Water-Quality Data for the Talkeetna River and Four Streams in National Parks, Cook Inlet Basin, Alaska, 1998

by Steven A. Frenzel and Joseph M. Dorava

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CONTENTS

FIGURES

TABLES

CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATIONS

Multiply	by	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second

Vertical Datum:

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—A geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviations:

Water temperature, chemical concentrations, and certain biological measurements are given only in metric units.

Degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) by the following equation: °F = 1.8 (°C) + 32

Chemical
mg/L, milligram per liter
µS/cm, microsiemen per centimeter at 25 °C

Biological
mm, millimeter
µm, micrometer
m^2, square meter
g, gram
µg/g, microgram per gram
µg/kg, microgram per kilogram

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ABSTRACT

Five streams in the Cook Inlet Basin, Alaska, were sampled in 1998 to provide the National Park Service with baseline information on water quality. Four of these streams drain National Park Service land: Costello and Colorado Creeks in Denali National Park and Preserve, Johnson River in Lake Clark National Park and Preserve, and Kamishak River in Katmai National Park and Preserve. The fifth site was on the Talkeetna River, outside of national park boundaries. Samples of stream water, streambed sediments, and fish tissues were collected for chemical analyses. Biological and geomorphic information was also collected at each site.

Nutrient concentrations in stream water were low and commonly were less than analytical detection limits. Analyses of fish tissues for 28 organochlorine compounds at Talkeetna River and Costello Creek produced just one detection. Hexachlorobenzene was detected at a concentration of 5.70 micrograms per kilogram in slimy sculpin from the Talkeetna River. Streambed sediment samples from the Talkeetna River had three organochlorine compounds at detectable levels; hexachlorobenzene was measured at 13 micrograms per kilogram and two other compounds were below the minimum reporting levels. At Colorado Creek, Johnson River, and Kamishak River, where fish samples were not collected, no organochlorine compounds were detected in streambed sediment samples. Several semivolatile organic compounds were detected at Colorado Creek and Costello Creek. Only one compound, dibenzothiophene, detected at Costello Creek at a concentration of 85 micrograms per kilogram was above the minimum reporting limit. No semivolatile organic compounds were detected at the Talkeetna, Kamishak, or Johnson Rivers. Trace elements were detected in both fish tissues and streambed sediments.

Macroinvertebrate and fish samples contained few taxa at all sites. Total numbers of macroinvertebrate taxa ranged from 19 at the Johnson River to 38 at the Talkeetna River. Diptera were the most abundant and diverse order of macroinvertebrates at all sites. Total numbers of diptera taxa ranged from 8 at the Kamishak River to 19 at the Talkeetna River. Fish communities were represented by a maximum of nine taxa at the Talkeetna River and were absent at Colorado Creek. The Johnson River sampling site produced small numbers of juvenile Dolly Varden, and Costello Creek produced small numbers of both juvenile Dolly Varden and slimy sculpin.

INTRODUCTION

Purpose

During Federal fiscal year 1998 (FY98) the U.S. Geological Survey (USGS) and the National Park Service (NPS) Water Resources Division, Denali National Park and Preserve, Katmai National Park and Preserve, and Lake Clark National Park and Preserve entered into a cooperative agreement. This agreement authorized the USGS, National Water-Quality Assessment (NAWQA), Cook Inlet Basin study unit team to use NAWQA techniques to obtain baseline water-quality data for sites in national parks in the Cook Inlet Basin (fig. 1).

The purpose of this report is to outline the USGS accomplishments during FY98 toward the goals of this agreement. The report identifies and describes the physical, chemical, and biological aspects of the sites. Data presented in this report are summaries of results: USGS data bases containing complete data sets will be accessible in other published reports and are expected to be available by March 1, 2000 on the world wide web at *http://ak.water.usgs.gov*.

Sampling Strategy

The Cook Inlet Basin is approximately 39,325 mi^2 in area, of which less than 1 percent is developed. The NAWQA study in the basin was initiated with an evaluation of the occurrence and distribution of contaminants. To help supplement a sampling strategy that primarily concentrated on sites along the road system, additional sampling sites in the national parks were established. The national parks provided undeveloped pristine sites where little was known about the background water quality.

Acknowledgment

We thank the many individuals with the National Park Service who assisted us with site selection, logistical support, data collection, and review.

SITE SELECTION

During the late winter and spring of 1998, sampling sites in national parks in Alaska that have land area draining to Cook Inlet were considered for water-quality assessments. Five sites were selected (table 1) after consultations with area biologists and park resource managers. Local issues specific to each park as well as the national interests of the NPS and NAWQA program were considered during site selection. This process also considered the availability of data describing water quality and environmental characteristics of each site. Two sites were selected for assessment in Denali National Park (Colorado and Costello Creeks), one site in Lake Clark National Park (Johnson River), and one in Katmai National Park (Kamishak River). One site (Talkeetna River) outside of the park boundaries also was selected because it has long-term records of water quality, drains undeveloped pristine lands, and provides a data set of comparative information to help evaluate the water-quality characteristics found in the parks.

Figure 1. Location of Cook Inlet Basin, Alaska, and sampling sites.

Table 1. Water-quality data-collection sites in the Cook Inlet Basin, Alaska
[mi^2, square mile]

Site name	USGS Station No.	Latitude	Longitude	Drainage area (mi^2)
Talkeetna River near Talkeetna	15292700	62°20'49"	150°01'01"	[a]1,996
Costello Creek near Colorado (Denali National Park)	6310181493237	63°16'18"	149°32'37"	23.2
Colorado Creek near Colorado (Denali National Park)	6316291493520	63°16'29"	149°35'20"	10.6
Johnson River above Lateral Glacier near Tuxedni Bay (Lake Clark National Park)	15294700	60°05'41"	152°54'38"	24.8
Kamishak River near Kamishak (Katmai National Park)	5857501541011	58°57'50"	154°10'11"	262

[a]Drainage area revised from previously published value

Talkeetna River Site

In mid-June 1998, the NAWQA team began the assessment of NPS sites with an investigation of the Talkeetna River (fig. 1; table 1) near the USGS stream-gaging station. At this site, the river is at an elevation of about 400 ft and drains about 1,996 mi^2. Streamflow and water-quality data have been collected at this site by the USGS since 1965.

Denali National Park Sites

Colorado and Costello Creeks, tributaries to the West Fork of the Chulitna River, were selected from areas within Denali National Park (fig. 1). These two sites are near the park's southeastern border and were selected because they represent a presently undisturbed area where historical mining has occurred. Costello Creek drains about 23.2 mi^2 of the southern Alaska Range. The study reach is upstream from the historical Dunkle Mine. Colorado Creek drains about 10.6 mi^2 of the southern Alaska Range and is about 1 mi west of Costello Creek. Little historical mining has occurred in the Colorado Creek basin.

Lake Clark National Park Site

The Johnson River (fig. 1; table 1) flows into the western edge of Cook Inlet approximately 60 mi southwest of Kenai. The Johnson River site was at the USGS stream-gaging station about 20 mi upstream from the mouth at an elevation of about 450 ft. At this location, river flows eastward and drains about 24.8 mi^2 of the northern and eastern flanks of Iliamna Volcano. The USGS has collected discharge data during open-water periods (from May to early October) at this site since July 1995. This site was selected for investigation because the lands draining into the river have been identified as a likely source of precious metals, and the potential exists for substantial mining in the watershed. In addition, the site is of interest because it reflects unique influences of a nearby active volcano and nearby glaciers.

Katmai National Park Site

The Kamishak River drains the extreme southwestern corner of the Cook Inlet Basin (fig. 1). The river drains about 262 mi^2 of land area including the northwestern part of Katmai National Park. This site was selected for investigation primarily because there is little information on streamflow or water quality for this area of the Cook Inlet Basin.

METHODS

At each site selected for investigation, standard published NAWQA techniques were used to evaluate the physical, chemical, and biological characteristics (Crawford and Luoma 1993; Cuffney and others, 1993; Fitzpatrick and others, 1998; and Porter and others, 1993). Initially, a study reach representative of the local stream conditions was identified and established with monuments such as metal rods, wooden stakes, or nails driven into a tree. Data were then collected throughout the reach. Specific elements of the physical, chemical, and biological investigation methods used are described in greater detail below.

Physical Characteristics

Collection of stream physical characteristics was completed at 11 equally spaced channel transects along each established study reach where physically possible. The data on physical characteristics of each study reach were collected according to protocols described in detail by Fitzpatrick and others (1998). Physical characteristics were measured with compasses, current meters, and total-station surveying instruments. Data collection included field notes, sketches, and photographs; channel-geometry surveys; and measurements of channel widths, depths, and water velocities at each channel transect.

Physical characterization of each study reach also included measurements of riparian and instream aquatic-habitat features. Habitat features measured included flow aspect, open-canopy angles, and canopy closure, as well as the presence of any submerged habitat features such as boulders or woody debris. *Flow aspect* is the compass orientation of the streamflow in the center of each transect. *Open canopy angle* is a measure of the maximum possible sun exposure to the center of each transect and has a maximum value of 180 degrees. *Canopy closure* is a measure of the riparian vegetation density.

Physical characteristics of each study reach were documented with a set of notes and photographs taken during a one- or two-day site visit. These initial observations included a detailed hand sketch of each study reach. The sketches depict major geomorphic features such as sloughs, riffles, and rapids within the identified study reach. The hand sketch and photographs of the reach were supplemented with detailed channel-geometry surveys of individual transects.

Chemical Characteristics

All samples for chemical analyses were collected according to published protocols (Crawford and Luoma,1993; Shelton, 1994; and Shelton and Capel, 1994). Field water-quality characteristics including water temperature, specific conductance, pH, and dissolved oxygen concentration were determined with a field-calibrated Hydrolab instrument.

Nutrient concentrations were determined from water samples collected from a single cross section at each reach. Bed sediments and tissues of slimy sculpin (*Cottus cognatus*) were collected from various locations in the reaches for analysis of synthetic organic compounds and trace elements. Slimy sculpin were targeted for tissue sampling because they are not migratory and they are omnivorous bottom feeders. Also, slimy sculpin were thought to be present all sites in the Cook Inlet Basin, which allowed for more direct site-to-site comparison of results. Most of the targeted organic compounds were not detected in bed sediment or tissue samples (appendix 1). Typically, organochlorine compounds were analyzed in fish tissues, and semivolatile organic compounds (SVOCs) were analyzed in bed sediments. Whole fish were used for both organic and trace-element analyses due to the small size of adult slimy sculpin. Where adequate fish were not available for analysis or for comparing the two media, organochlorine compounds were analyzed in bed sediments. Streambed sediments were sieved to less than 2 mm for the organochlorine and SVOC samples and to less than 0.063 mm for the trace-element sample. That size fraction is used for the trace-element sample because concentrations tend to be greatest with smaller particle sizes due to increased surface areas for sorption of the trace elements. Analysis of the trace-element sample is made after a complete digestion; therefore, results indicate the chemical make-up of the entire sediment matrix.

Analytical results are shown as measured concentrations that exceed a minimum reporting limit. The minimum reporting limit is determined by the analytical methods. Compounds may be detected at concentrations smaller than the minimum reporting limit, but cannot be confidently quantified at those levels. When this occurs, the compounds are shown as detected, but no concentration value is reported.

Biological Characteristics

Biological characteristics of each study reach were evaluated by sampling algal, benthic macroinvertebrate, and fish communities. These biological samples were collected according to published NAWQA protocols (Cuffney and others, 1993; Meador and others, 1993; Porter and others, 1993).

An assessment of the algal community was done to identify algal density, as well as the species of algae present at the study reaches. Delays at the algal contract laboratory prevented those data from being available for this report. Two types of samples were collected: (1) a quantitative sample was collected from a known surface area and composited to determine density and species composition, and (2) the variety of algal habitats within a reach were qualitatively sampled for a more complete assessment of the species composition for the study reach.

Benthic macroinvertebrates were sampled using two methods that correspond to those used for algae samples (Cuffney and others, 1993). One sample, collected from the "Richest Targeted Habitat" (RTH), was used to quantify the relative density of macroinvertebrates. A second sample, the "Qualitative Multi-Habitat" (QMH), was used to determine macroinvertebrate taxa present at the sites by sampling all the available habitats. An RTH sample is the composite of five 0.25 m^2 areas in which the streambed is disturbed in order to wash macroinvertebrates into a collection net. At all sites, riffles were sampled as the richest habitat. The QMH sample is collected from the variety of habitats present in the reach and uses a dip net and hand picking of macroinvertebrates from woody debris. The two sample methods differ in the mesh size of the collection nets: RTH samples are collected with a 425-μm mesh and QMH samples are collected with a 210-μm mesh.

Macroinvertebrates were identified at the USGS National Water Quality Laboratory's Biological Unit. Subsampling techniques are used in the identification and enumeration of macroinvertebrates at the Biological Unit. RTH samples are subsampled with a technique that is based on a 300-organism subsample. If fewer than 300 organisms are present in a sample, subsampling is not necessary. QMH samples are subsampled by a timed method rather than by specific number of organisms. Because the abundance of organisms is not determined for QMH samples, the taxonomist need only sort out a few individuals of each taxon for identification.

Fish community assessments evaluated the relative abundance of fish, their size, and their health. Fish were collected using backpack electrofishing equipment in combination with dip nets and seines. At nonwadeable sites, only habitats along channel margins that were wadeable were sampled. By not sampling deeper habitats, some species or larger individuals may not be represented in the samples collected. Length and weight measurements were made of the first 30 individuals of each species collected. Fish health was qualitatively determined by an examination for external abnormalities, such as lesions or tumors. Individuals that were identified in the field were returned to the stream; others that could not be readily identified were preserved for later identification.

TALKEETNA RIVER STUDY REACH

The Talkeetna River study reach near the USGS stream-gaging station is about 5 mi upstream from the mouth and 1.7 mi downstream from Chunilna (Clear) Creek (fig. 2). The reach had 11 transects spaced approximately 330 ft apart. These transects were numbered from 1 at the downstream end of the reach to 11 at the upstream end (fig. 2).

Physical Characteristics

The Talkeetna River site was visited on June 15-16, 1998. Physical characteristics were measured on June 16, 1998 at the time of chemical and biological sampling. Discharge during this visit was less than the June monthly average of 10,960 ft^3/s (Bertrand and others, 1999). The physical characteristics are shown below. The mean width, depth, and velocity were calculated from the discharge measurement.

Reach length (feet)	Stream gradient (foot per foot)	Stream discharge (cubic feet per second)	Width (feet)	Mean depth (feet)	Mean velocity (feet per second)	Dominant substrate (mm)
3,300	0.0040	9,960	355	4.5	6.23	128-256 (Large cobble)

Flow aspect ranged from 195 degrees at the downstream end of the reach to 160 degrees at the upstream end. Open canopy angles ranged from a minimum of 106 degrees at transect 6 to a maximum of 155 degrees at transect 1. The average for the reach was about 132 degrees or about 73 percent open, based on measurements made facing each bank from the mid-channel of each of the transects. Canopy closure averaged about 88 percent as measured with a densiometer near the shoreline at each transect. This high percentage of closure indicates that the shorelines were well vegetated (fig. 3). The dominant riparian land use along the study reach on the Talkeetna River was undeveloped shrub woodland. Because the Talkeetna River is about 355 ft wide, densely vegetated banks provide little shading of the channel; this is documented by the open canopy angles.

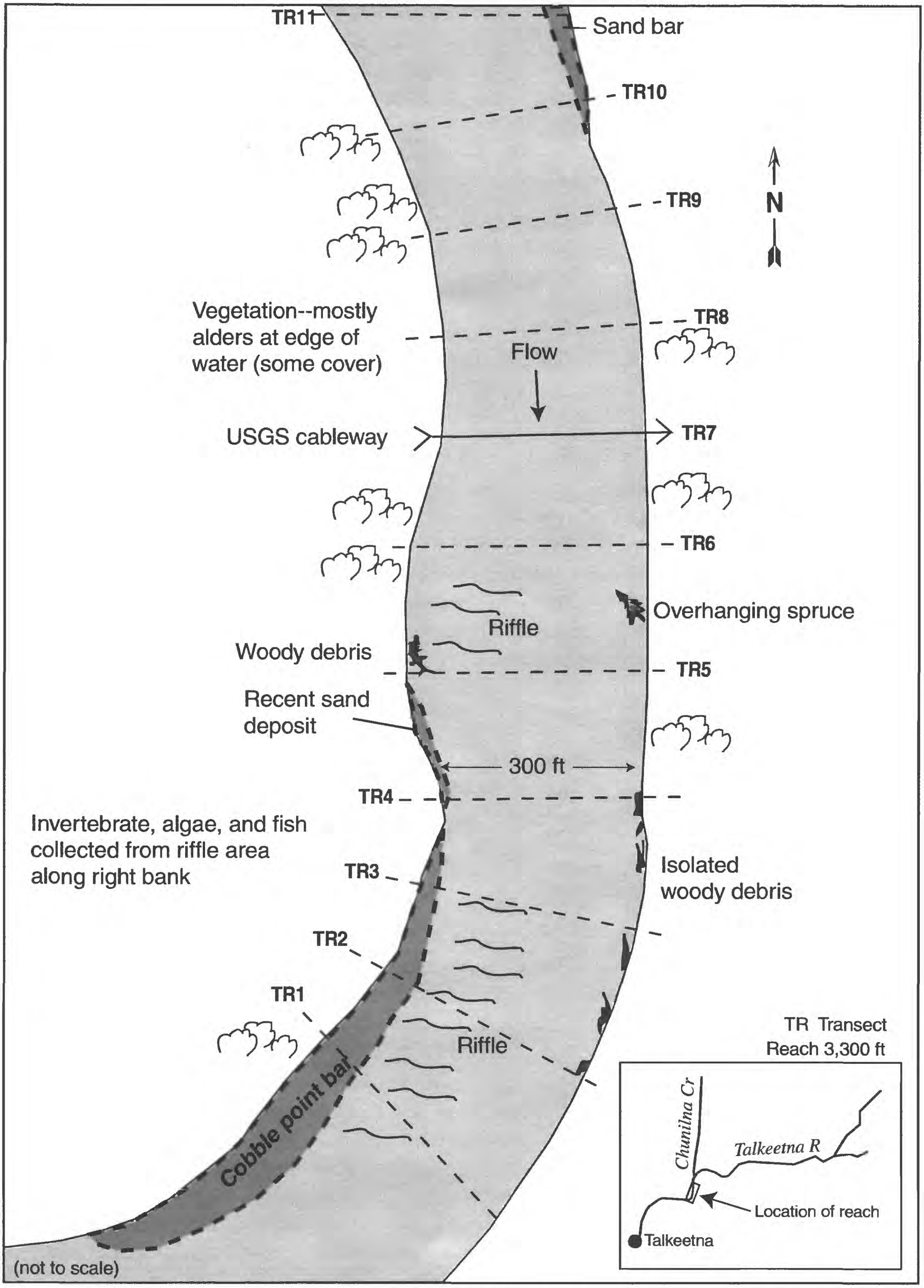

Figure 2. Major geomorphic features of the Talkeetna River study reach.

Figure 3. Banks along the Talkeetna River covered with dense vegetation.

Bank angles averaged about 31 degrees above horizontal. Bank material was predominantly sand, and the combination of dense vegetation and shallow bank angles provided fairly stable banks. Bank erosion was predominant along both banks of downstream transects 1 through 5, evident only along the left bank of transects 6 and 7, and not clearly evident along either bank upstream from the cableway at transect 7. Habitat cover, where available, was provided primarily by undercut banks and overhanging vegetation, although some large boulders were present near transects 9, 10, and 11 at the upper end of the reach.

