Prepared in cooperation with the U.S. Fish and Wildlife Service and
Chickaloon Village Traditional Council

Distribution, Persistence, and Hydrologic Characteristics of Salmon Spawning Habitats in Clearwater Side Channels of the Matanuska River, Southcentral Alaska

Scientific Investigations Report 2011–5102

U.S. Department of the Interior
U.S. Geological Survey

Cover: Photograph showing a clearwater side channel flowing across the braid plain and into a turbid channel of the Matanuska River, Alaska.
Photograph taken by Janet Curran, U.S. Geological Survey, August 14, 2007.

Inset: Photograph showing sockeye and chum salmon swimming from a turbid channel into a clearwater side channel of the Matanuska River, Alaska.
Photograph taken by Christian Zimmerman, U.S. Geological Survey, August 28, 2008.

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KEN SALAZAR, Secretary

U.S. Geological Survey
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Contents

Abstract.....	1
Introduction.....	1
Description of Study Area	2
Methods of Study and Data Collection	5
Determinations of Channel Distribution, Geomorphic Characteristics, and Salmon Use of Side Channels.....	5
Selection of Field Reconnaissance, Intensive-Survey, and Monitoring Sites.....	6
Measurements and Monitoring of Surface Water and Channel Characteristics.....	10
Measurements and Monitoring of Intergravel Water Temperature	11
Distribution and Persistence of Side Channels and Their Use by Salmon	11
Hydrologic, Physical, and Water-Quality Characteristics of Side Channels	18
Physical Characteristics and Riparian Vegetation.....	24
Surface Water Characterization and Comparison to Source Waters	24
Reach-Scale Spawning Site Selection	27
Intergravel Water Temperature.....	30
Summary and Conclusions.....	34
Acknowledgments.....	34
References Cited.....	34
Appendix A. Description of Matanuska River Clearwater Side Channel Geographic Information System Products.....	37

Figures

Figure 1. Map showing location of Matanuska River and vicinity, Alaska	3
Figure 2. Orthophotograph showing typical clearwater side channels in the 2006 braid plain of the Matanuska River, Alaska	4
Figure 3. Map showing locations of reconnaissance measurement, survey, and monitoring sites in clearwater side channels, tributaries, springs, and mainstem channels of the Matanuska River, Alaska, 2007–09	7
Figure 4. Map showing locations of monitoring sites in clearwater side channels and tributaries of the Matanuska River, Alaska	9
Figure 5. Map showing locations of side channels delineated from 2006 orthophotography, Matanuska River, Alaska	13
Figure 6. Graph showing total length of side channels in 1 kilometer-long polygons and braid plain width at 1 kilometer transects, Matanuska River, Alaska	14
Figure 7. Orthophotographs and corresponding maps showing clearwater side channels and mainstem from braid plain kilometer 3–9 in 1949, 1978, 1985, and 1996, Matanuska River, Alaska	15
Figure 8. Orthophotographs showing clearwater side channels and tributaries from braid plain kilometers 37–40 in 1949 and 2006, Matanuska River, Alaska	16
Figure 9. Map showing salmon presence/absence survey limits and results, Matanuska River, Alaska, September 13, 2007	17
Figure 10. Photograph showing salmon in a clearwater side channel of the Matanuska River, Alaska	18
Figure 12. Photograph showing lack of ice cover typical of winter conditions in clearwater side channels, site SC18, Matanuska River, Alaska	25
Figure 11. Graph showing maximum, mean, and minimum daily surface water temperatures at side channel monitoring site SC19, Matanuska River, Alaska, 2007–09	25
Figure 13. Graph showing specific conductance in side channels and spring, mainstem, and tributary source waters along the Matanuska River, Alaska, 2007–08	26
Figure 14. Graphs showing surface and intergravel water temperature at monitoring sites on side channels and tributaries along Matanuska River, Alaska, September 2008–May 2009	31
Figure 15. Graphs showing longitudinal distribution of intergravel temperature within 100-m reaches at intensive survey sites on clearwater side channels and a tributary along Matanuska River, Alaska, September–October 2008.....	33

