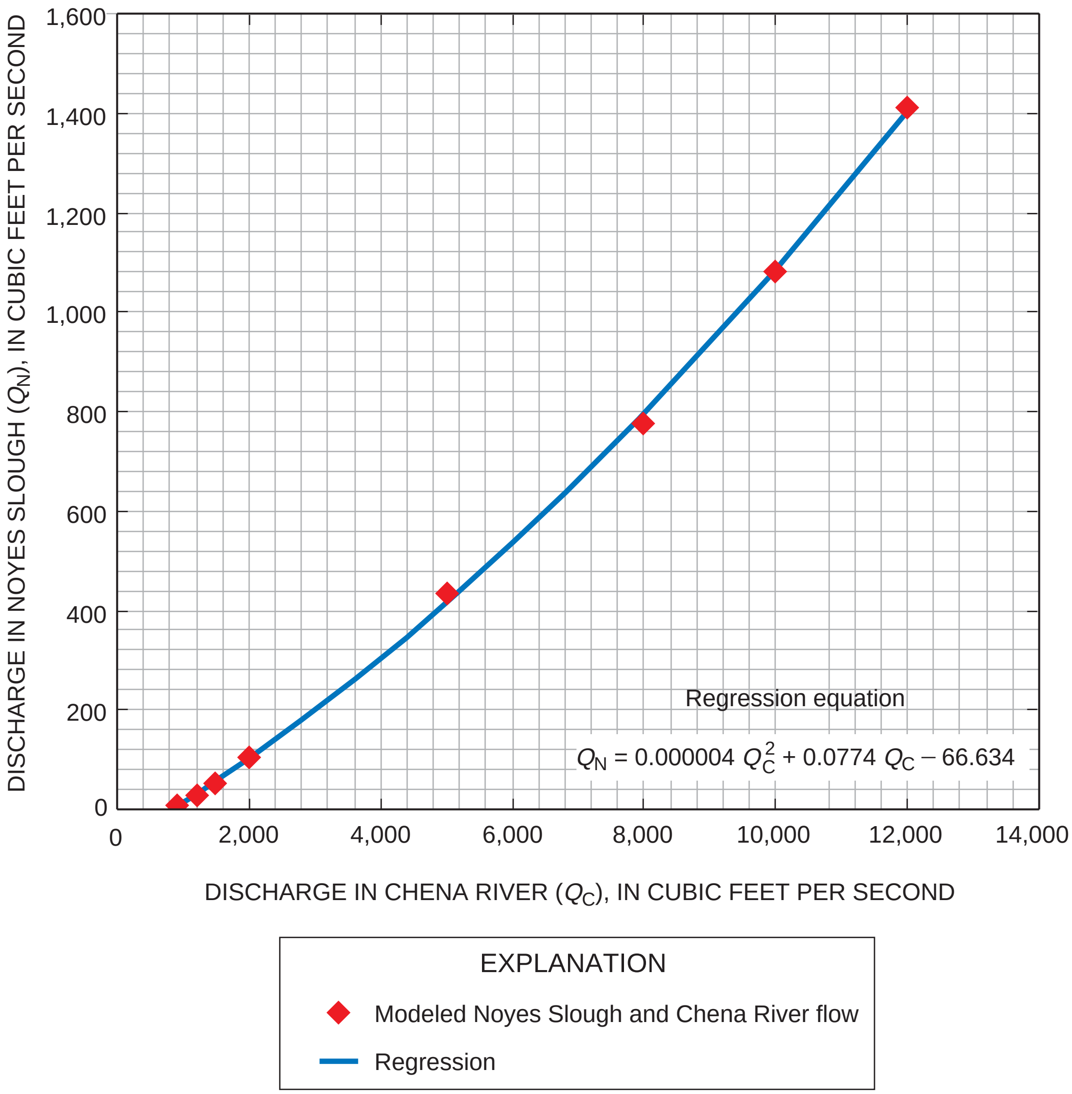


Figure 20. Regression relation between Noyes Slough and Chena River flows for modified channel conditions in Noyes Slough as modeled by HECRAS.