Detailed channel-geometry data were collected only where the channel was wadeable except at transect 7, where soundings were taken from a boat during a discharge measurement (fig. 4). Time constraints precluded establishing additional instrument locations needed to survey transects 1 to 4 or obtaining depth soundings at any transect other than transect 7. Water-surface elevations were surveyed along both banks at transects 5 to 11. The stream gradient and the following transect widths were determined from those surveyed points:

Transect number ...	5	6	7	8	9	10	11
Width (feet) ...	383	373	355	333	297	293	275

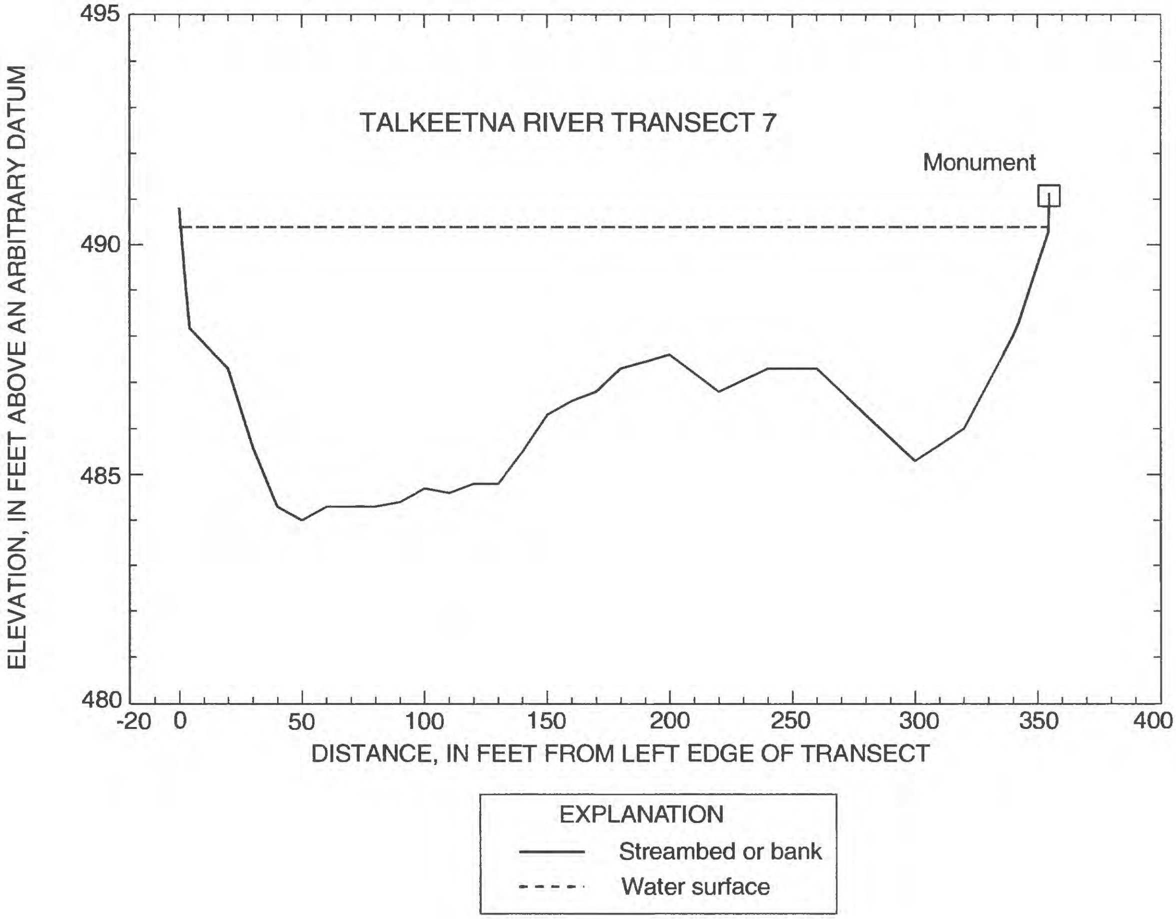

Figure 4. Transect 7 of the study reach on the Talkeetna River.

Chemical Characteristics

Field water-quality properties collected on June 16, 1998 were:

Water temperature (°C)	Specific conductance (μS/cm)	Dissolved oxygen concentration (mg/L)	pH
10.2	86	10.5	7.5

Nutrient concentrations were analyzed from a width- and depth-integrated sample. About 40 nutrient samples had been collected in previous years at the Talkeetna River site (Glass, 1999). Samples collected for the current study showed dissolved phosphorus concentration equal to the 90th percentile value from the previous data. Ammonia concentration was greater than the 90th percentile value. Nitrite-plus-nitrate concentration fell between the 25th and 50th percentile values. Nutrient concentrations on June 16, 1998 were (values in milligrams per liter):

Phosphorus (P) total as P	Orthophosphate (PO_4) dissolved as P	Phosphorus (P) dissolved as P	Nitrite + nitrate (NO_2+NO_3) dissolved as N	Ammonia (NH_3) dissolved as N	Ammonia + organic nitrogen (NH_3+OrgN) total as N	Ammonia + organic nitrogen (NH_3+OrgN) dissolved as N
0.104	0.015	0.030	0.258	0.060	<0.10	<0.10

Streambed sediments and the tissue of slimy sculpin were collected for analysis of various contaminant concentrations. Slimy sculpin collected at the Talkeetna River were small relative to those collected at 13 other sites sampled in the Cook Inlet Basin in 1998. The mean weight for individual slimy sculpin used in tissue samples was less than 3 g at the Talkeetna River, whereas the mean weight was nearly 4.5 g for the 13 other sites. On the basis of length/age relation from a previous study in Alaska (McPhail and Lindsey, 1970), slimy sculpin in the size range sampled at the Talkeetna River were likely 2-year-olds. In the Talkeetna River samples, no trace-element concentration in streambed sediments or whole fish tissues were at levels exceeding suggested guidelines from the Canadian Council of Ministers of the Environment (1999) or from the U.S. Environmental Protection Agency (1996) (table 2).

Table 2. Trace element concentrations in streambed sediments finer than 0.063 mm and slimy sculpin, and scores relative to national median values for streambed sediments

[Values in micrograms per gram; --, not applicable.
Streambed score is each element divided by the appropriate national median value and the summed value divided by 9;
Ranks are by quartiles, with 1 as the best 25 percent of sites and 4 as the worst 25 percent of sites nationally;
scores ≤0.85 are rank 1, scores >0.85-1.07 are rank 2, scores >1.07-1.57 are rank 3, scores >1.57 are rank 4]

Site name	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Zinc	Score	Rank
Streambed sediments											
Talkeetna River	5.2	<0.1	38	27	7	0.04	18	0.1	53	0.46	1
Costello Creek	23	0.27	174	64	16	0.23	98	0.72	144	2.22	4
Colorado Creek	44	0.47	215	59	15	0.18	131	0.73	154	2.78	4
Johnson River	16	0.24	66	75	3.9	0.13	17	0.27	127	1.3	3
Kamishak River	8.9	0.1	78	38	7	0.04	29	0.4	93	0.87	2
National median value[a]	*6.35*	*0.4*	*62*	*26*	*24*	*0.06*	*25*	*0.7*	*110*	--	--
Probable effect level[b]	*17*	*3.5*	*90*	*197*	*91.3*	*0.486*	--	--	*315*	--	--
Slimy sculpin											
Talkeetna River	0.5	<0.2	1.7	2.1	<0.2	0.08	0.3	4.4	92.9	--	--
Costello Creek	1.2	0.4	2.8	4.6	<0.3	0.08	1.5	8.5	123.0	--	--
Kamishak River	0.4	<0.2	1.7	2.6	<0.2	0.09	0.5	5.2	74.4	--	--

[a]Gilliom and others (1998)
[b]Concentration in bulk sediment samples at which adverse effects would be expected to occur frequently (guidelines for trace-element concentrations in streambed sediments established by the Canadian Council of Ministers of the Environment, 1999)

Organochlorines were analyzed in both fish tissues and in streambed sediment at the Talkeetna River. In the composite sample of whole slimy sculpin, one organochlorine compound, hexachlorobenzene (a fungicide), was detected at a concentration of 5.70 μg/kg. In streambed sediments, hexachlorobenzene was measured at 13 μg/kg, whereas dieldrin and *p,p'*-DDE (a degradation product of the pesticide DDT) were detected at levels below the 1 μg/kg minimum reporting level. No SVOCs were detected in streambed sediments from the Talkeetna River.

Biological Characteristics

Benthic macroinvertebrates were collected along the right bank near the downstream end of the Talkeetna River study reach (appendix 2). Twenty-three taxa of invertebrates were identified in the RTH sample. Diptera accounted for 78 percent of the individuals in the RTH sample, and one genus (Orthocladius) in that order was 32 percent of the sample. The QMH sample identified an additional 15 taxa at the Talkeetna River. A variety of taxa in the orders Ephemeroptera, Plecoptera, and Trichoptera were present, although the community was numerically dominated by Diptera.

Fish were collected from wadeable areas along the stream margins on June 15, 1998 (table 3). Because adult fish of many species prefer deeper habitats, few adults were collected. The Talkeetna River fish community was dominated by slimy sculpin and juvenile chinook salmon, which together accounted for 96 percent of the fish collected.

Table 3. Summary of fish collected at Talkeetna River, June 15, 1998

Species	Abundance	Mean length (millimeters)	Mean weight (grams)
Slimy sculpin (*Cottus cognatus*)	137	53	2.2
Chinook salmon (*Oncorhynchus tshawytscha*)	206	47	0.8
Sockeye salmon (*Oncorhynchus nerka*)	2	44	0.6
Coho salmon (*Oncorhynchus kisutch*)	2	60	2.2
Chum salmon (*Oncorhynchus keta*)	1	42	0.8
Rainbow trout (*Oncorhynchus mykiss*)	1	50	1.3
Dolly Varden (*Salvelinus malma*)	5	157	55
Arctic grayling (*Thymallus arcticus*)	2	166	40
Round whitefish (*Prosopium cylindraceum*)	1	179	37

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Costello Creek Study Reach

The study reach at Costello Creek is about 1 mi upstream from the confluence with the West Fork of the Chulitna River (fig. 5). The reach is about 0.5 mi upstream from Camp Creek and the Dunkle Mine. Access to the site was provided by an NPS helicopter. NPS personnel assisting with sampling noted that the stage of Costello Creek had been about 1 ft higher 2 days prior to sampling.

Physical Characteristics

Physical characteristics of the Costello Creek reach were measured on August 12, 1998, at the time of chemical and biological sampling. Mean depth, velocity, and dominant substrate were measured from three points at each of 11 transects. Physical characteristics were:

Reach length (feet)	Stream gradient (foot per foot)	Stream discharge (cubic feet per second)	Mean width (feet)	Mean depth (feet)	Mean velocity (feet per second)	Dominant substrate (mm)
600	0.0044	118	49.4	1.2	3.33	128-256 (Large cobble)

Costello Creek flows through the sampling reach in a south-southeastward direction. Flow aspect ranged from 128 to 184 degrees. The open canopy angle averaged 143 degrees and the shrubby riparian vegetation provided only about 13 percent canopy closure along the banks. Bank material generally was sand, and little erosion was evident. Bank angles averaged about 49 degrees at each of the 11 transects. Streambed substrate generally was large gravel to small cobble. The dominant riparian land use on Costello Creek was undeveloped shrub woodland. Fish habitat consisted of an occasional boulder or sparse overhanging vegetation. A detailed survey provided measurements of channel geometry at each transect (fig. 6).

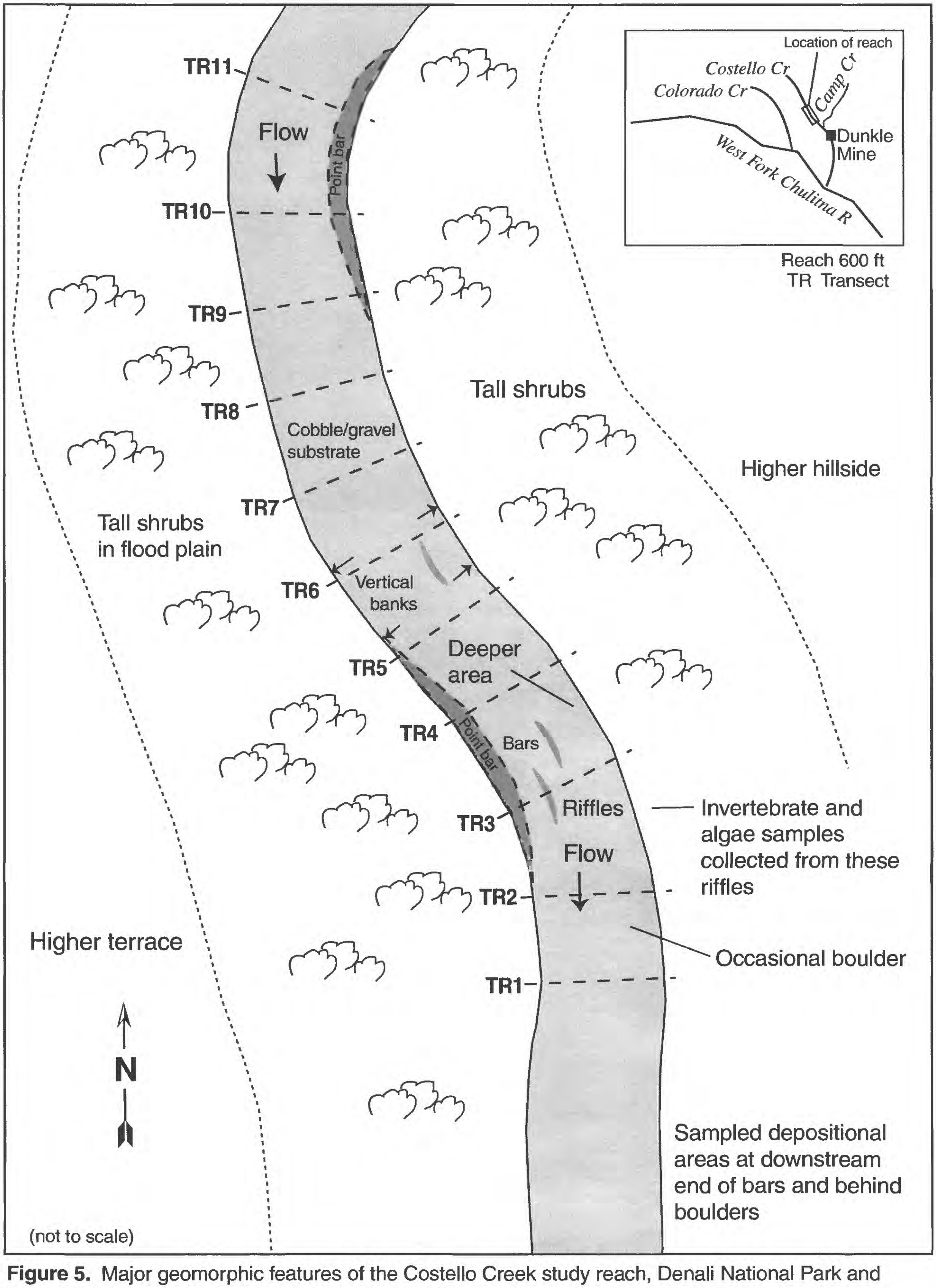


Figure 5. Major geomorphic features of the Costello Creek study reach, Denali National Park and Preserve.

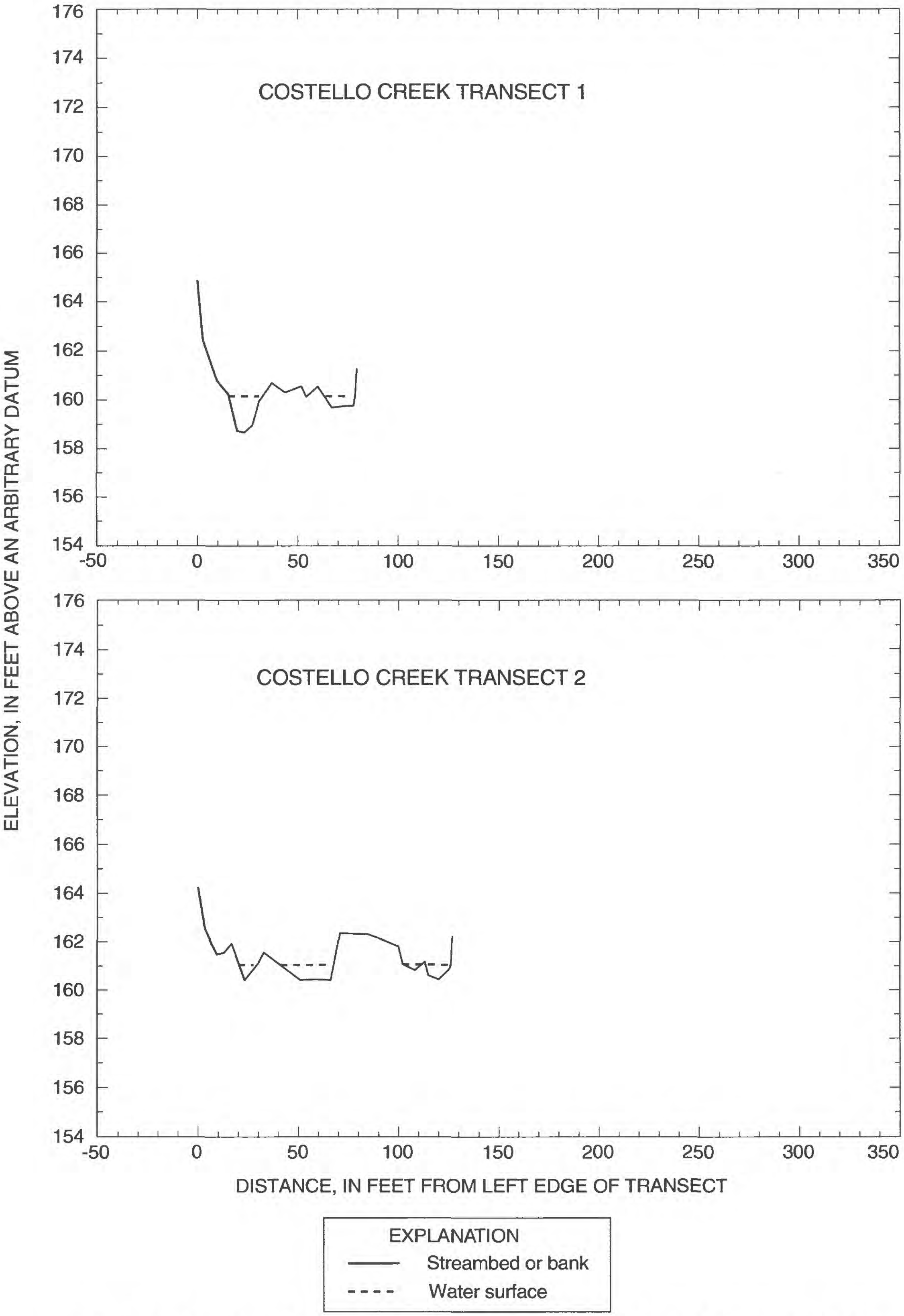
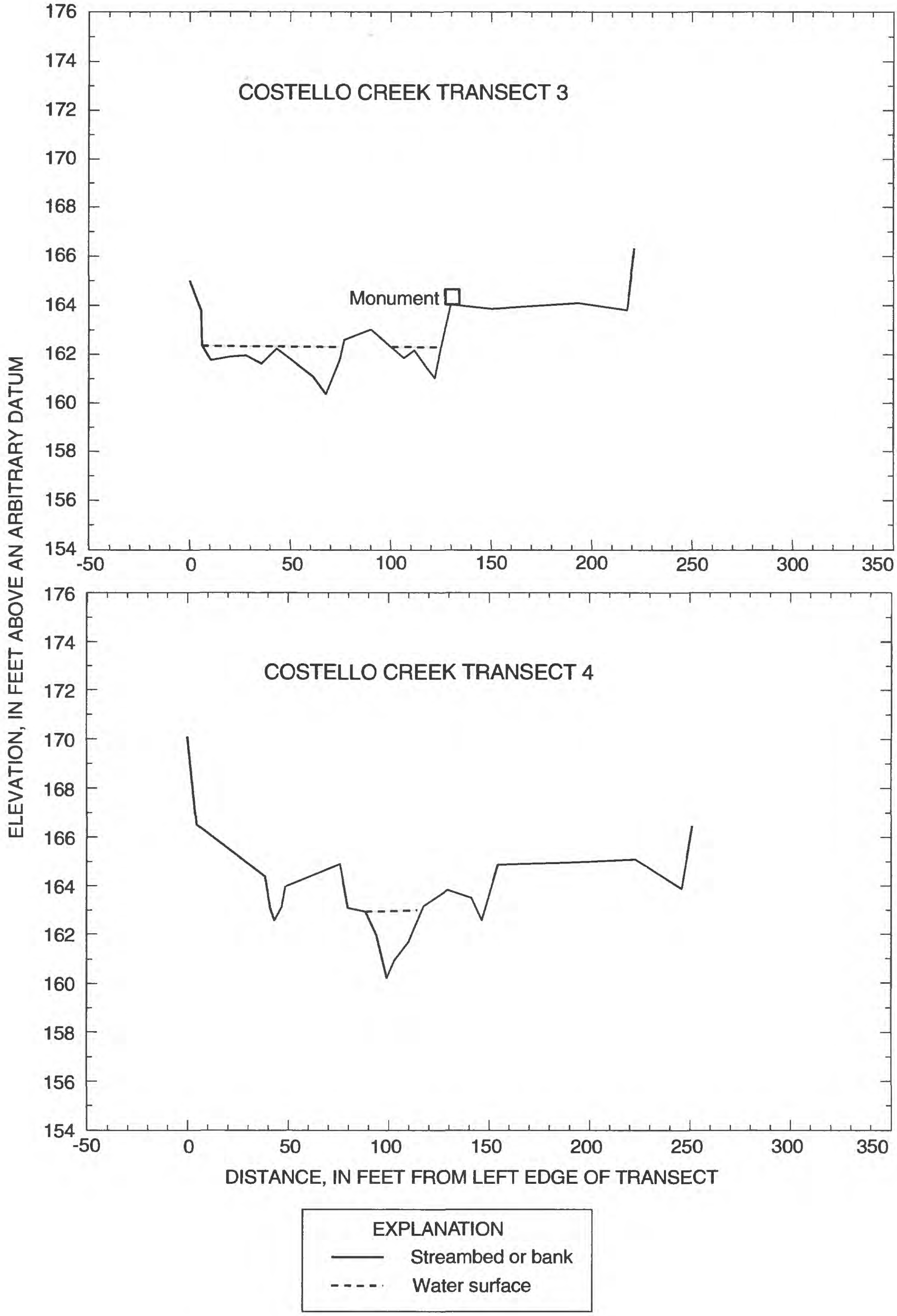


Figure 6. Transects of the study reach on Costello Creek, Denali National Park and Preserve.