Tables

Table 1. Orthophotography and satellite orthoimagery used to determine location, turbidity, braid plain characteristics, and historical conditions of clearwater side channels, Matanuska River, Alaska	5
Table 2. Map numbers, location data, and activities at field sites in clearwater side channels, springs, tributaries, and mainstem channels of the Matanuska River, Alaska, 2007–09	8
Table 3. Length, distribution, and density of side channels in six geomorphic reaches of the Matanuska River, Alaska, 2006	11
Table 4. Summary of selected attributes of clearwater side channels of the Matanuska River, Alaska, 2006	12
Table 5. Surface water and channel characteristic reconnaissance data for clearwater side channels, springs, tributaries, and mainstem streams, Matanuska River, Alaska, 2007–08	19
Table 6. Summary statistics for spring-autumn surface water and channel characteristic reconnaissance data for side channels and source waters, Matanuska River, Alaska	24
Table 7. Discharge measurements in side channel sites for the Matanuska River (sites SC18 and SC19) and the Moose Creek tributary (site T4), Matanuska River, Alaska, 2007–08	27
Table 8. Surface water and channel characteristic intensive survey data for a Matanuska River clearwater side channel (site SC19) near Palmer and Moose Creek (site T4), Alaska	28
Table 9. Descriptive statistics for surface water and channel characteristic intensive survey data for Matanuska River side channel sites SC19(a) and SC19(b) and Moose Creek tributary site T4, Alaska	30
Table 10. Summary of intergravel and surface water temperature data and accumulated thermal units from monitoring sites at three clearwater side channels and two tributaries of the Matanuska River, Alaska	32

Conversion Factors and Datums

Conversion Factors

Multiply	By	To obtain
Length		
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
Area		
square kilometer (km ²)	247.1	acre
square kilometer (km ²)	0.3861	square mile (mi ²)
Flow rate		
meter per second (m/s)	3.281	foot per second (ft/s)
cubic meter per second (m ³ /s)	35.31	cubic foot per second (ft ³ /s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$^{\circ}\text{F}=(1.8\times^{\circ}\text{C})+32.$$

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (μS/cm at 25°C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (μg/L).

Datums

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Elevation, as used in this report, refers to distance above the vertical datum.

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Abstract

Turbid, glacially influenced rivers are often considered to be poor salmon spawning and rearing habitats and, consequently, little is known about salmon habitats that do occur within rivers of this type. To better understand salmon spawning habitats in the Matanuska River of southcentral Alaska, the distribution and characteristics of clearwater side-channel spawning habitats were determined and compared to spawning habitats in tributaries. More than 100 kilometers of clearwater side channels within the braided mainstem of the Matanuska River were mapped for 2006 from aerial images and ground-based surveys. In reaches selected for historical analysis, side channel locations shifted appreciably between 1949 and 2006, but the relative abundance of clearwater side channels was fairly stable during the same period. Geospatial analysis of side channel distribution shows side channels typically positioned along abandoned bars at the braid plain margin rather than on bars between mainstem channels, and shows a strong correlation of channel abundance with braid plain width. Physical and geomorphic characteristics of the channel and chemical character of the water measured at 19 side channel sites, 6 tributary sites, 4 spring sites, and 5 mainstem channel sites showed conditions suitable for salmon spawning in side channels and tributaries, and a correlation of side channel characteristics with the respective tributary or groundwater source water. Autumn-through-spring monitoring of intergravel water temperatures adjacent to salmon redds (nests) in three side channels and two tributaries indicate adequate accumulated thermal units for incubation and emergence of salmon in side channels and relatively low accumulated thermal units in tributaries.

Introduction

In the management of salmon populations, mainstem glacial rivers are primarily considered as migration corridors, with little attention given to their possible role as spawning habitats. Tributaries are typically the focus of salmon habitat protection and restoration, while actions or practices on mainstem waterways focus on facilitating passage of migrating salmon. Mainstem habitats, however, have been shown to provide valuable spawning areas and to contribute significantly to the overall production of some salmon populations (Wood and others, 1987; Eiler and others, 1992). Further, because glacial rivers are characterized by high turbidity levels and high concentrations of suspended sediments, they are generally considered to be poor spawning habitat for salmon (Lloyd and others, 1987; Young and Woody, 2007). In glacial river systems, salmon habitat has often been assumed to consist primarily of clearwater tributaries, but the mainstem of braided rivers commonly consists of large, turbid channels, smaller turbid channels, and clearwater side channels that potentially provide non-turbid habitat. Other studies have documented habitat use by salmon in clearwater channels and small, seasonally turbid channels within mainstem valleys (Lorenz and Eiler, 1989; Eiler and others, 1992; McPhee and others, 2009), but many large glacial river systems have been virtually ignored as salmon habitat. Thus, the nature of clearwater side channels and the extent to which they provide salmon spawning habitat is underexplored but has implications for habitat restoration and preservation.