RELATED OBSERVATIONS

In general, as the Chena River rises and Noyes Slough begins to flow, most of the flow is lost from the slough channel to the aquifer; for example, this occurred in August 2000 during the installation of a sewer lift station about 500 ft from the Minnie Street bridge. Because the bottom of the excavation was well below the water table, dewatering was required. Water was pumped from the project into the storm drain, which has an outfall immediately upstream from the Minnie Street bridge on the right bank. Because no water had flowed from the river into the slough for several weeks, the pumped water was the only surface inflow to the slough. According to J.L. Hulsey (Great Northwest, Inc., oral commun., 2000), the pump rate was 1,300 gal/min (or 2.7 ft^3/s). A discharge measurement of 2.0 ft^3/s was made in the slough just downstream from the outfall, and a second one was made at the Illinois Street bridge showing zero flow. The entire discharge presumably recharged the aquifer within 2,900 ft along the length of the Noyes Slough channel.

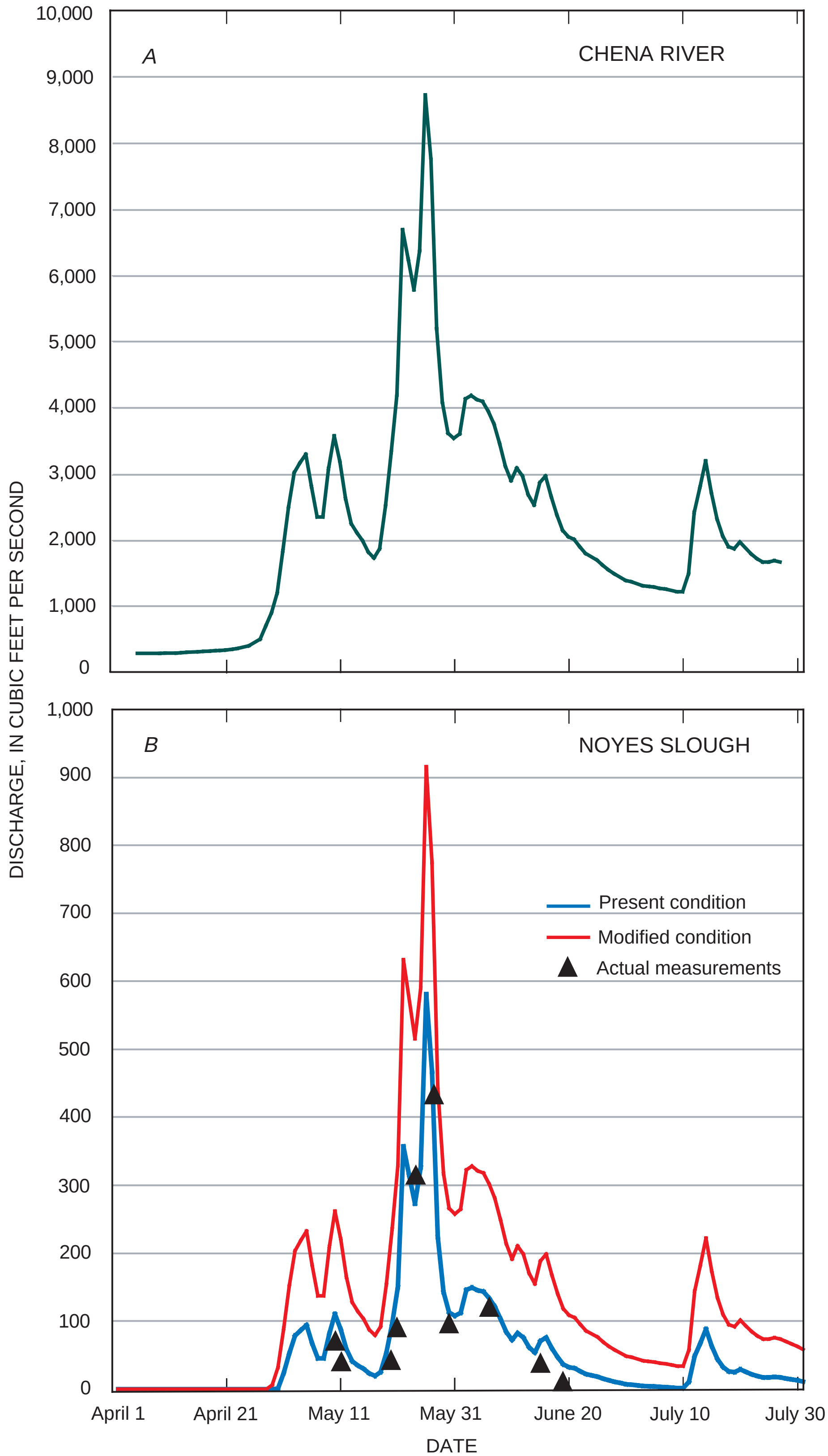


Figure 21. Hydrographs for period April 1–July 31, 2000. *A*, Chena River, from gaging-station records. *B*, Noyes Slough, computed from regression equations for existing and modified channel and also showing discharge measurements made in May and June.