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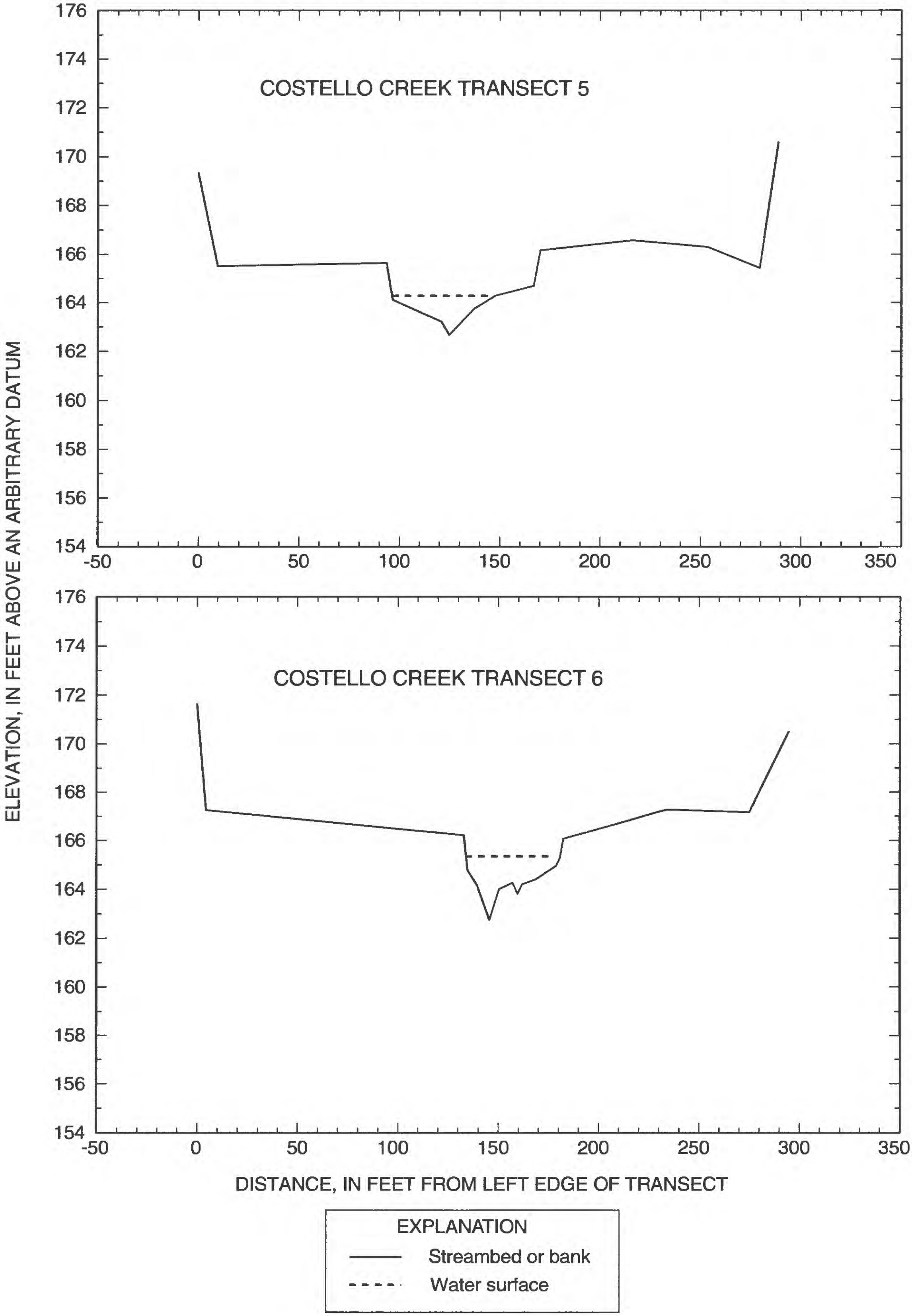

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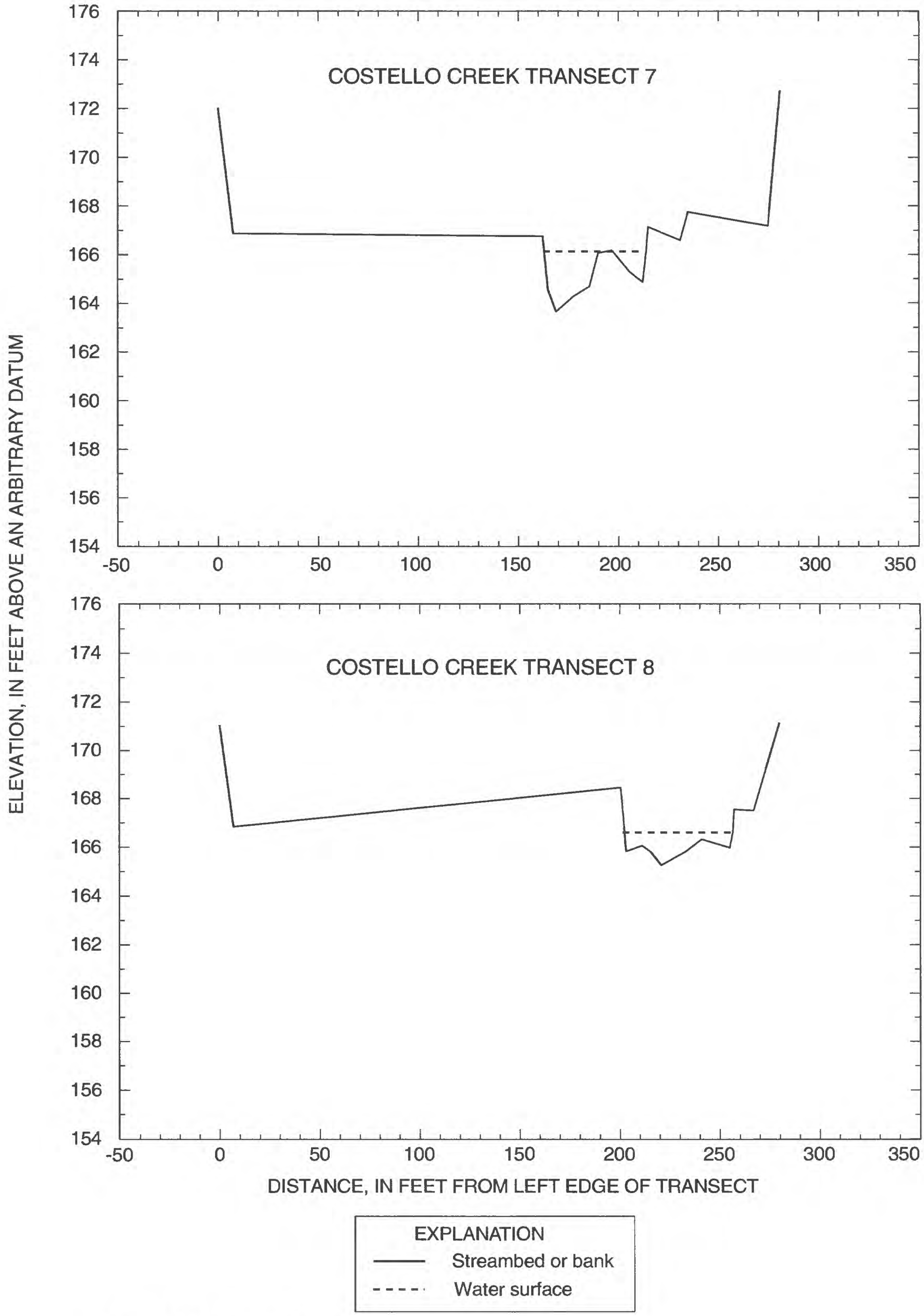

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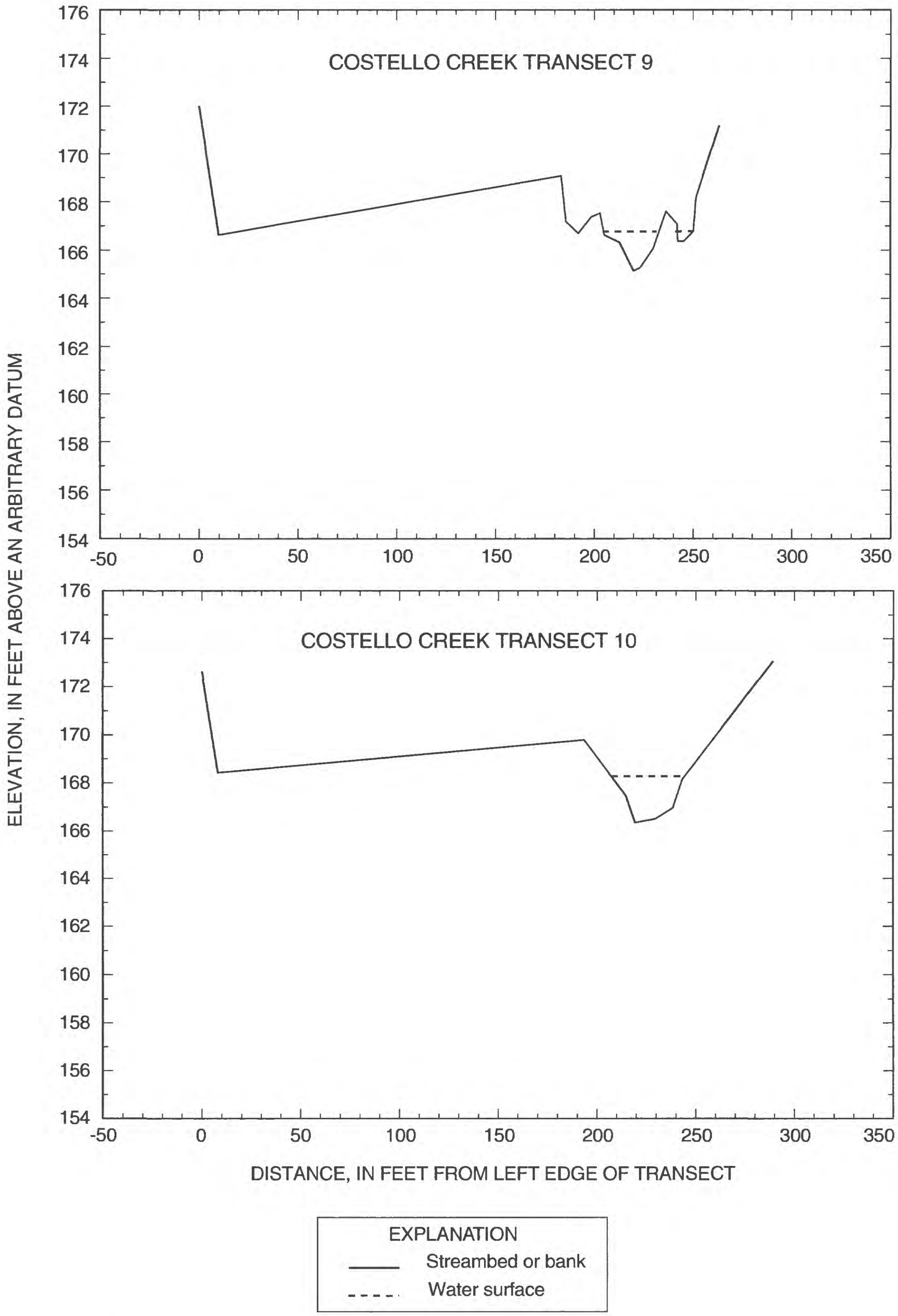

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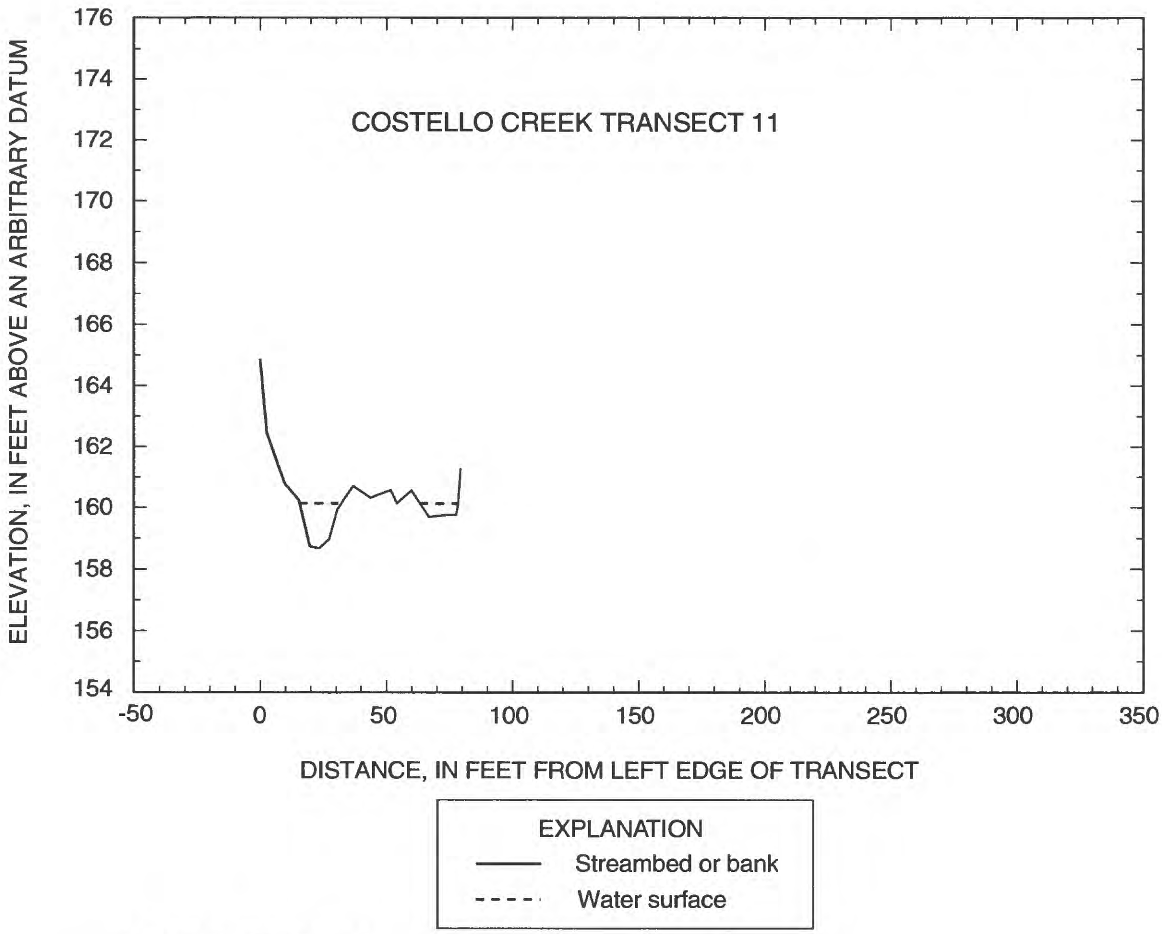


Figure 6. Continued.

Chemical Characteristics

Field water-quality properties collected on August 12, 1998 at Costello Creek were:

Water temperature (°C)	Specific conductance (µS/cm)	Dissolved oxygen concentration (mg/L)	pH
4.5	208	14.2	8.1

Field-measured pH was slightly alkaline at 8.1, which was similar to values measured in 1995 to 1996 during a study by the NPS (Edwards and Tranel, 1997).

Nutrient concentrations were determined from a width- and depth-integrated sample of Costello Creek. Phosphorus concentrations were less than detection levels. Ammonia concentration was comparable to median and mean values from a site on the upper reaches of the Susitna River (Glass, 1999). Previous information on nutrient concentrations in Costello Creek showed that ammonia and nitrate were less than detection level (Edwards and Tranel, 1997). Nutrient concentrations on August 13, 1998 were (values in milligrams per liter):

Phosphorus (P) total as P	Orthophos-phate (PO_4) dissolved as P	Phosphorus (P) dissolved as P	Nitrite + nitrate (NO_2+NO_3) dissolved as N	Ammonia (NH_3) dissolved as N	Ammonia + organic nitrogen (NH_3+OrgN) total as N	Ammonia + organic nitrogen (NH_3+OrgN) dissolved as N
<0.01	<0.01	<0.01	0.062	0.047	<0.10	<0.10

Trace-element concentrations were determined from samples of slimy sculpin and streambed sediments (table 2). Arsenic, chromium, and nickel concentrations of 23, 174, and 98 µg/g respectively, were at least two and one-half times larger than the median values from 198 samples analyzed from previous NAWQA studies across the country (Gilliom and others, 1998). If trace elements were cumulatively compared with those 198 streambed samples, Costello Creek would rank within the 25 percent of sites having the largest trace-element concentrations. Guidelines for trace-element concentrations in streambed sediments established by the Canadian Council of Ministers of the Environment (1999) are for bulk sediments. Concentrations in bulk sediment tend to be smaller than the less than 0.063 mm size fraction analyzed for this study. If those guidelines were used with these samples, arsenic and chromium would be at levels where adverse effects would be expected to occur frequently (table 2). Selenium concentrations in slimy sculpin were 8.5µµg/g, and concentrations greater than 4.0 µg/g may have adverse effects (U.S. Department of the Interior, 1998).

Only one SVOC, dibenzothiophene, was detected in streambed sediments samples at a concentration (85 µg/kg) greater than the minimum reporting limit of 50 µg/kg. Seven other SVOCs (1-methylphenanthrene; 2,6-dimethylnaphthalene; chrysene; fluoranthene; naphthalene; phenanthrene; and pyrene) were detected at concentrations below the minimum reporting level. These compounds typically are associated with coal tar or coal gas (Budavari and others, 1996) and incomplete combustion of fossil fuels. Organochlorine compounds were not detected in a composite sample of four slimy sculpin. Slimy sculpin were not abundant at Costello Creek, but were relatively large, averaging 8.9 g. These fish are likely 4- to 5-year-olds. More detailed results of the streambed sediment and tissue sampling are available at the Alaska District Office of the USGS.

Biological Characteristics

Benthic macroinvertebrates were collected from riffles along both banks and in the center of the channel at Costello Creek (appendix 2). Eighteen invertebrate taxa were identified in the RTH sample. Diptera accounted for 58 percent of the individuals in the RTH sample, and one genus (Diamesa) in that order was 32 percent of the sample. The QMH sample identified an additional nine taxa at Costello Creek. A variety of taxa in the orders Ephemeroptera and Plecoptera were present. Only one Trichoptera taxon was identified. Although the community was numerically dominated by Diptera, one Ephemeroptera taxon, *Baetis bicaudatus,* also was abundant.