Table 3. Mean daily discharge for Chena River at Fairbanks (station no. 15514000), April 1–September 30, 1981–99

Day of month	Mean daily discharge (cubic feet per second)																	
	April			May			June			July			August			September		
	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum
1	390	277	180	6,000	2,262	400	9,770	2,774	1,030	7,180	2,484	633	3,920	1,782	780	6,630	2,450	1,030
2	395	278	180	7,300	2,380	460	9,680	2,720	996	5,610	2,286	623	3,540	1,762	756	7,760	2,572	1,020
3	410	281	185	8,400	2,528	500	9,860	2,760	943	4,580	2,143	604	3,240	1,729	748	7,460	2,598	1,010
4	410	284	185	8,340	2,667	540	10,300	2,686	893	4,140	1,969	591	3,050	1,687	722	7,170	2,506	989
5	410	286	190	9,470	2,698	580	9,800	2,536	836	3,990	1,846	578	2,950	1,645	718	8,020	2,429	981
6	410	288	190	10,600	2,745	640	9530	2,355	796	3,930	1,827	574	2,950	1,627	730	7,490	2,347	961
7	430	292	195	11,200	2,749	680	9,500	2,240	809	4,000	1,852	576	2,870	1633	768	6,500	2,320	942
8	430	295	190	11,400	2,794	720	9,240	2,232	803	4,440	1,767	574	2,710	1,660	798	7,980	2,353	930
9	440	298	195	11,300	2,854	730	9,010	2,159	766	4,450	1,746	577	2,710	1,705	911	8,440	2,392	913
10	450	304	200	10,500	2,929	750	8,850	2,045	726	4,690	1,735	609	2,700	1,774	1,030	7,190	2,349	899
11	490	311	200	10,100	2,946	790	8720	2,016	692	3,930	1690	625	2,900	1,860	1,050	5,990	2,247	897
12	495	316	200	9,570	2,944	890	6,370	1,904	668	3,350	1,681	613	3,640	1,895	1,040	5,460	2,159	890
13	500	323	200	9,260	2,954	1,050	4,900	1,839	653	4,900	1,794	612	3,220	1,809	1,020	5,090	2,105	930
14	540	332	200	9,100	2,962	987	3770	1,704	632	6,060	1,878	609	2,780	1,747	1,000	4,610	2,068	952
15	615	343	200	8,300	2,996	938	3,430	1,688	620	6130	1,916	613	2,570	1,754	1,040	4,230	2,031	1,000
16	579	350	200	660	3,044	917	3,190	1,680	600	5,240	1,953	625	3,620	1,854	1,080	4,040	2,022	1,130
17	633	366	210	6,350	3,094	940	3,600	1,795	594	4,150	1,940	628	3,560	1,878	1,120	5,080	2,040	1,130
18	700	384	210	6,750	3,036	1,000	7,470	2,091	635	3,840	1,863	626	4,330	1,949	1,150	5,400	2,040	1,120
19	890	416	220	8,030	2,971	1,030	5,670	2,034	709	4,260	1,880	670	4,830	2,083	1,130	4,810	1,986	1,090
20	1,100	461	220	7,740	2,819	1,050	3,990	1,970	767	4,500	1,846	757	6,700	2,249	1,130	4,300	1,925	1,060
21	1,300	520	230	6,000	2,693	1,020	6,010	2,239	746	4,910	1,922	758	7,420	2,288	1,150	5,150	1,954	1,030
22	2,120	611	240	6,750	2,661	978	8,300	2,658	725	6,970	2,028	742	5,870	2,350	1,200	5,610	1,943	1,020
23	2,800	730	250	7,020	2,787	976	9,040	2,496	718	6,790	2,155	726	5,920	2,402	1,230	5,300	1,902	1,010
24	3,350	850	260	7,650	2,862	1,020	9,340	2,306	704	8,270	2,247	755	8,140	2,513	1,210	4,800	1,857	935
25	3,690	993	270	7,900	2,782	972	7,720	2,305	711	6,820	2,167	901	8,320	2,555	1,180	4,180	1,819	920
26	3,760	1,153	280	9,590	2,923	965	6,980	2522	707	5,110	2,123	980	8280	2,569	1,150	4,350	1,809	920
27	3,500	1,328	300	10,600	3,140	1,120	8,960	2,848	710	6,180	2,135	1,020	6,980	2,476	1,130	4,690	1,793	880
28	4,000	1,626	310	10,400	3,204	1,080	9,570	2,990	691	7,580	2,226	955	5,230	2,407	1,110	4,290	1,762	860
29	5,220	1,869	330	10,500	3,020	1,060	9,340	3,060	666	6,910	2,174	899	4,450	2,293	1,090	3,990	1,733	840
30	4,870	2,022	370	10,400	2,898	1,040	8,610	2,842	651	5,310	1,974	852	4,030	2,207	1,070	3,880	1,702	865
31				10,200	2,832	1,020				4,440	1,842	814	5,170	2,280	1,050			

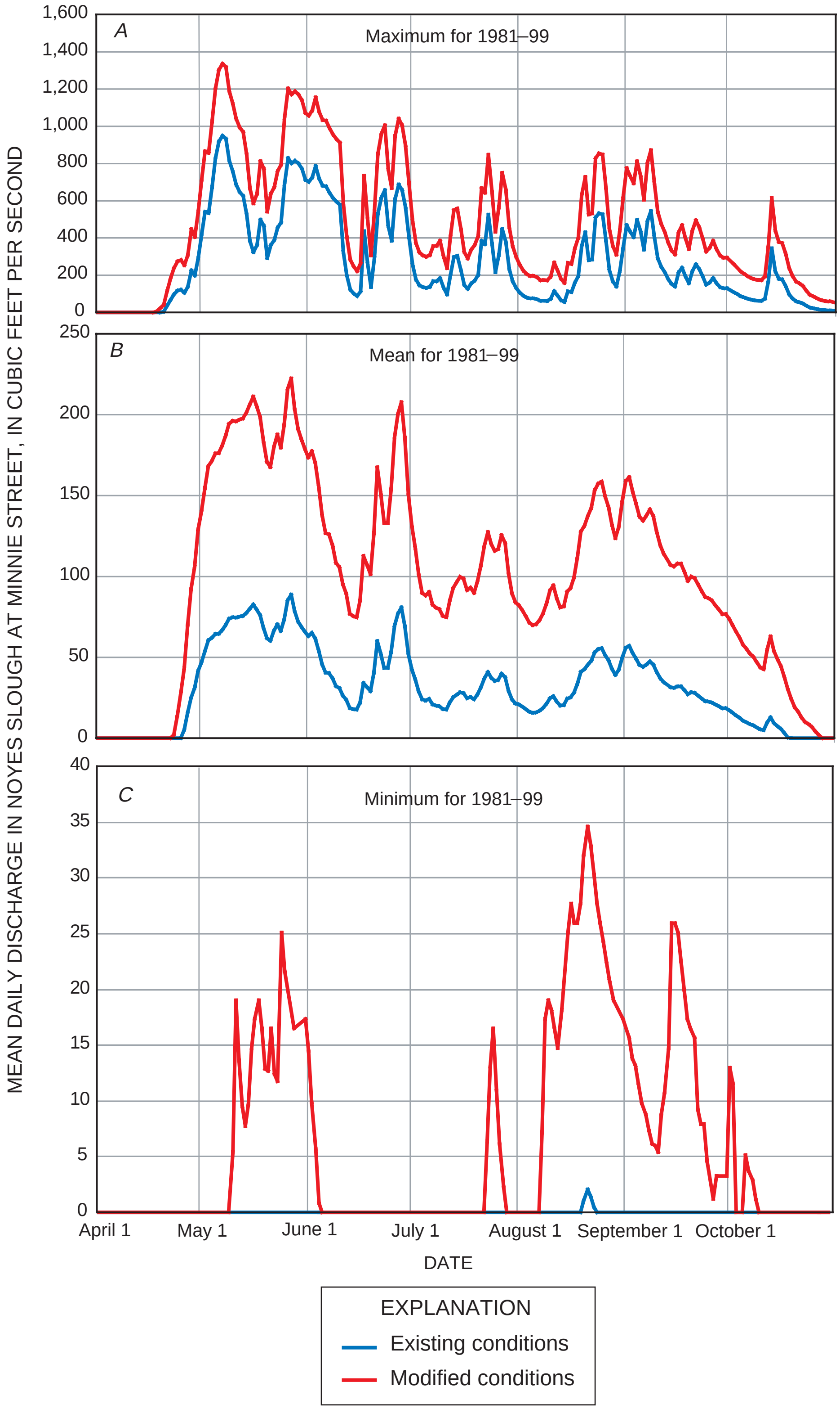


Figure 22. Estimated hydrographs for Noyes Slough for existing and modified channel conditions at maximum (*A*), mean (*B*), and minimum (*C*) mean daily flows in Chena River for period April 1–October 31, 1981–99.

Table 4. Flow duration for Chena River at Fairbanks, April 1–September 30, 1981–99, and for Noyes Slough (computed for present-day and modified channel geometry)

[≤, less than or equal to; —, none]

Chena River flow		Noyes Slough flow			
		Present-day channel geometry		Modified channel geometry	
Discharge (cubic feet per second)	Average number of days for period	Equivalent discharge (cubic feet per second)	Average number of days for period	Equivalent discharge (cubic feet per second)	Average number of days for period
≤499	24	—	—	—	—
500–999	32	—	—	0	56
1,000–1,499	52	0	108	15–57	52
1,500–1,999	40	11–29	40	58–103	40
2,000–2,499	22	30–51	22	104–150	22
2,500–2,999	13	52–77	13	151–201	13
3,000–3,499	8	78–105	8	202–252	8
3,500–3,999	6	106–136	6	253–306	6
4,000–4,499	4	137–170	4	307–362	4
4500–4,999	3	171–207	3	363–419	3
5,000–5,499	2	208–247	2	420–479	2
5500–5,999	2	248–290	2	480–541	2
6,000–6,999	2	291–386	2	542–670	2
7,000–7,999	1	387–493	1	671–808	1
8,000–8,999	1	494–612	1	809–953	1
9,000–9,999	1	613–744	1	954–1,106	1
10,000–10,999	1	745–887	1	1,107–1,268	1
Days of greater than zero discharge					
Total, all periods..........................	214		106		158
As percentage of total..................	100		49.5		73.8