Electrofishing at Costello Creek produced only two species of fish—slimy sculpin and Dolly Varden (*Salvelinus malma*). A total of nine slimy sculpin were captured ranging from 66 mm long and 2.3 g to 110 mm long and 12.5 g. Eight of these fish were used for tissue samples. Dolly Varden were slightly more abundant (total of 13) and larger than slimy sculpin. None of the Dolly Varden were adults. Sizes ranged from 90 mm long and 4.7 g to 162 mm long and 35.6 g. The largest Dolly Varden displayed an external anomaly; a large piece of the gill covering was missing, which appeared to be the result of an injury.

Colorado Creek Study Reach

Colorado Creek (fig. 7), about 1 mi west of Costello Creek, is similar to Costello Creek in size. Therefore, a 600-foot-long reach was established on Colorado Creek to correspond with the reach on Costello Creek. However, the gradient of Colorado Creek is much steeper and it is in a more canyon-like setting than Costello Creek. This results in a channel characterized by a series of cascades and steep runs (fig. 7). Near the mouth of Colorado Creek, a waterfall appears to be a barrier to migration of fish. Prior to sampling Colorado Creek, it was believed that non-migratory fish species such as slimy sculpin would be present at the sampling study reach; however, no fish were observed during nearly one hour of electrofishing in the reach during the mid-August 1998 sampling.

Physical Characteristics

Physical characteristics of the Colorado Creek reach were measured on August 13, 1998, at the time of chemical and biological sampling. Mean depth, velocity, and dominant substrate were measured from three points at each of 11 transects. Physical characteristics were:

Reach length (feet)	Stream gradient (foot per foot)	Stream discharge (cubic feet per second)	Mean width (feet)	Mean depth (feet)	Mean velocity (feet per second)	Dominant substrate (mm)
600	0.0087	34	28.3	1.1	2.41	256-512 (Small boulder)

Colorado Creek flows through the sampling reach in a generally eastward direction. Flow aspect ranged from 45 to 150 degrees indicating a high degree of meandering. The open canopy angle averaged 145 degrees and tall shrubs provided an average 70 percent closure of the riparian canopy. These tall shrubs, along with the bouldery substrate, provide potential fish habitat throughout the reach. The sand and cobble banks had an average angle of about 41 degrees, and little evidence of bank erosion was observed throughout the reach. A detailed survey provided measurements of channel geometry at each transect (fig. 8).

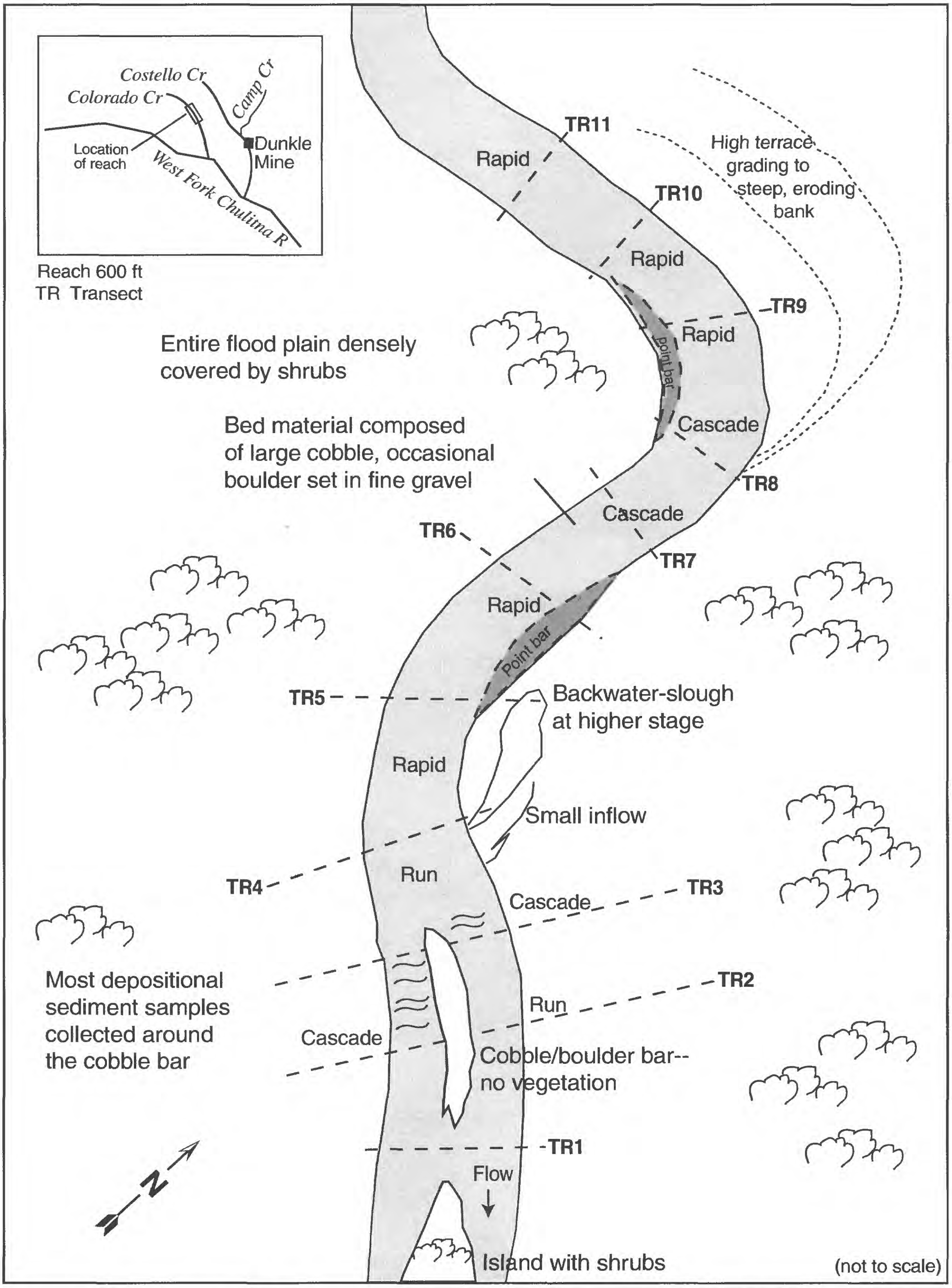


Figure 7. Major geomorphic features of the Colorado Creek study reach, Denali National Park and Preserve.

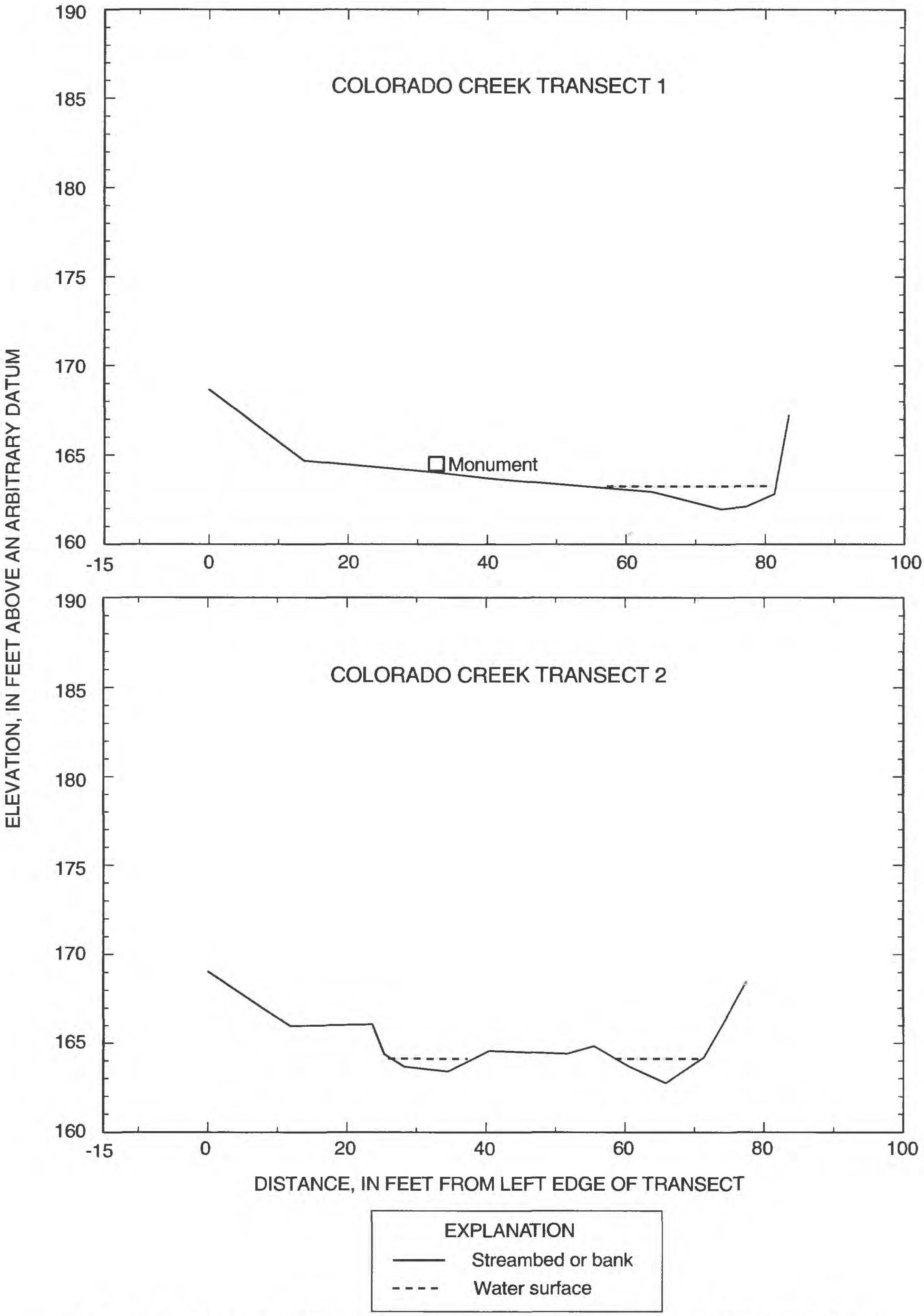
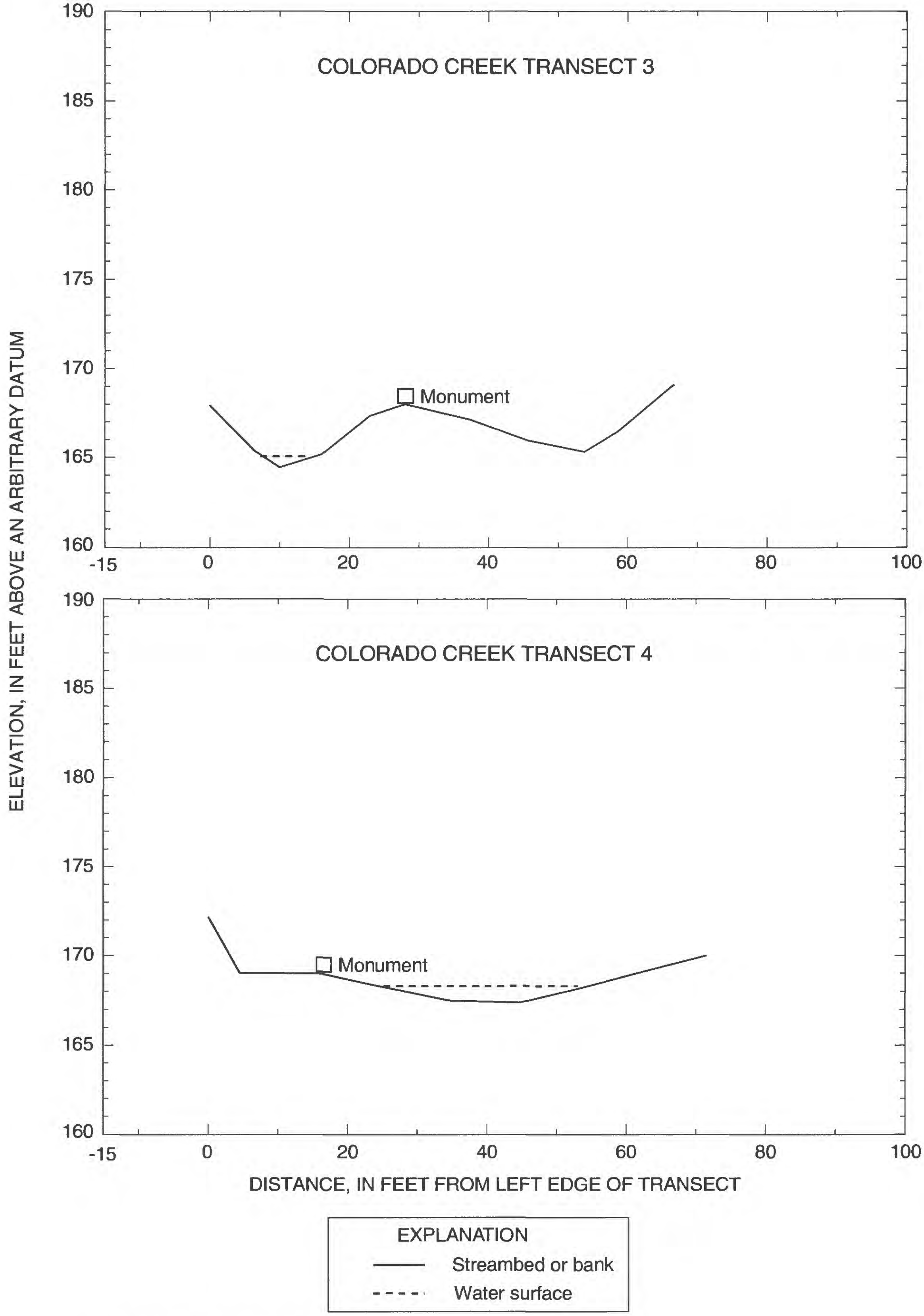


Figure 8. Transects of the study reach on Colorado Creek, Denali National Park and Preserve.



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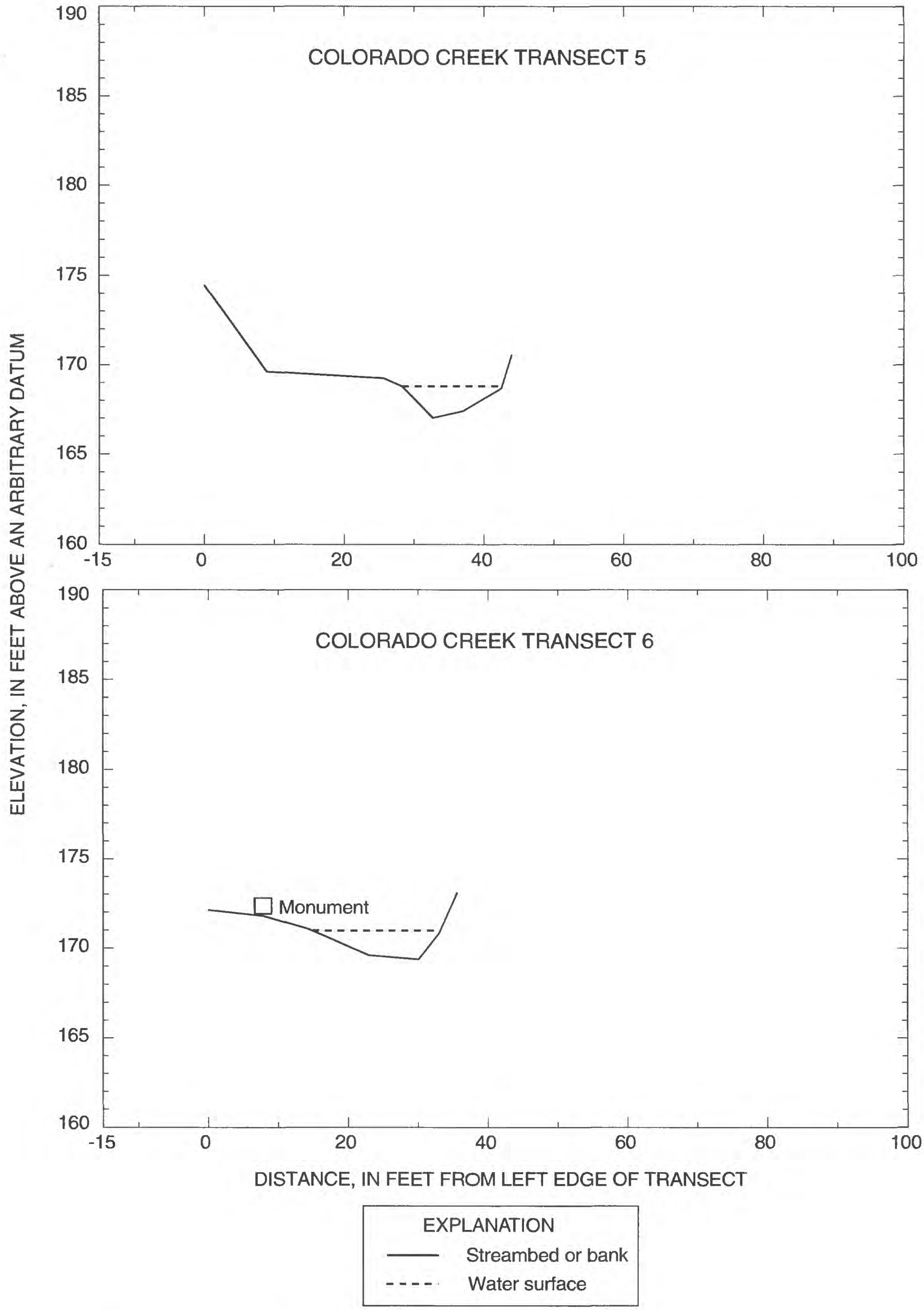

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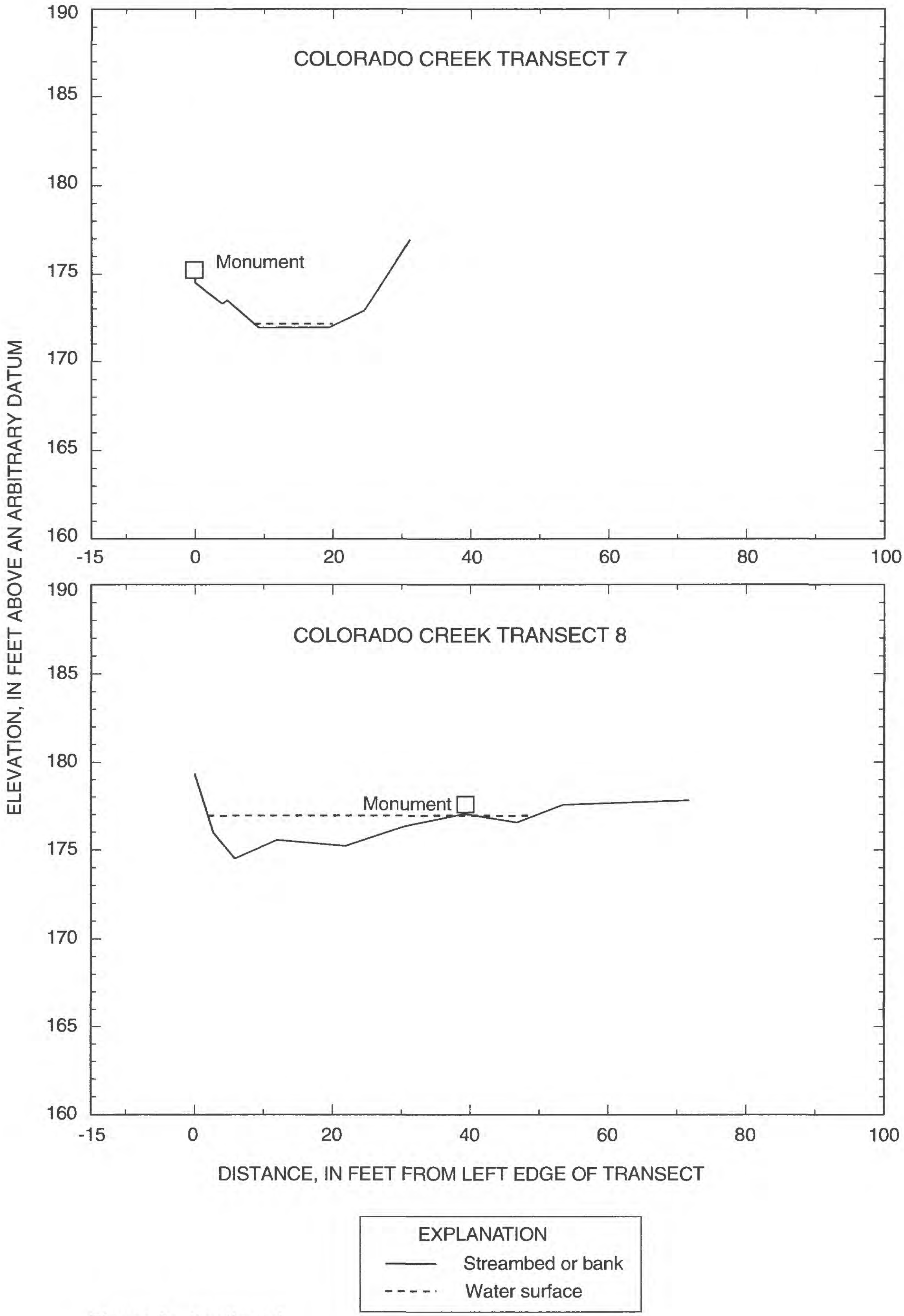