In years when the slough receives little flow, trash and brush may accumulate and entrance conditions change. Conversely, as in the spring of 2000, when the slough receives significant flow, the obstructions are washed out and flow conditions in the channel improve. As flow in the Chena River recedes, the slough entrance again becomes an area of deposition, affecting the threshold at which flow begins to enter the slough; subsequently the entrance is scoured out again during another rise. This alternating pattern and the ground-water inflow and outflow likely account for the variation in the discharge measurements at lower flows (fig. 8).

The trend of the lowering of the bed of the Chena River at the entrance of Noyes Slough may or may not continue but seems likely. During 1999–2000, the lower Chena River was dredged near its mouth on the Tanana River; as a result, the upstream channel may adjust its bed to the change in slope along the reach. Also unknown are the present-day sediment load of the Chena River and the sedimentation rate in the Noyes Slough.

The sediment-transport rate computed from the one bed-load sample collected on the Chena River, at a flow of 6,380 ft^3/s, was 50 tons/d, and a point sample collected midchannel in Noyes Slough yielded a rate of less than 1 ton/d. Although no other bed-load data are available for the Chena River at Fairbanks, Burrows and others (1981) reported that bed-load-transport rates on the Tanana River ranged from 300 to 9,000 tons/d. Suspended-sediment-transport rates for the Chena River, computed from samples collected during 1953–75, range from less than 100 to 29,500 tons/d.

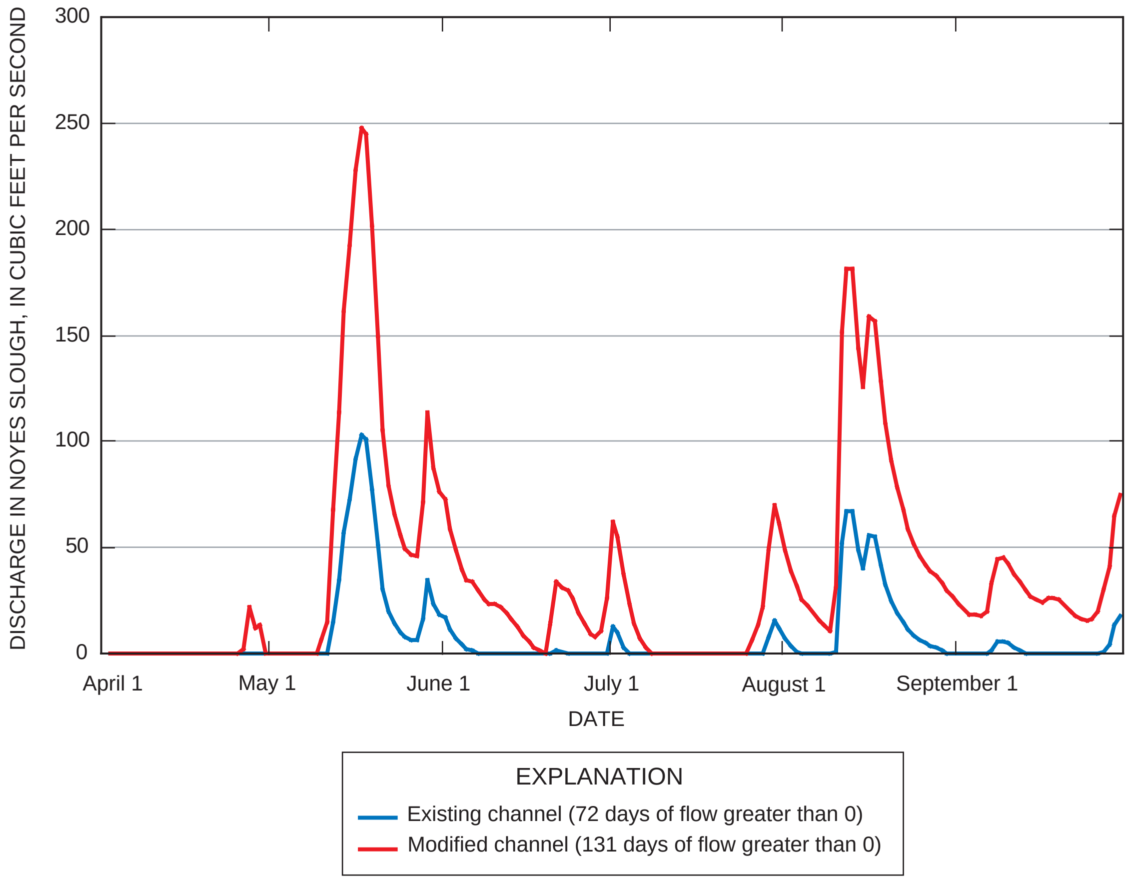


Figure 23. Estimated hydrographs for Noyes Slough for period April 1–September 30, 1999, for existing and modified channel conditions.

SUMMARY AND CONCLUSIONS

Prior to 1945, both the Chena River and the Tanana River contributed water to Chena Slough, which is now the lower Chena River through Fairbanks. Chena Slough, in turn, contributed to Noyes Slough at times of high flow. In 1947, two years after the completion of the Moose Creek Dike, Tanana River water no longer flowed through Fairbanks, and flow in Noyes Slough was from high flow only of the Chena River. Peak flows in the Chena River were reduced further in 1980 after the completion of the Chena River Lakes Flood Control Project, which was designed to limit Chena River flow through Fairbanks to 12,000 ft^3/s. The impact on Noyes Slough from these flow reductions has been increased by downcutting (or lowering) of the channel of the Chena River at the entrance to Noyes Slough. This downcutting means that the Chena River must be at a higher stage and greater flow for water to enter Noyes Slough today than in the past. Levels in the Tanana and Chena Rivers affect ground-water levels in the Fairbanks alluvial plain. Without any apparent surface flow in Noyes Slough, water in isolated ponds along the slough is assumed to represent local ground-water levels. During rising flow of the Chena River, Noyes Slough loses flow along the channel by recharge to the ground-water system.

The regression of flow in Noyes Slough based on recent discharge measurements indicates that the slough presently receives flow from the Chena River when the Chena reaches about 2,400 ft^3/s at a stage of about 2.72 ft (elevation 425.64 ft above sea level). The regression based on the HECRAS model predicts that flow in the slough begins at about 1,200 ft^3/s at a stage of 1.08 ft (elevation 423.30 ft above sea level). This discrepancy resulted because the HECRAS model was calibrated to fit the wide range of flows measured in Noyes Slough for a given flow in the Chena River. Based on flow-duration analysis, the slough would be flowing about 106 days during the open-water season.