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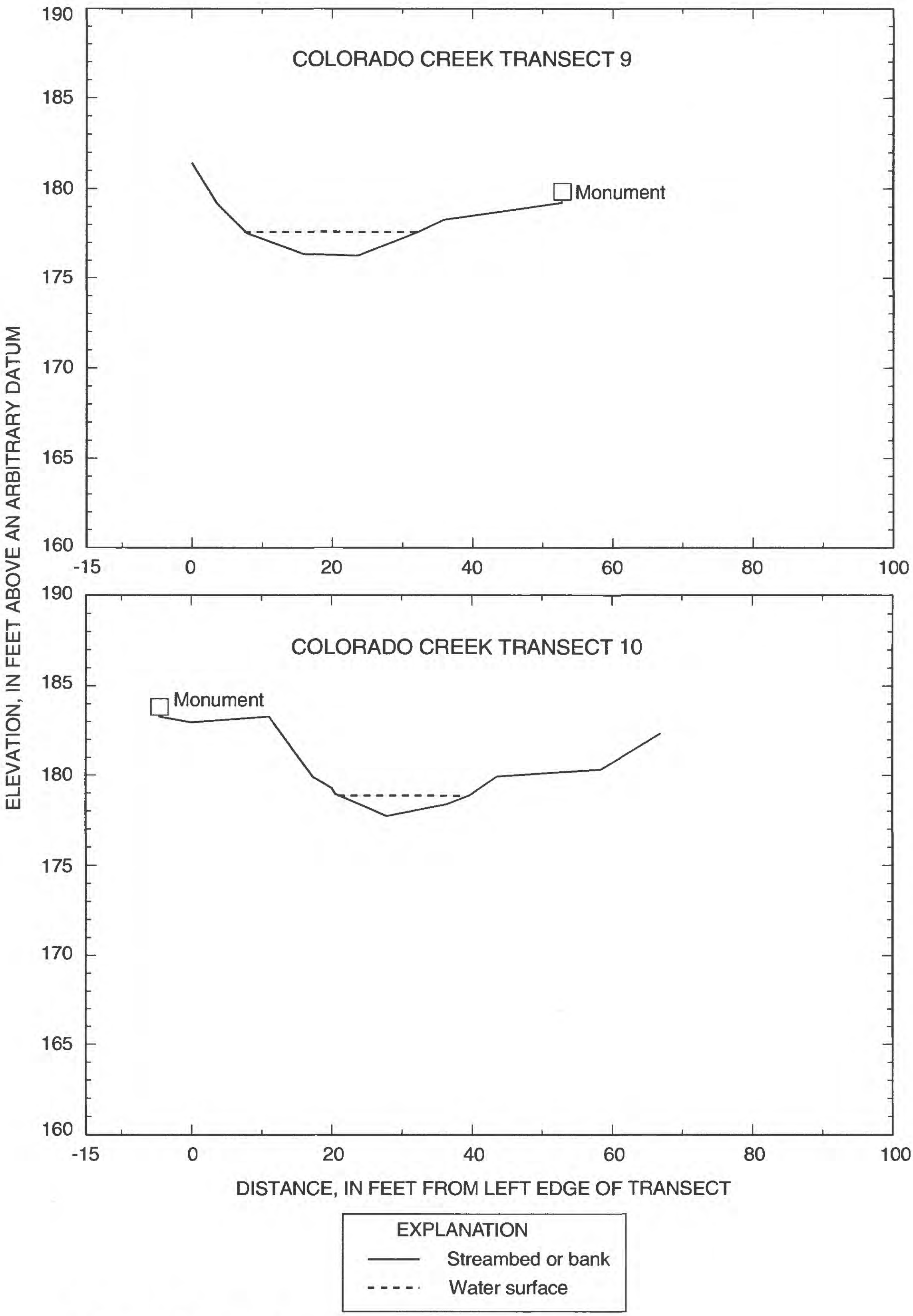

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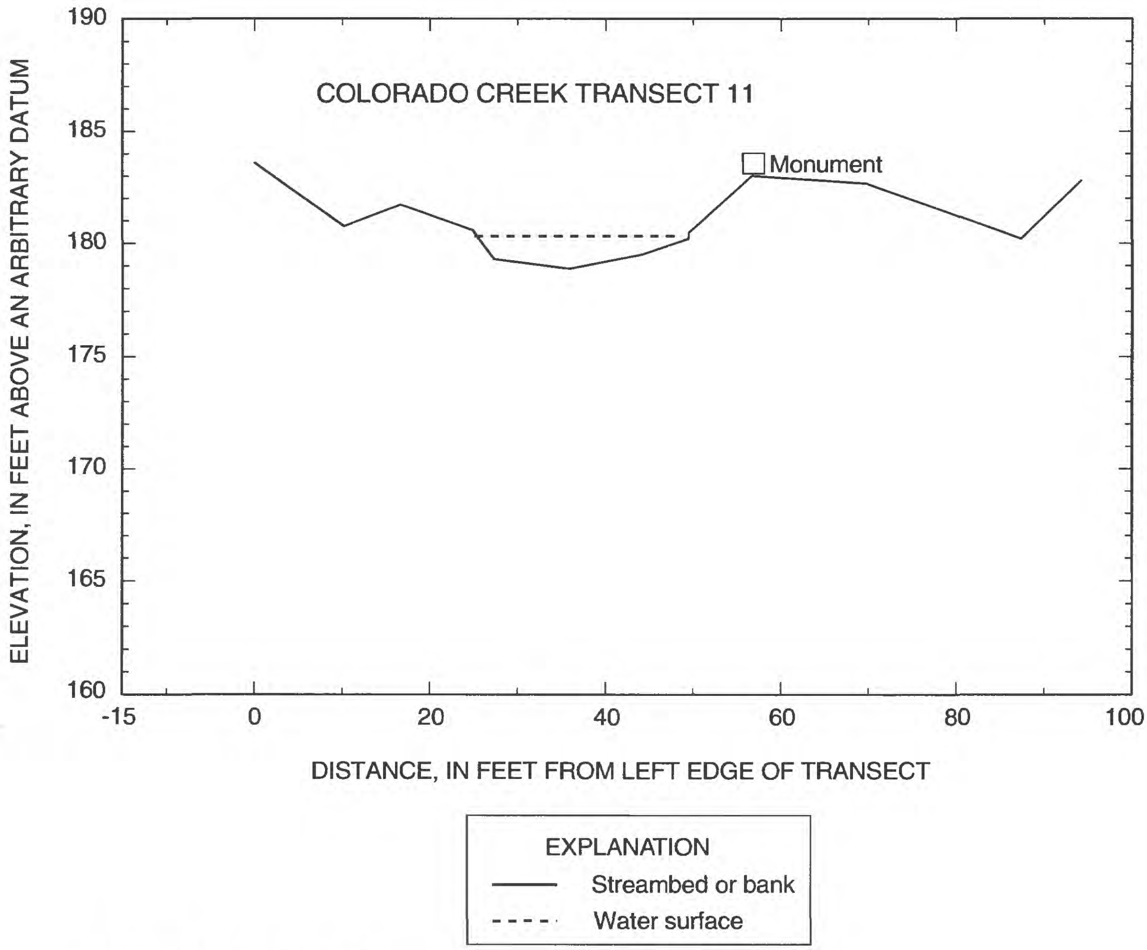


Figure 8. Continued.

Chemical Characteristics

Field water-quality properties collected at Colorado Creek on August 13, 1998 were:

Water temperature (°C)	Specific conductance (μS/cm)	Dissolved oxygen concentration (mg/L)	pH
4.0	390	13.9	7.8

Colorado Creek was cold (4 °C), well oxygenated, and contained moderate amounts of dissolved ions as indicated by the specific conductance of 390 μS/cm. Specific conductance at Colorado Creek was nearly double that of the adjacent Costello Creek (208 μS/cm), suggesting a difference in geologic setting. The difference in specific conductance between these two streams also was noted during a study by the NPS in 1995-96 (Edwards and Tranel, 1997).

Nutrient concentrations were determined from a width- and depth-integrated sample of Colorado Creek. Concentrations generally were similar to those measured in Costello Creek. Previous information showed nitrate concentrations similar to those observed in this study, but as with Costello Creek, ammonia was not detected by Edwards and Tranel (1997). Nutrient concentrations on August 14, 1998 were (values in milligrams per liter):

Phosphorus (P) total as P	Orthophosphate (PO_4) dissolved as P	Phosphorus (P) dissolved as P	Nitrite + nitrate (NO_2+NO_3) dissolved as N	Ammonia (NH_3) dissolved as N	Ammonia + organic nitrogen (NH_3+OrgN) total as N	Ammonia + organic nitrogen (NH_3+OrgN) dissolved as N
<0.01	<0.01	<0.01	<0.05	0.067	<0.10	<0.10

Trace-element concentrations were determined from streambed sediments. Arsenic, chromium, and nickel concentrations of 44, 215, and 131 μg/g respectively (table 2), were the largest of 14 sites sampled in the Cook Inlet Basin during 1998 and at least three times larger than the median values from 198 samples analyzed from previous NAWQA studies across the country (Gilliom and others, 1998). If trace elements were cumulatively compared with those 198 samples, Colorado Creek would rank within the 25 percent of sites having the largest trace-element concentrations. As with Costello Creek, arsenic and chromium concentrations in fine-grained streambed sediments exceeded suggested guidelines from the Canadian Council of Ministers of the Environment (1999).

Seven SVOCs (1-methylpyrene; 2,6-dimethylnaphthalene; benzo[*ghi*]perylene; chrysene; fluoranthene; phenanthrene; and pyrene) were detected in streambed sediment samples. None of the SVOCs detected were as large as the minimum reporting limit of 50 μg/kg. No organochlorines were detected in Colorado Creek streambed sediment samples. No tissue samples were collected because of the apparent absence of fish at the Colorado Creek sampling site. More detailed results of the streambed sediment sampling are available at the Alaska District Office of the USGS.

Biological Characteristics

Benthic macroinvertebrates were collected from riffles near the downstream end of the reach at Colorado Creek (appendix 2). An abundance of benthic macroinvertebrates, particularly mayflies (Ephemeroptera) was noted at this study reach. Twenty-one taxa of invertebrates were identified in the RTH sample. Diptera accounted for 59 percent of the individuals in the RTH sample, and one genus (Diamesa) in that order was 24 percent of the sample. The QMH sample identified an additional five taxa at Colorado Creek. Several taxa in the orders Ephemeroptera and Plecoptera were present. Three taxa of Trichoptera were present. Although the community was numerically dominated by Diptera, the Ephemeroptera taxon, *Baetis bicaudatus*, also was abundant.

LAKE CLARK NATIONAL PARK SITE—JOHNSON RIVER STUDY REACH

The Johnson River study reach (fig. 9) was at the USGS stream-gaging station about 20 mi upstream from the mouth. Water clarity was poor and streambed sediments were tightly embedded due to the glacial and volcanic history of the basin; the river's proximity to existing glaciers creates an abundance of fine-grained sediments. Upstream transects were easily wadeable, but the two most downstream transects could not be waded at their deepest and swiftest parts. The channel narrows and the gradient increases at the lower end of the reach. Two small sandbars were present in mid-channel near the lower end of the reach, and a large point bar was present along much of the left bank (fig. 9).

Physical Characteristics

Physical characteristics of the Johnson River reach were measured on August 18, 1998, at the time of chemical and biological sampling. The measured discharge of 502 ft^3/s was about 6 percent lower than the August monthly average of 536 ft^3/s reported for 1998 (Bertrand and others, 1999). Mean depth, velocity, and dominant substrate were measured from three points at each of 11 transects. Physical characteristics were:

Reach length (feet)	Stream gradient (foot per foot)	Stream discharge (cubic feet per second)	Mean width (feet)	Mean depth (feet)	Mean velocity (feet per second)	Dominant substrate (mm)
1,000	0.0139	502	129	1.7	2.89	32-64 (Very coarse gravel)

The Johnson River flows through the sampling reach in a southeastward direction, with flow aspect ranging from 76 to 157 degrees. Because the channel was relatively wide, the open canopy angle was large, averaging 151 degrees. The spherical densiometer used for measuring canopy closure was lost while attempting to wade across the farthest downstream transect. Only qualitative descriptions of the riparian canopy closure were made. Along most of the left bank, a point bar had formed that had no vegetation. Only at the downstream end of the reach did vegetation overhang the channel. Shrubby vegetation was present all along the right bank flood plain. The nearly vertical upper parts of the right bank were bare and eroding. Bank angles averaged about 39 degrees; however, the right bank was generally much steeper than the left bank. Bank substrate was generally a very coarse gravel, tightly embedded with sand. The left-bank point bar was a sand substrate. Fish habitat was sparse and consisted of an occasional fallen willow or boulder in the channel.

Detailed channel-geometry data were collected (fig. 10) where the channel was wadeable. The channel-geometry measurements provide the baseline from which to evaluate potential future channel-geometry changes for this study reach.

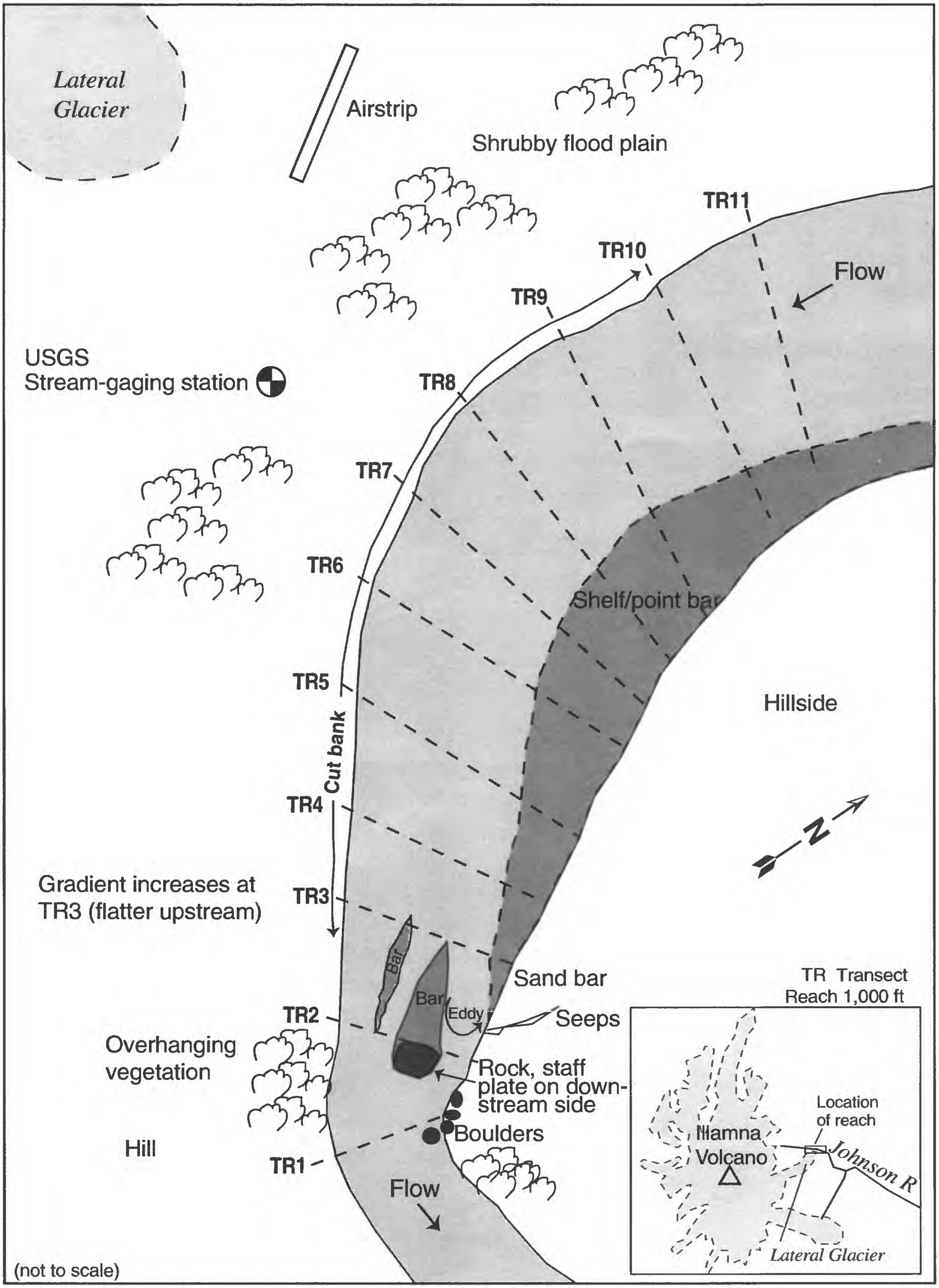


Figure 9. Major geomorphic features of the Johnson River study reach, Lake Clark National Park and Preserve.

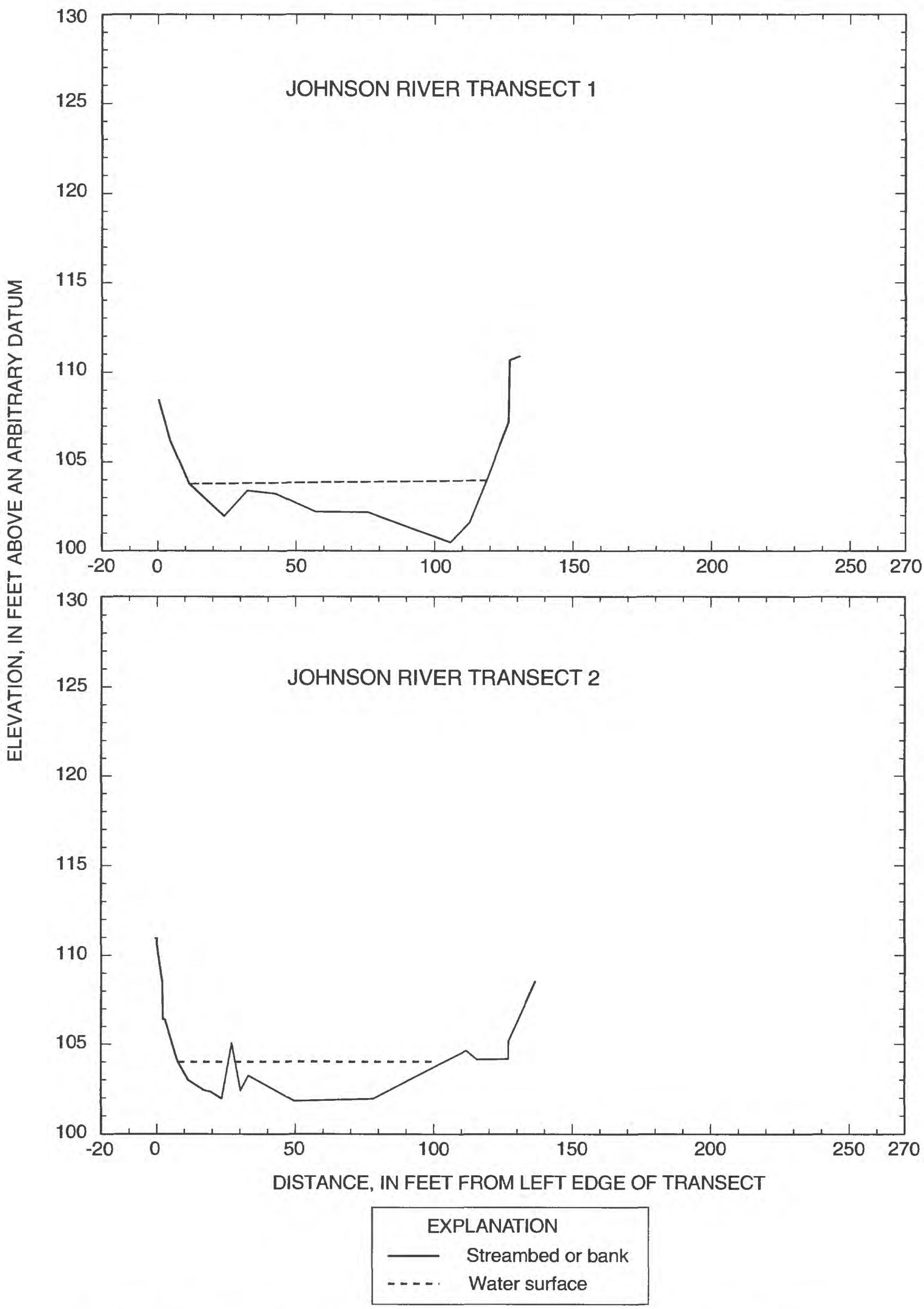
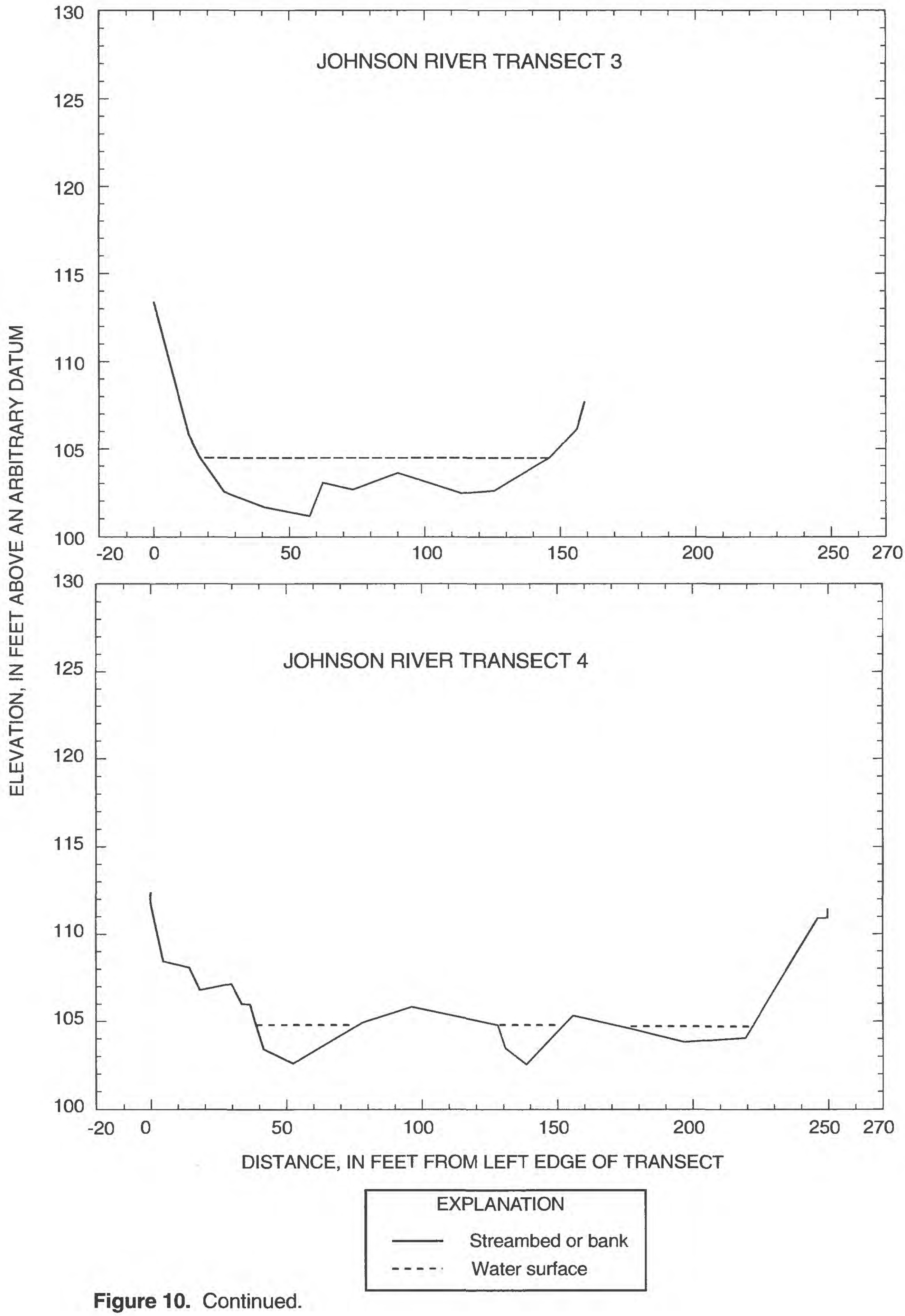


Figure 10. Transects of the study reach on the Johnson River, Lake Clark National Park and Preserve.



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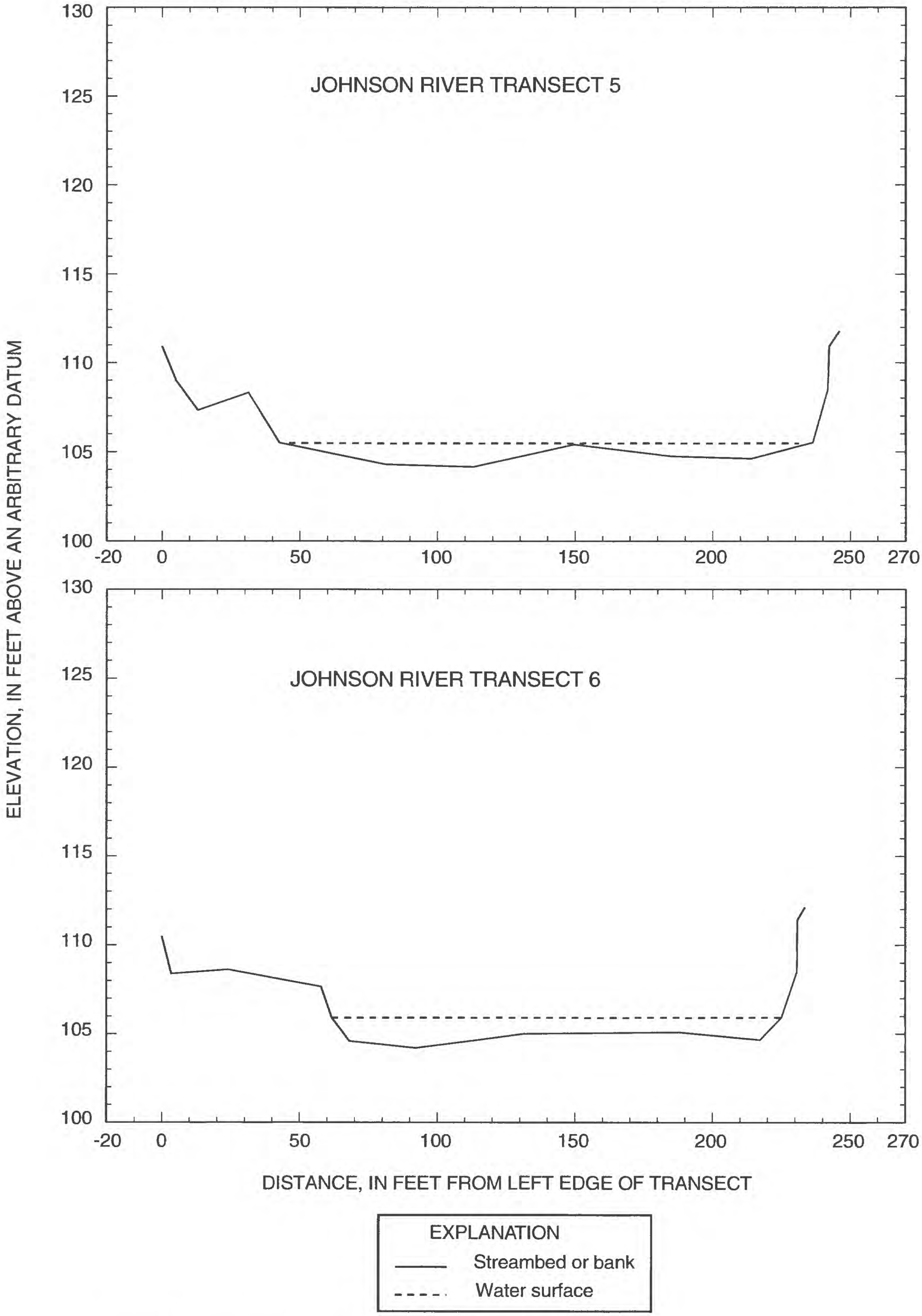

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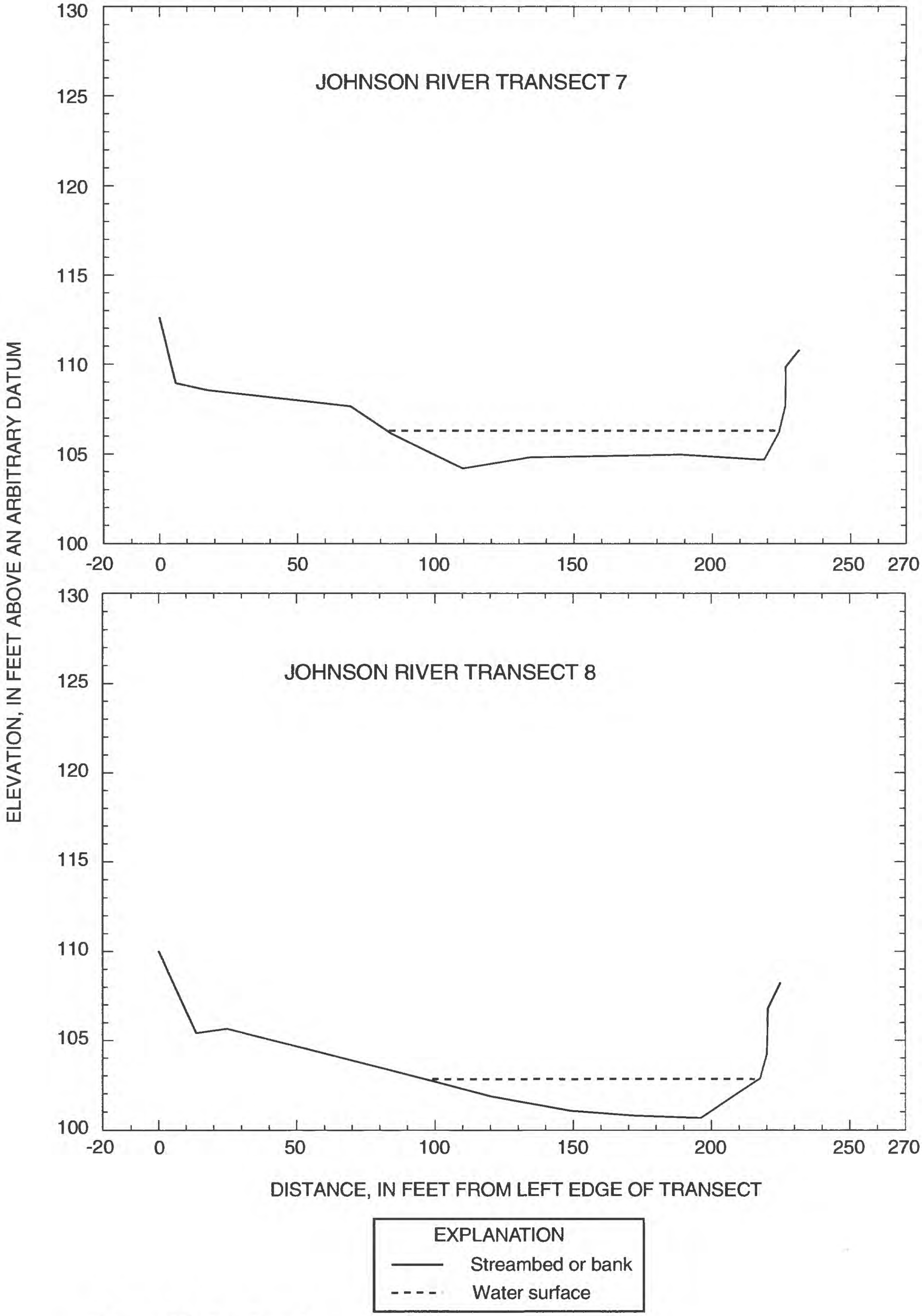

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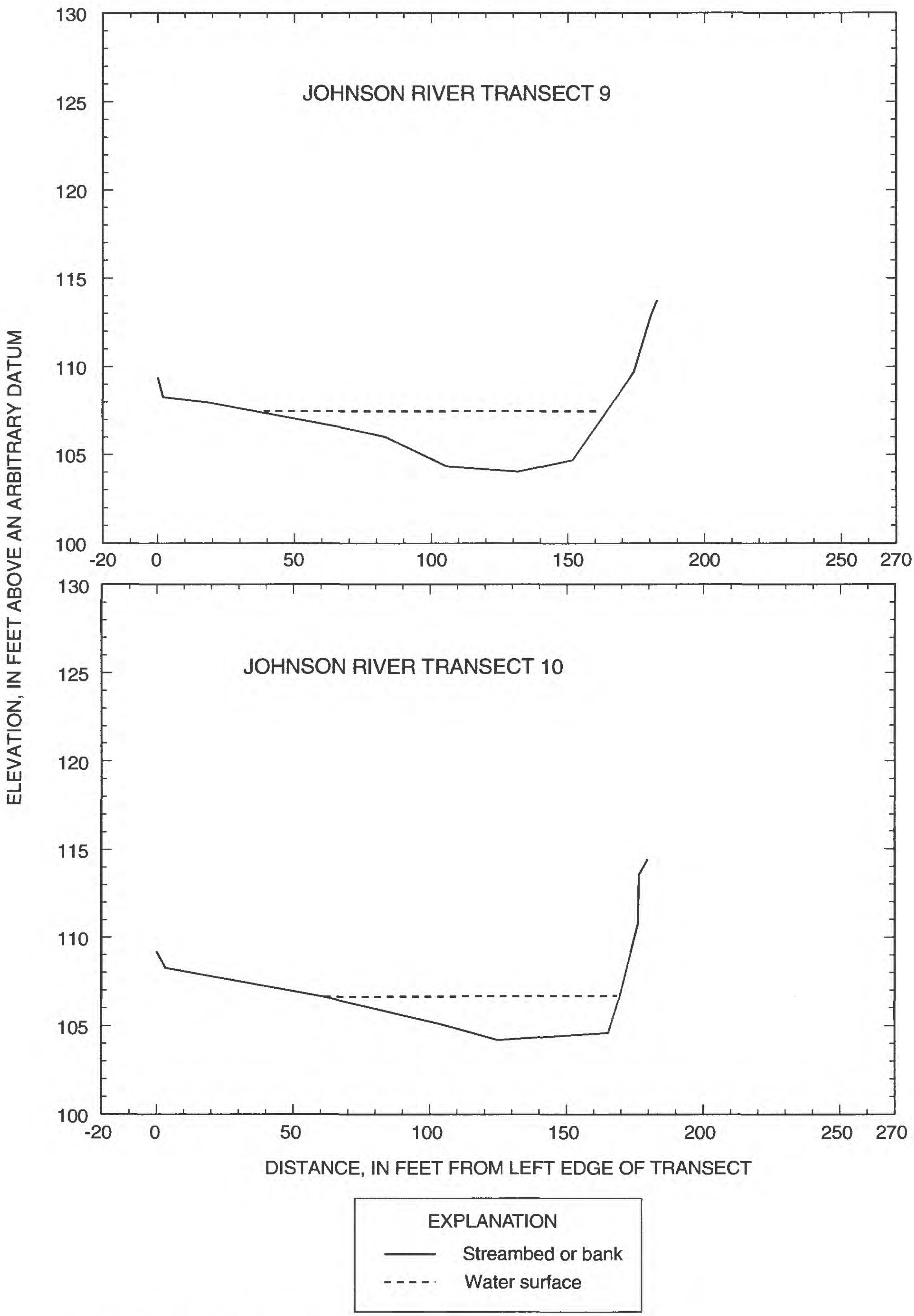

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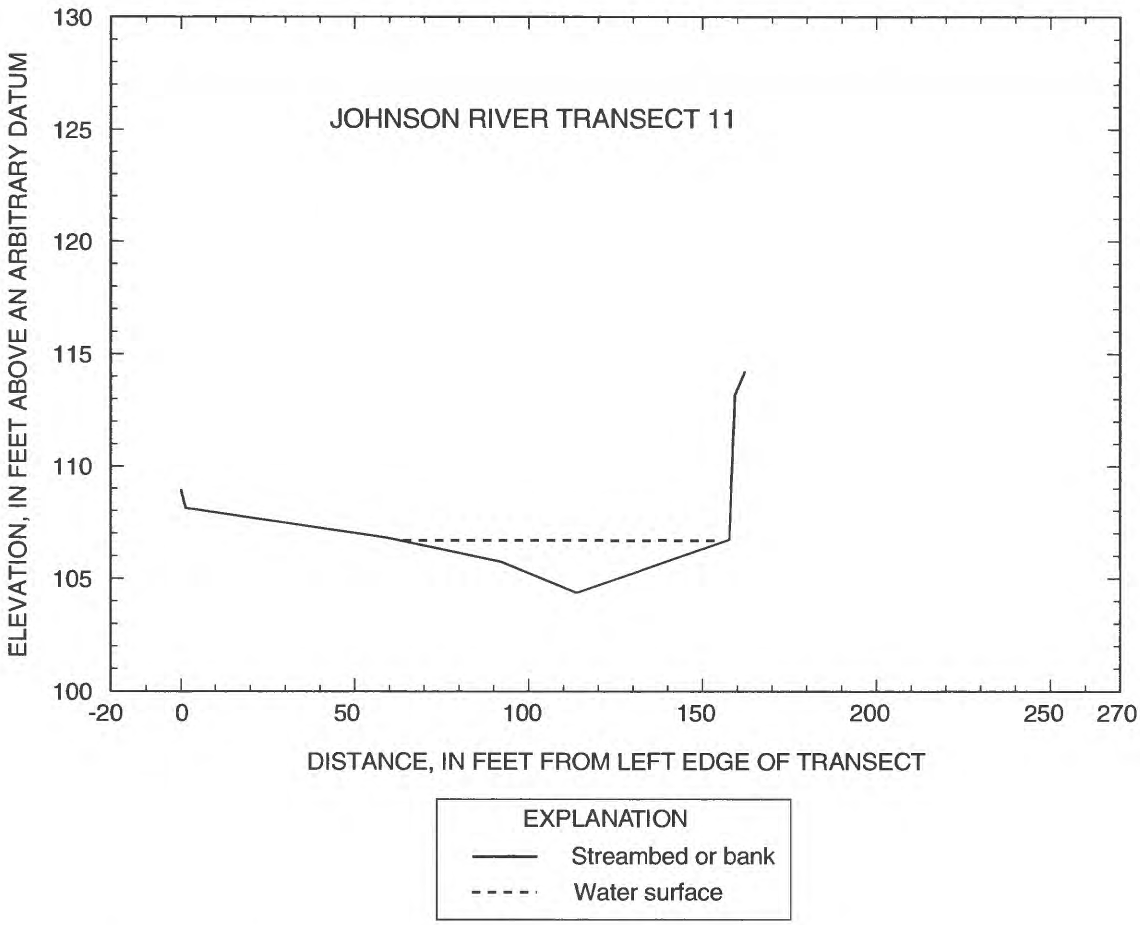

Figure 10. Continued.

Chemical Characteristics

Field water-quality properties collected at the Johnson River on August 18, 1998 were:

Water temperature (°C)	Specific conductance (μS/cm)	Dissolved oxygen concentration (mg/L)	pH
4.5	48	13.1	7.3

The Johnson River was cold (4.5 °C), well oxygenated, and contained relatively few dissolved ions as indicated by a low specific conductance (48 μS/cm). Glaciers feeding the river upstream from the sampling location produced poor water clarity.