The modeled flows indicated that at the maximum regulated flow of 12,000 ft^3/s in the Chena River, flow in Noyes Slough would be 1,050 ft^3/s.

One possible way to increase flow in Noyes Slough is to increase the capacity of the slough channel. The HECRAS model was used to analyze this option by altering the existing cross-section geometry in the model to reflect a modified, trapezoidal channel 40 ft wide at the bottom and about 2 ft deeper than present mean bed elevation at the entrance to the slough. This altered geometry was propagated downstream through all sections at a channel slope of 0.0003 ft/ft.

The model results indicate that after modifying the channel, Noyes Slough would begin to receive water from the Chena River at a flow of 830 ft^3/s and at a stage of 0.48 ft (elevation 423.4 ft above sea level) and could receive water at a maximum rate of 1,440 ft^3/s, based on the regulated maximum flow for the Chena River, 12,000 ft^3/s. On average, under these modified-channel conditions, Noyes Slough would flow 158 days during the open-water season.

Increasing channel capacity is only one possible engineering option for increasing flow in Noyes Slough. The resulting model runs did not account for real-world problems or issues associated with slough-channel excavation such as required allowances for utility crossings, probable destruction of beaver dams, and potential damage to bridge foundations. Increasing flow may yield indirect benefits such as increasing recreational opportunities and helping to maintain the channel by moving sediment through the reach. Significantly modifying the channel could diversify wildlife habitat in the slough but also is likely to destroy or damage some existing habitats. Such vulnerable features, which are difficult to reproduce, include the beaver dams, pools, and overhanging vegetation. Insufficient data are available to estimate rates of sediment deposition in Noyes Slough, which would affect further channel evolution.

Because flow has been declining in Noyes Slough for at least five decades, present-day conditions likely will not change significantly without some intervention. If the trend continues, the slough could have some years of almost no flow.

REFERENCES CITED

Brunner, G.W., 1997, HEC-RAS, River analysis system user’s manual—Version 2.0: U.S. Army Corps of Engineers Hydrologic Engineering Center, 243 p.

Burrows, R.L., Emmett, W.W., and Parks, Bruce, 1981, Sediment transport in the Tanana River in the vicinity of Fairbanks, Alaska, 1977–79: U.S. Geological Survey Water-Resources Investigations Report 81–20, 56 p.

Burrows, R.L., and Harrold, P.E., 1983, Sediment transport in the Tanana River near Fairbanks, Alaska, 1980–81: U.S. Geological Survey Water-Resources Investigations Report 83–4064, 116 p.

Glass, R.L., Lilly, M.R., and Meyer, D.F., 1996, Ground-water levels in an alluvial plain between the Tanana and Chena Rivers near Fairbanks, Alaska, 1986–93: U.S. Geological Survey Water-Resources Investigations Report 96–4060, 39 p., 1 app.

Heinrichs, T.A., Kennedy, B.W., Langley, D.E., and Burrows, R.L., in press, Methodology and estimates of scour at selected bridge sites in Alaska, U.S. Geological Survey Water-Resources Investigations Report.

Nelson, G.L., 1978, Hydrologic information for land-use planning, Fairbanks, Alaska: U.S. Geological Survey Open-File Report 78–959, 47 p.

State of Alaska, 1999, Catalog of waters important for the spawning, rearing, or migration of anadromous fishes: Department of Fish and Game Habitat Division, Alaska Administrative Code, Regulation 5AAC95.010, [variously paged].

Unwin, Scheben, Korynta, and Huettl, Inc., 1982, Feasibility study—Noyes Slough canoe trail, 1982: Fairbanks North Star Borough, 49 p.

U.S. Army Corps of Engineers, 1938, Preliminary examination of the Tanana River and Chena Slough: Letter Report, U.S. Army Corps of Engineers, Office of the Chief Engineer, 20 p., 6 pls.

———1997, Chena River watershed study: Reconnaissance Report, U.S. Army Corps of Engineers, 247 p., 4 apps.

U.S. Geological Survey, 1940, The Alaska Railroad—Yanert Fork to Fairbanks: U.S. Geological Survey, Alaska Map 27, scale 1:250,000.

Williams, G.P., and Wolman, M.G., 1984, Downstream effects of dams on alluvial rivers: U.S. Geological Survey Professional Paper 1286, 83 p.