Nutrient concentrations were determined from a width- and depth-integrated sample of Johnson River. Ammonia concentration was greater at Johnson River than at other sites sampled for this study. Nutrient concentrations on August, 18, 1998 were (values in milligrams per liter):

Phosphorus (P) total as P	Orthophosphate (PO_4) dissolved as P	Phosphorus (P) dissolved as P	Nitrite + nitrate (NO_2+NO_3) dissolved as N	Ammonia (NH_3) dissolved as N	Ammonia + organic nitrogen (NH_3+OrgN) total as N	Ammonia + organic nitrogen (NH_3+OrgN) dissolved as N
<0.01	<0.01	<0.01	<0.05	0.077	<0.10	<0.10

Streambed sediments were collected for analysis of various contaminant concentrations (table 2). No trace-element concentration in streambed sediments were above the probable effects level (Canadian Council of Ministers of the Environment, 1999). Although the Johnson River was sampled, in part, because of the gold-mining potential, trace-element concentrations were generally low in comparison to those found in other Cook Inlet Basin sites. For example, lead (3.9 µg/g) and nickel (17 µg/g) concentrations in the Johnson River were the lowest from all sites sampled during 1998. Only copper concentrations (75 µg/g) were high relative to other samples collected in the Cook Inlet Basin. Streambed sediments at the Johnson River were analyzed for organochlorines and SVOCs, but none were detected.

Biological Characteristics

Benthic macroinvertebrates were collected from riffles near the downstream end of the reach and surrounding the mid-channel bar at the Johnson River (appendix 2). Thirteen taxa of invertebrates were identified in the RTH sample. Diptera accounted for 95 percent of the individuals in the RTH sample and one genus (Diamesa) in that order was 49 percent of the sample. The QMH sample identified an additional six taxa at Johnson River. Small numbers of Ephemeroptera and Trichoptera were present. Two taxa of Plecoptera were present. The extreme dominance of Chironomidae, which composed 98 percent of the Diptera assemblage, is typical for streams with a large glacier influence (Milner and Petts, 1994).

Dolly Varden were the only fish species collected while electrofishing at the Johnson River sampling reach. Twelve Dolly Varden were collected from the reach with an average length of 68 mm and average weight of 3.8 g. No adult fish were collected. Poor habitat conditions resulting from the proximity to an upstream glacier probably affect the fish community at the Johnson River site.

KATMAI NATIONAL PARK SITE —KAMISHAK RIVER STUDY REACH

The 1,000-foot study reach on the Kamishak River (fig. 11) is about 8 mi upstream from its mouth at Cook Inlet. Little tidal influence was anticipated at this location. The upstream end of the reach was defined by the downstream end of a mid-channel island. A smaller island near the left bank provided habitat suitable for sampling of algae, macroinvertebrates, and slimy sculpin. Most of the reach was not wadeable. Areas surrounding the island located within the reach boundaries became nonwadeable because the river stage rose approximately 8 ft during the site visit on July 19-20, 1998. High winds and heavy rain limited the channel-geometry survey to measuring only the channel width. Because of the flooding, data at this study reach were incomplete and likely not representative of typical conditions.

Physical Characteristics

The Kamishak River flows through the sampling reach in a northward direction. Much of the habitat data that are usually collected at a site were not collected at the Kamishak River because of flooding conditions and inadequate equipment to safely deal with those conditions. The mean width was estimated with a laser rangefinder at 290 ft and the dominant substrate was small cobble (64-128 mm). Some quantitative data on banks are available, but instream conditions are of a descriptive nature. Both banks were heavily vegetated (about 80 percent covered) and moderately steep (averaging 62 degrees). Some areas of erosion existed, particularly along the left bank.

Channel-geometry measurements were limited to the areas surrounding the island within the reach and some areas along the left bank. A global positioning system instrument was used along the banks to define their spatial location. No permanent markers were left at the Kamishak River study reach. Stream gradient at the site was affected by tides and winds. The combination of high tides and a strong northerly wind may have had a damming effect, temporarily decreasing the gradient. Repetitive measurements of specific conductance during the first day at the study reach revealed no change with increasing stage.

Chemical Characteristics

Field water-quality properties collected on July 20, 1998 were:

Water temperature (°C)	Specific conductance (μS/cm)	Dissolved oxygen concentration (mg/L)	pH
6.7	68	12.2	7.4

The Kamishak River was cool (6.7°C) and well oxygenated, and contained relatively few dissolved ions as indicated by a low specific conductance (68 μS/cm). Water clarity was initially fair, but became very poor during the flooding.

Nutrient concentrations were determined from a depth-integrated sample of the Kamishak River collected from the streamward side of the island approximately in mid-reach. The sample could not be width-integrated because of inadequate equipment for the flooding conditions. The stream rose rapidly in response to the continuous rainfall of the previous 24 hours. The water became increasingly turbid during the rising stage, and the sediment carried by the stream probably

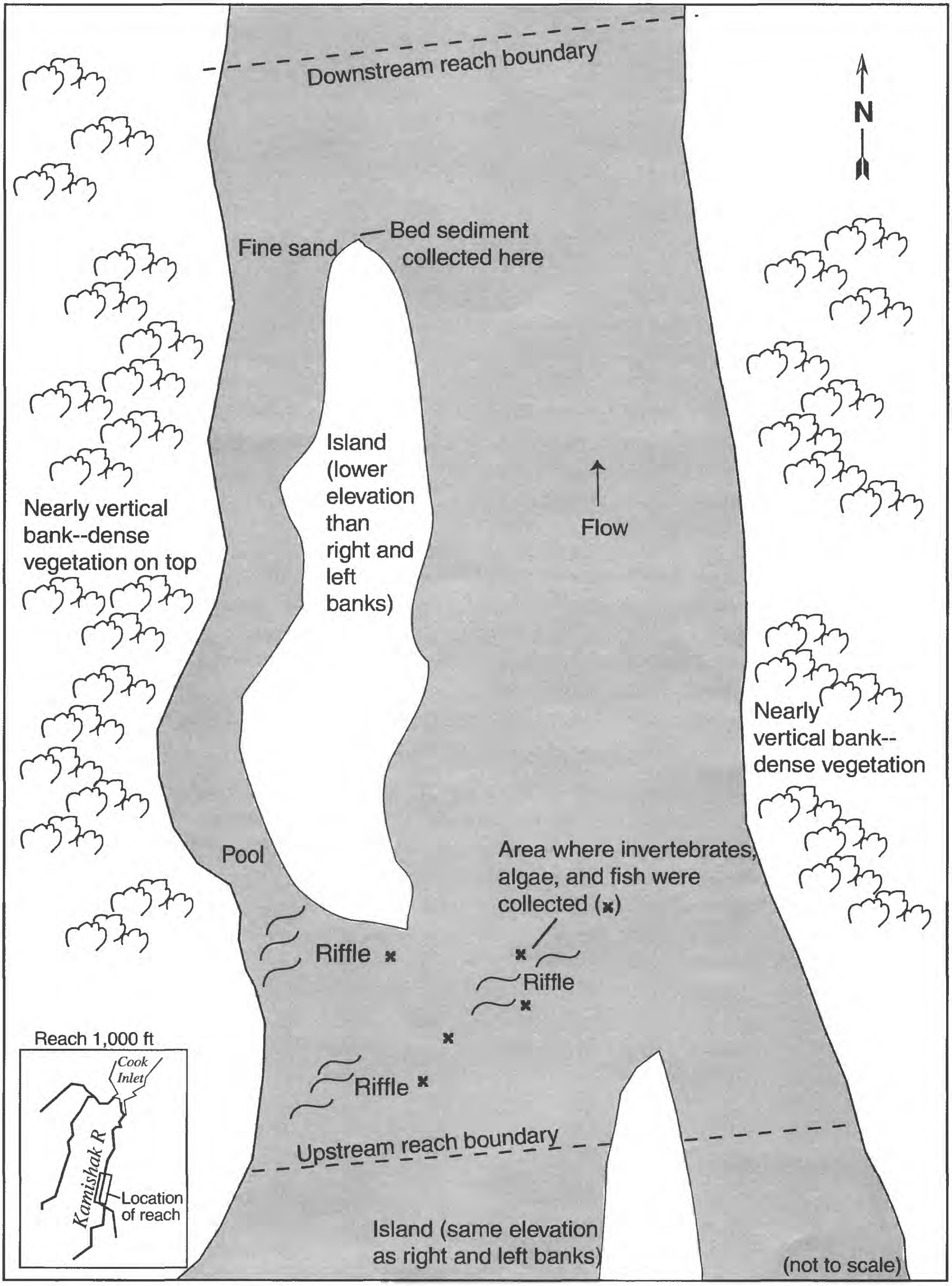

Figure 11. Major geomorphic features of the Kamishak River study reach, Katmai National Park and Preserve.

accounts for the relatively large phosphorus concentration. Nutrient concentrations on July 20, 1998 were (values in milligrams per liter):

Phosphorus (P) total as P	Orthophosphate (PO_4) dissolved as P	Phosphorus (P) dissolved as P	Nitrite + nitrate (NO_2+NO_3) dissolved as N	Ammonia (NH_3) dissolved as N	Ammonia + organic nitrogen (NH_3+OrgN) total as N	Ammonia + organic nitrogen (NH_3+OrgN) dissolved as N
0.357	0.012	<0.010	0.088	0.027	0.24	<0.10

Streambed sediments were collected for analysis of various contaminant concentrations (table 2). No trace-element concentration in streambed sediments or fish tissues were at levels exceeding the guidelines of the Canadian Council of Ministers of the Environment (1999). Trace-element concentrations in the streambed sediments were small relative to other Cook Inlet Basin sites. Because only a few of the 130 slimy sculpin collected were of adequate size, only trace elements and not organochlorines were analyzed in fish tissues. Streambed sediments were analyzed for organochlorines and SVOCs, and none were detected.

Biological Characteristics

Benthic macroinvertebrates were collected from riffles along the island near the left bank of the Kamishak River (appendix 2). Twelve taxa of invertebrates were identified in the RTH sample. Diptera accounted for 93 percent of the individuals in the RTH sample, and one genus (Orthocladius) in that order was 62 percent of the sample. The QMH sample identified an additional seven taxa at the Kamishak River. Small numbers of Ephemeroptera were present. Tidal influence at this site probably creates conditions less suited to Ephemeroptera, Plecoptera, and Trichoptera than to Diptera, leading to an overwhelming numerical dominance of Diptera at the Kamishak River.

Electrofishing in wadeable areas surrounding the island and along the left banks produced slimy sculpin and juveniles of four salmonid species (table 4). Adult salmonids were observed in deeper water but were not captured. Slimy sculpin were abundant, but were the smallest collected at any of the sites sampled in the Cook Inlet Basin. The largest slimy sculpin was 95 mm long and weighed 9.1 g.

Table 4. Summary of fish collected at Kamishak River, July 20, 1998

Species	Abundance	Mean length (millimeters)	Mean weight (grams)
Slimy sculpin (*Cottus cognatus*)	130	52	1.7
Chinook salmon (*Oncorhynchus tshawytscha*)	7	62	2.1
Sockeye salmon (*Oncorhynchus nerka*)	1	60	1.4
Rainbow trout (*Oncorhynchus mykiss*)	2	29	0.2
Dolly Varden (*Salvelinus malma*)	1	71	2.8

SUMMARY

At the five study sites, only one of the 10 SVOCs detected was at a concentration greater than the minimum reporting level. Analyses of fish tissues for 28 organochlorine compounds at Talkeetna River and Costello Creek produced just one detection. Hexachlorobenzene was detected at a concentration of 5.70 µg/kg in slimy sculpin from the Talkeetna River. At Colorado Creek, Johnson River, and Kamishak River, where fish samples were not collected, no organochlorine compounds were detected in streambed sediment samples. Streambed sediment samples from the Talkeetna River had three organochlorine compounds detected with only hexachlorobenzene measured at concentrations greater than the minimum reporting levels. Trace elements were detected in both fish tissues and streambed sediments. More detailed results of the bed sediment and fish tissue analyses are available at the Alaska District Office of the USGS.

Macroinvertebrate samples were taxonomically poor at all sites. Total numbers of taxa including both RTH and QMH samples ranged from 19 at the Johnson River to 38 at the Talkeetna River. The lack of taxonomic richness is characteristic of Alaska rivers (Oswood and others, 1995). Diptera were the most diverse order of macroinvertebrates at all sites and contained the most abundant taxa. Total numbers of diptera taxa ranged from 8 at the Kamishak River to 19 at the Talkeetna River. A mayfly, *Baetis bicaudatus,* was abundant at the two sites in Denali National Park.

REFERENCES CITED

Bertrand, C.M., Hess, D.L., Meyer, D.F., Jackson, M.L., and Smith, C.W., 1999, Water resources data for Alaska—Water year 1998: U.S. Geological Survey Water-Data Report 98-1, 321 p.

Budavari, S., O'Neil, M.J., Smith, A., Heckelman, P.E., and Kinneary, J.F., eds., 1996, The Merck index—An encyclopedia of chemicals, drugs, and biologicals (12th ed.): Whitehouse Station, New Jersey, Merck & Co., 1,741 p. and miscellaneous tables.

Canadian Council of Ministers for the Environment, 1999, Canadian sediment quality guidelines for the protection of aquatic life—Summary tables, *in* Canadian environmental quality guidelines, 1999: Winnipeg, Canadian Council of Ministers of the Environment.

Crawford, J.K., and Luoma, S.N., 1993, Guidelines for studies of contaminants in biological tissues for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 92-492, 69 p.

Cuffney, T.F., Gurtz, M.E., and Meador, M.R., 1993, Methods for collecting benthic invertebrate samples as part of the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 93-406, 66 p.

Edwards, P.J., and Tranel, M.J., 1997, Physical and chemical characterization of streams and rivers within Denali National Park and Preserve: Final Report submitted to National Park Service and USDA Forest Service, 76 p.

Fitzpatrick, F.A., Waite, I.R., D'Arconte, P.J., Meador, M.R., Maupin, M.A., and Gurtz, M.E., 1998, Revised methods for characterizing stream habitat in the National Water-Quality Assessment Program: U.S. Geological Survey Water-Resources Investigations Report 98-4052, 67 p.

Gilliom, R.J., Mueller, D.K., and Nowell, L.H., 1998, Methods for comparing water-quality conditions among National Water-Quality Assessment study units, 1992-1995: U.S. Geological Survey Open-File Report 97-589, 54 p.

Glass, R.L., 1999, Water-quality assessment of the Cook Inlet Basin, Alaska—Summary of data through 1997: U.S. Geological Survey Water-Resources Investigations Report 99-4116, 110 p.

McPhail, J.D., and Lindsey, C.C., 1970, Freshwater fishes of Northwestern Canada and Alaska: Fisheries Research Board Bulletin 173, 381 p.

Meador, M.R., Cuffney, T.F., and Gurtz, M.E., 1993, Methods for fish communities as part of the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 93-104, 40 p.

Milner, A.M. and Petts, G.E., 1994 Glacial rivers—Physical habitat and ecology: Freshwater Biology v. 32, p. 295-308.

Oswood, M.W., Irons, J.G. III, and Milner, A.M., 1995, River and stream ecosystems of Alaska, *in* Cushing, C.E., Cummins, K.W., and Minchall, G.W., (eds.), River and stream ecosystems: Ecosystems of the World, volume 22, Amsterdam, Elsevier, p. 9-32.

Porter, S.D., Cuffney, T.F., Gurtz, M.E., and Meador, M.R., 1993, Methods for collecting algal samples as part of the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 93-409, 39 p.

Shelton, L.R., 1994, Field guide for collecting and processing stream water samples for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 94-455, 42 p.

Shelton, L.R., and Capel, P.D., 1994, Guidelines for collecting and processing samples of streambed sediment for analysis of trace elements and organic contaminants for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 94-458, 39 p.

U.S. Department of the Interior, 1998, Guidelines for interpretation of the biological effects of selected constituents in biota, water, and sediment: National Irrigation Water Quality Program Information Report No. 3, 198 p. + appendixes.

U.S. Environmental Protection Agency, 1996, Integrated Risk Information System (IRIS) [CD-ROM]: Enterprise, Florida, Solutions Software Corporation.

APPENDIX 1

Organochlorine compounds and semivolatile organic compounds that were detected and not detected in samples of streambed sediments or fish tissues.

Compounds That Were Detected in Samples of Streambed Sediment or Fish Tissue

Organochlorine Compounds Detected

Hexachlorobenzene
p,p'-DDE

Semivolatile Organic Compounds Detected

1-Methylpyrene
1-Methylphenanthrene
2,6-Dimethylnaphthalene
Benzo[*ghi*]perylene
Chrysene
Dibenzosthiophene
Fluoranthene
Naphthalene
Phenanthrene
Pyrene

Compounds That Were Not Detected in Any Sample of Streambed Sediment or Fish Tissue

Organochlorine Compounds Not Detected

Aldrin
cis-Chlordane
trans-Chlordane
Chloroneb
Dacthal
o,p'-DDD
o,p'-DDE
o,p'-DDT
p,p'-DDD
p,p'-DDT
α-Endosulfan
Endrin
Heptachlor
Heptachlor epoxide
Isodrin
Lindane
o,p'-Methoxychlor
p,p'-Methoxychlor
Mirex
cis-Nonachlor
trans-Nonachlor
Oxychlordane
Pentachloroanisole
cis-Permethrin
trans-Permethrin
Toxaphene

Semivolatile Organic Compounds Not Detected

1,2,4-Trichlorobenzene
1,2-Dichlorobenzene
1,2-Dimethylnaphthalene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,6-Dimethylnaphthalene
1-Methyl-9H-fluorene
2,2'-Biquinoline
2,3,5,6-Tetramethylphenol
2,3,6-Trimethylnaphthalene
2,4,6-Trichlorophenol
2,4,6-Trimethylphenol
2,4-Dichlorophenol
2,4-Dinitrophenol
2,4-Dinitrotoluene
2,6-Dimethylnaphthalene
2,6-Dinitrotoluene
2-Chloronaphthalene
2-Chlorophenol
2-Ethylnaphthalene
2-Methylanthracene
2-Nitrophenol
3,5-Dimethylphenol
4,6-Dinitro-2-methylphenol
4-Bromophenylphenylether
4-Chloro-3-methylphenol
4-Chlorophenylphenylether
4-Nitrophenol
4H-cyclopenta[*def*]phenanthrene
Acenaphthene
Acenaphthylene
Acridine
Anthracene
Anthraquinone
Azobenzene
Benz[*a*]anthracene
Benzo[*a*]pyrene
Benzo[*b*]fluoranthene
Benzo[*c*]cinnoline
Benzo[*k*]fluoranthene
C_8-Alkylphenol
Carbazole
Di-*n*-octyl phthalate
Dibenz[*a,h*]anthracene
Diethyl phthalate
Dimethyl phthalate
Fluorene
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane
Indeno[1,2,3-*cd*]pyrene
Isophorone
Isoquinoline
N-Nitrosodiphenylamine
Nitrobenzene
Pentachloroanisole
Pentachloronitrobenzene
Pentachlorophenol
Phenanthridine
Phenol
Quinoline
bis(2-Chloroethoxy)methane
bis(2-Chloroethyl)ether
bis(2-Chloroisopropyl) ether
p-Cresol

APPENDIX 2

Benthic macroinvertebrate data

Benthic macroinvertebrate data

[Abundance data for RTH samples is number of organisms per square meter; abundance data for QMH samples indicates the presence of that organism; Life stage: A, adult, L, larvae, P, pupae]

Class	Order	Family	Genus	Lowest taxonomic level	Life stage	Abundance
Talkeetna River RTH Sample						
Oligochaeta		Enchytraeidae		Enchytraeidae		6
	Acari			Hydrachnidia		36
Insecta	Ephemeroptera	Baetidae		Baetidae	L	12
Insecta	Ephemeroptera	Baetidae	Acentrella	Acentrella sp.	L	6
Insecta	Ephemeroptera	Baetidae	Baetis	Baetis bicaudatus Dodds	L	18
Insecta	Ephemeroptera	Heptageniidae		Heptageniidae	L	36
Insecta	Ephemeroptera	Heptageniidae	Cinygmula	Cinygmula sp.	L	42
Insecta	Plecoptera	Chloroperlidae	Suwallia	Suwallia sp.	L	6
Insecta	Plecoptera	Perlodidae	Isoperla	Isoperla sp.	L	12
Insecta	Trichoptera	Brachycentridae	Brachycentrus	Brachycentrus americanus (Banks)	L	18
Insecta	Trichoptera	Limnephilidae		Limnephilidae	L	12
Insecta	Diptera	Chironomidae		Chironomidae	A	48
Insecta	Diptera	Chironomidae		Chironomidae	P	48
Insecta	Diptera	Chironomidae	Cladotanytarsus	Cladotanytarsus sp.	L	18
Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra sp.	L	30
Insecta	Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus sp.	L	30
Insecta	Diptera	Chironomidae	Stempellinella	Stempellinella sp.	L	6
Insecta	Diptera	Chironomidae	Diamesa	Diamesa sp.	L	12
Insecta	Diptera	Chironomidae	Pagastia	Pagastia sp.	L	6
Insecta	Diptera	Chironomidae		Orthocladiinae	L	18
Insecta	Diptera	Chironomidae		Orthocladiinae	P	12
Insecta	Diptera	Chironomidae		Cricotopus/Orthocladius sp.	L	252
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella sp.	L	18
Insecta	Diptera	Chironomidae	Paraphaenocladius	Paraphaenocladius sp.	L	6
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia sp.	L	54
Insecta	Diptera	Chironomidae		Thienemannimyia group sp.	L	6
Insecta	Diptera	Psychodidae		Pericoma/Telmatoscopus sp.	L	6
Insecta	Diptera	Simuliidae		Simuliidae	L	18
Insecta	Diptera	Empididae	Chelifera	Chelifera sp.	L	6

Benthic macroinvertebrate data--Continued

[Abundance data for RTH samples is number of organisms per square meter; abundance data for QMH samples indicates the presence of that organism; Life stage: A, adult, L, larvae, P, pupae]

Class	Order	Family	Genus	Lowest taxonomic level	Life stage	Abundance
Talkeetna River QMH Sample						
Gastropoda		Lymnaeidae	Fossaria	Fossaria sp.		1
	Acari			Hydrachnidia		1
Insecta	Ephemeroptera	Ephemerellidae	Drunella	Drunella doddsi (Needham)	L	1
Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	Ephemerella aurivillii (Bengtsson)	L	1
Insecta	Ephemeroptera	Ameletidae	Ameletus	Ameletus sp.	L	1
Insecta	Ephemeroptera	Baetidae	Baetis	Baetis sp.	L	1
Insecta	Ephemeroptera	Baetidae	Baetis	Baetis bicaudatus Dodds	L	1
Insecta	Ephemeroptera	Heptageniidae	Cinygmula	Cinygmula sp.	L	1
Insecta	Plecoptera	Capniidae		Capniidae	A	1
Insecta	Plecoptera	Nemouridae	Zapada	Zapada sp.	L	1
Insecta	Plecoptera	Chloroperlidae	Suwallia	Suwallia sp.	L	1
Insecta	Plecoptera	Perlodidae	Isoperla	Isoperla sp.	L	1
Insecta	Trichoptera	Glossosomatidae	Glossosoma	Glossosoma sp.	P	1
Insecta	Trichoptera	Limnephilidae		Limnephilidae	L	1
Insecta	Trichoptera	Limnephilidae	Onocosmoecus	Onocosmoecus unicolor (Banks)	L	1
Insecta	Coleoptera	Dytiscidae	Oreodytes	Oreodytes sp.	A	1
Insecta	Diptera	Chironomidae		Chironomidae	L	1
Insecta	Diptera	Chironomidae		Tanytarsini	L	1
Insecta	Diptera	Chironomidae	Cladotanytarsus	Cladotanytarsus sp.	L	1
Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra sp.	L	1
Insecta	Diptera	Chironomidae	Diamesa	Diamesa sp.	L	1
Insecta	Diptera	Chironomidae	Pagastia	Pagastia sp.	L	1
Insecta	Diptera	Chironomidae		Orthocladiinae	L	1
Insecta	Diptera	Chironomidae		Cricotopus/Orthocladius sp.	L	1
Insecta	Diptera	Chironomidae	Corynoneura	Corynoneura sp.	L	1
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella sp.	L	1
Insecta	Diptera	Chironomidae	Heleniella	Heleniella sp.	L	1
Insecta	Diptera	Chironomidae	Paraphaenocladius	Paraphaenocladius sp.	L	1
Insecta	Diptera	Chironomidae	Rheocricotopus	Rheocricotopus sp.	L	1
Insecta	Diptera	Chironomidae	Thienemanniella	Thienemanniella sp.	L	1
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia sp.	L	1
Insecta	Diptera	Chironomidae		Thienemannimyia group sp.	L	1
Insecta	Diptera	Simuliidae		Simuliidae	L	1
Insecta	Diptera	Tipulidae	Dicranota	Dicranota sp.	L	1

Benthic macroinvertebrate data--Continued

[Abundance data for RTH samples is number of organisms per square meter; abundance data for QMH samples indicates the presence of that organism; Life stage: A, adult, L, larvae, P, pupae]

Class	Order	Family	Genus	Lowest taxonomic level	Life stage	Abundance
Costello Creek RTH Sample						
	Acari			Hydrachnidia		18
Insecta	Ephemeroptera	Caenidae	Caenis	Caenis sp.	L	3
Insecta	Ephemeroptera	Ephemerellidae	Drunella	Drunella doddsi (Needham)	L	7
Insecta	Ephemeroptera	Leptohyphidae	Tricorythodes	Tricorythodes sp.	L	3
Insecta	Ephemeroptera	Baetidae		Baetidae	A	18
Insecta	Ephemeroptera	Baetidae	Acentrella	Acentrella sp.	L	3
Insecta	Ephemeroptera	Baetidae	Acentrella	Acentrella insignificans (McDunnough)	L	15
Insecta	Ephemeroptera	Baetidae	Baetis	Baetis sp.	L	33
Insecta	Ephemeroptera	Baetidae	Baetis	Baetis bicaudatus Dodds	L	285
Insecta	Ephemeroptera	Heptageniidae	Cinygmula	Cinygmula sp.	L	21
Insecta	Ephemeroptera	Heptageniidae	Epeorus	Epeorus sp.	L	72
Insecta	Plecoptera	Taeniopterygidae		Taeniopterygidae	L	3
Insecta	Plecoptera	Chloroperlidae		Chloroperlidae	L	27
Insecta	Plecoptera	Chloroperlidae	Suwallia	Suwallia sp.	L	9
Insecta	Trichoptera	Glossosomatidae	Glossosoma	Glossosoma sp.	L	3
Insecta	Diptera	Chironomidae		Chironomidae	A	39
Insecta	Diptera	Chironomidae		Chironomidae	P	21
Insecta	Diptera	Chironomidae	Diamesa	Diamesa sp.	L	396
Insecta	Diptera	Chironomidae		Orthocladiinae	L	3
Insecta	Diptera	Chironomidae		Orthocladiinae	P	39
Insecta	Diptera	Chironomidae		Cricotopus/Orthocladius sp.	L	129
Insecta	Diptera	Chironomidae	Cricotopus	Cricotopus trifascia group	L	3
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella sp.	L	12
Insecta	Diptera	Simuliidae		Simuliidae	L	72
Insecta	Diptera	Simuliidae	Prosimulium	Prosimulium sp.	L	9
Insecta	Diptera	Tipulidae	Tipula	Tipula sp.	L	1
Insecta	Diptera	Empididae	Oreogeton	Oreogeton sp.	L	3

Benthic macroinvertebrate data--Continued

[Abundance data for RTH samples is number of organisms per square meter; abundance data for QMH samples indicates the presence of that organism; Life stage: A, adult, L, larvae, P, pupae]

Class	Order	Family	Genus	Lowest taxonomic level	Life stage	Abund-ance
			Costello Creek QMH Sample			
Insecta	Ephemeroptera	Ephemerellidae	Drunella	Drunella doddsi (Needham)	L	1
Insecta	Ephemeroptera	Baetidae	Baetis	Baetis bicaudatus Dodds	L	1
Insecta	Ephemeroptera	Heptageniidae	Cinygmula	Cinygmula sp.	L	1
Insecta	Ephemeroptera	Heptageniidae	Epeorus	Epeorus sp.	L	1
Insecta	Plecoptera	Capniidae		Capniidae	L	1
Insecta	Plecoptera	Nemouridae	Zapada	Zapada sp.	L	1
Insecta	Plecoptera	Chloroperlidae		Chloroperlidae	L	1
Insecta	Plecoptera	Chloroperlidae	Suwallia	Suwallia sp.	L	1
Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	Rhyacophila sp.	L	1
Insecta	Diptera	Chironomidae		Chironomidae	L	1
Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra sp.	L	1
Insecta	Diptera	Chironomidae	Diamesa	Diamesa sp.	L	1
Insecta	Diptera	Chironomidae	Pagastia	Pagastia sp.	L	1
Insecta	Diptera	Chironomidae		Cricotopus/Orthocladius sp.	L	1
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella sp.	L	1
Insecta	Diptera	Chironomidae	Parorthocladius	Parorthocladius sp.	L	1
Insecta	Diptera	Chironomidae	Rheocricotopus	Rheocricotopus sp.	L	1
Insecta	Diptera	Chironomidae	Thienemanniella	Thienemanniella sp.	L	1
Insecta	Diptera	Psychodidae		Pericoma/Telmatoscopus sp.	L	1
Insecta	Diptera	Simuliidae		Simuliidae	L	1
Insecta	Diptera	Simuliidae	Prosimulium	Prosimulium sp.	L	1
Insecta	Diptera	Tipulidae	Tipula	Tipula sp.	L	1

Benthic macroinvertebrate data--Continued

[Abundance data for RTH samples is number of organisms per square meter; abundance data for QMH samples indicates the presence of that organism; Life stage: A, adult, L, larvae, P, pupae]

Class	Order	Family	Genus	Lowest taxonomic level	Life stage	Abundance
Colorado Creek RTH Sample						
Turbellaria				Turbellaria		5
Oligochaeta		Enchytraeidae		Enchytraeidae		5
	Acari			Hydrachnidia		91
Insecta	Ephemeroptera	Ameletidae	Ameletus	Ameletus sp.	L	10
Insecta	Ephemeroptera	Baetidae	Baetis	Baetis sp.	L	77
Insecta	Ephemeroptera	Baetidae	Baetis	Baetis bicaudatus Dodds	L	365
Insecta	Ephemeroptera	Heptageniidae		Heptageniidae	L	5
Insecta	Ephemeroptera	Heptageniidae	Cinygmula	Cinygmula sp.	L	82
Insecta	Ephemeroptera	Heptageniidae	Epeorus	Epeorus sp.	L	149
Insecta	Plecoptera	Capniidae		Capniidae	L	5
Insecta	Plecoptera	Nemouridae	Zapada	Zapada sp.	L	38
Insecta	Plecoptera	Taeniopterygidae		Taeniopterygidae	L	5
Insecta	Plecoptera	Taeniopterygidae	Taenionema	Taenionema sp.	L	5
Insecta	Plecoptera	Chloroperlidae		Chloroperlidae	L	77
Insecta	Plecoptera	Chloroperlidae	Suwallia	Suwallia sp.	L	5
Insecta	Trichoptera	Glossosomatidae	Glossosoma	Glossosoma sp.	L	5
Insecta	Trichoptera	Limnephilidae		Limnephilidae	L	5
Insecta	Diptera	Chironomidae		Chironomidae	A	34
Insecta	Diptera	Chironomidae		Chironomidae	P	149
Insecta	Diptera	Chironomidae	Diamesa	Diamesa sp.	L	542
Insecta	Diptera	Chironomidae		Orthocladiinae	L	10
Insecta	Diptera	Chironomidae		Orthocladiinae	P	24
Insecta	Diptera	Chironomidae		Cricotopus/Orthocladius sp.	L	216
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella sp.	L	19
Insecta	Diptera	Chironomidae	Parorthocladius	Parorthocladius sp.	L	29
Insecta	Diptera	Simuliidae		Simuliidae	L	211
Insecta	Diptera	Simuliidae	Prosimulium	Prosimulium sp.	L	58
Insecta	Diptera	Tipulidae		Tipulidae	L	5
Insecta	Diptera	Tipulidae	Tipula	Tipula sp.	L	1
Insecta	Diptera			Brachycera	L	5
Insecta	Diptera	Empididae	Oreogeton	Oreogeton sp.	L	67

Benthic macroinvertebrate data--Continued

[Abundance data for RTH samples is number of organisms per square meter; abundance data for QMH samples indicates the presence of that organism; Life stage: A, adult, L, larvae, P, pupae]

Class	Order	Family	Genus	Lowest taxonomic level	Life stage	Abundance
Colorado Creek QMH Sample						
Turbellaria				Turbellaria		1
Insecta	Ephemeroptera	Ameletidae	Ameletus	Ameletus sp.	L	1
Insecta	Ephemeroptera	Baetidae	Baetis	Baetis bicaudatus Dodds	L	1
Insecta	Ephemeroptera	Heptageniidae	Cinygmula	Cinygmula sp.	L	1
Insecta	Ephemeroptera	Heptageniidae	Epeorus	Epeorus sp.	L	1
Insecta	Plecoptera	Nemouridae	Zapada	Zapada sp.	L	1
Insecta	Plecoptera	Taeniopterygidae		Taeniopterygidae	L	1
Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	Rhyacophila sp.	L	1
Insecta	Coleoptera	Staphylinidae		Staphylinidae	A	1
Insecta	Diptera	Chironomidae		Chironomidae	L	1
Insecta	Diptera	Chironomidae	Diamesa	Diamesa sp.	L	1
Insecta	Diptera	Chironomidae		Cricotopus/Orthocladius sp.	L	1
Insecta	Diptera	Chironomidae	Parorthocladius	Parorthocladius sp.	L	1
Insecta	Diptera	Chironomidae	Rheocricotopus	Rheocricotopus sp.	L	1
Insecta	Diptera	Chironomidae	Thienemanniella	Thienemanniella sp.	L	1
Insecta	Diptera	Simuliidae		Simuliidae	L	1
Insecta	Diptera	Simuliidae	Prosimulium	Prosimulium sp.	L	1
Insecta	Diptera	Tipulidae	Tipula	Tipula sp.	L	1
Insecta	Diptera	Tipulidae	Gonomyodes	Gonomyodes tacoma (Alexander)	L	1
Insecta	Diptera	Empididae	Oreogeton	Oreogeton sp.	L	1

Benthic macroinvertebrate data--Continued

[Abundance data for RTH samples is number of organisms per square meter; abundance data for QMH samples indicates the presence of that organism; Life stage: A, adult, L, larvae, P, pupae]

Class	Order	Family	Genus	Lowest taxonomic level	Life stage	Abundance
Johnson River RTH Sample						
Oligochaeta		Lumbriculidae		Lumbriculidae		18
	Acari			Hydrachnidia		6
Insecta	Ephemeroptera	Baetidae		Baetidae	L	12
Insecta	Ephemeroptera	Baetidae	Baetis	Baetis bicaudatus Dodds	L	72
Insecta	Ephemeroptera	Heptageniidae	Cinygmula	Cinygmula sp.	L	6
Insecta	Plecoptera	Chloroperlidae		Chloroperlidae	L	6
Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	Rhyacophila sp.	L	6
Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	Rhyacophila alberta group	L	6
Insecta	Diptera	Chironomidae		Chironomidae	A	84
Insecta	Diptera	Chironomidae		Chironomidae	P	96
Insecta	Diptera	Chironomidae	Diamesa	Diamesa sp.	L	1254
Insecta	Diptera	Chironomidae		Orthocladiinae	L	78
Insecta	Diptera	Chironomidae		Orthocladiinae	P	192
Insecta	Diptera	Chironomidae		Cricotopus/Orthocladius sp.	L	366
Insecta	Diptera	Chironomidae		Cricotopus/Orthocladius sp.	P	24
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella sp.	L	54
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius sp.	L	174
Insecta	Diptera	Chironomidae	Parorthocladius	Parorthocladius sp.	L	48
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia sp.	L	6
Insecta	Diptera	Simuliidae		Simuliidae	L	42
Insecta	Diptera	Empididae	Oreogeton	Oreogeton sp.	L	6

Benthic macroinvertebrate data--Continued

[Abundance data for RTH samples is number of organisms per square meter; abundance data for QMH samples indicates the presence of that organism; Life stage: A, adult, L, larvae, P, pupae]

Class	Order	Family	Genus	Lowest taxonomic level	Life stage	Abund-ance
			Johnson River QMH Sample			
Insecta	Ephemeroptera	Ameletidae	Ameletus	Ameletus sp.	L	1
Insecta	Ephemeroptera	Baetidae	Baetis	Baetis bicaudatus Dodds	L	1
Insecta	Ephemeroptera	Heptageniidae	Cinygmula	Cinygmula sp.	L	1
Insecta	Ephemeroptera	Heptageniidae	Epeorus	Epeorus sp.	L	1
Insecta	Plecoptera	Nemouridae	Zapada	Zapada sp.	L	1
Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	Rhyacophila sp.	L	1
Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	Rhyacophila alberta group	L	1
Insecta	Diptera	Chironomidae		Chironomidae	L	1
Insecta	Diptera	Chironomidae	Diamesa	Diamesa sp.	L	1
Insecta	Diptera	Chironomidae		Orthocladiinae	L	1
Insecta	Diptera	Chironomidae		Cricotopus/Orthocladius sp.	L	1
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella sp.	L	1
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius sp.	L	1
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia sp.	L	1
Insecta	Diptera	Simuliidae		Simuliidae	L	1
Insecta	Diptera	Simuliidae	Prosimulium	Prosimulium sp.	L	1
Insecta	Diptera	Simuliidae	Simulium	Simulium sp.	L	1
Insecta	Diptera	Tipulidae	Tipula	Tipula sp.	L	1
Insecta	Diptera	Empididae	Hemerodromia	Hemerodromia sp.	L	1

Benthic macroinvertebrate data--Continued

[Abundance data for RTH samples is number of organisms per square meter; abundance data for QMH samples indicates the presence of that organism; Life stage: A, adult, L, larvae. P, pupae]

Class	Order	Family	Genus	Lowest taxonomic level	Life stage	Abundance
Kamishak River RTH Sample						
Gastropoda		Planorbidae		Planorbidae		8
Oligochaeta		Naididae		Naididae		8
	Acari			Hydrachnidia		17
Insecta	Ephemeroptera	Ephemerellidae	Drunella	Drunella doddsi (Needham)	L	17
Insecta	Ephemeroptera	Heptageniidae	Cinygmula	Cinygmula sp.	L	8
Insecta	Ephemeroptera	Heptageniidae	Epeorus	Epeorus sp.	L	25
Insecta	Plecoptera	Chloroperlidae	Suwallia	Suwallia sp.	L	17
Insecta	Diptera	Chironomidae		Chironomidae	A	17
Insecta	Diptera	Chironomidae		Chironomidae	P	34
Insecta	Diptera	Chironomidae		Chironomini	L	8
Insecta	Diptera	Chironomidae	Diamesa	Diamesa sp.	L	67
Insecta	Diptera	Chironomidae		Orthocladiinae	L	17
Insecta	Diptera	Chironomidae		Orthocladiinae	P	17
Insecta	Diptera	Chironomidae		Cricotopus/Orthocladius sp.	L	832
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella sp.	L	193
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius sp.	L	17
Insecta	Diptera	Simuliidae		Simuliidae	L	17
Kamishak River QMH Sample						
Oligochaeta		Enchytraeidae		Enchytraeidae		1
	Acari			Hydrachnidia		1
Insecta	Ephemeroptera	Ephemerellidae	Drunella	Drunella doddsi (Needham)	L	1
Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	Ephemerella aurivillii (Bengtsson)	L	1
Insecta	Ephemeroptera	Heptageniidae	Cinygmula	Cinygmula sp.	L	1
Insecta	Ephemeroptera	Heptageniidae	Epeorus	Epeorus sp.	L	1
Insecta	Plecoptera	Chloroperlidae		Chloroperlidae	L	1
Insecta	Plecoptera	Chloroperlidae	Suwallia	Suwallia sp.	L	1
Insecta	Plecoptera	Perlodidae	Isoperla	Isoperla sp.	L	1
Insecta	Trichoptera	Limnephilidae		Limnephilidae	L	1
Insecta	Diptera	Chironomidae		Chironomidae	L	1
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum sp.	L	1
Insecta	Diptera	Chironomidae	Diamesa	Diamesa sp.	L	1
Insecta	Diptera	Chironomidae		Orthocladiinae	L	1
Insecta	Diptera	Chironomidae		Cricotopus/Orthocladius sp.	L	1
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella sp.	L	1
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius sp.	L	1
Insecta	Diptera	Tipulidae	Tipula	Tipula sp.	L	1
Insecta	Diptera	Tipulidae	Dicranota	Dicranota sp.	L	1

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