Pacific salmon spawn in a variety of habitats throughout their natural range, including large rivers, small streams, ponds, sloughs, and lakes (Quinn, 2005). Theoretically, salmon select sites that will maximize survival of incubating eggs and alevins by selecting locations and constructing redds (gravel nests) that maximize the delivery of oxygen-rich water and removal of metabolic wastes (Chapman, 1988; Bjornn and Reiser, 1991). Water temperature is a critical variable controlling the development and survival of salmonid embryos and alevins (Crisp, 1988; 1990). In northern latitudes, relatively warm water temperatures play an important role in providing potential sanctuary from lower temperature thresholds and freezing substrate, as well as accelerating the developmental rate of embryos and increasing egg-to-smolt survival (Kogl, 1965; Wangaard and Burger, 1983; Maclean, 2003). Salmon spawning habitats, therefore, comprise a multivariate suite of characteristics found in a patchy distribution throughout the hydrologic and geomorphic mosaic of a river basin (Stanford and others, 1996; Buffington and others, 2004).

The Matanuska River drains the Matanuska Glacier and other mountainous areas in a 5,400-km² basin in southcentral Alaska (fig. 1). The river braids actively along 85 percent of its course, which traverses a valley between the Talkeetna and Chugach Mountains and cuts through a broad lowland containing the city of Palmer and numerous rural residential areas. Abandoned channels and bars flanking the river form a mosaic of surfaces ranging in age from a few years (unvegetated) to many decades (shrubby to forested), collectively termed the braid plain. Where abandoned braid plain channels have filled with clear water from tributaries external to the braid plain or with groundwater from within the braid plain, they create clearwater side channels (fig. 2) whose use by spawning salmon has been anecdotally noted for decades but never systematically investigated.

When the Mat-Su Basin Salmon Habitat Partnership was organized in 2005 to address the management and restoration of salmon habitats in the Matanuska-Susitna Borough, it was determined that more information concerning the distribution and characteristics of salmon habitats was needed to achieve those goals (Mat-Su Basin Salmon Habitat Partnership, 2008). In response to that need, and in order to consider salmon spawning habitat in a watershed context, the U.S. Geological Survey (USGS), in cooperation with U.S. Fish and Wildlife Service (USFWS) and Chickaloon Native Village Traditional Council, collected baseline data on the distribution and characteristics of salmon spawning habitats in the braid plain and tributary streams of the Matanuska River. This report presents those data and summarizes the results of that effort.

Description of Study Area

The Matanuska Valley contains the city of Palmer, with a 2008 population of 8,201 (U.S. Census Bureau, 2008), and other, smaller communities, including Sutton and Chickaloon, clustered around the Glenn Highway, a major regional highway that parallels the Matanuska River. Activities within the river's historical braid plain have included gravel mining and recreation. Protection of residential development at the braid plain margins and maintenance of the Glenn Highway have prompted construction of erosion control structures in several locations.

The valley is a northeast-trending structural trough in rocks of Mesozoic and Tertiary age (Winkler, 1992; Wilson and others, 2009) that was occupied during the Pleistocene by the Matanuska Glacier, whose present-day terminus is 80 km east of Palmer. The Matanuska River watershed rises to a maximum elevation of 4,100 m in the Chugach Mountains and descends to near sea level at the river's confluence with the Knik River. The Matanuska River braid plain is flanked variously by bedrock banks, glacial deposits, narrow fluvial terraces, and tributary fans in a confined valley upstream from Palmer, and by broad glacial terraces in an unconfined valley near and downstream from Palmer. The river transports a lithologically diverse suite of sediment derived from the sedimentary and igneous rocks of the Talkeetna Mountains and metasedimentary and mélange-like accretionary rocks of the Chugach Mountains (Barnes, 1962; Winkler, 1992; Reger and others, 1996).

The Matanuska River valley has a maritime climate moderated by the orographic effect of the Chugach Mountains on Gulf of Alaska weather systems, which creates a rain shadow with reduced precipitation. Temperatures are moderated by the maritime influence and by strong winds down the Matanuska Valley (U.S. Department of Agriculture Natural Resources Conservation Service, 1998). Mean annual precipitation ranges from lows along the valley bottom—380 mm at Palmer and 330 mm at the Sheep Mountain airport near the Matanuska Glacier (Western Regional Climate Center, 2009)—to more than 2,000 mm at higher elevations in the mountainous areas (Western Regional Climate Center, 2000). Palmer's high temperatures average 7 °C and low temperatures average -3 °C. Freezing temperatures at Palmer begin between mid-August and mid-October and persist until mid-April to late May (Western Regional Climate Center, 2009). Farther upriver, the Sheep Mountain airport weather station has recorded freezing temperatures beginning from mid-August to mid-September and persisting until late May to late July.

Figure 1. Location of Matanuska River and vicinity, Alaska.

Figure 2. Typical clearwater side channels in the 2006 braid plain of the Matanuska River, Alaska. Three side channels in an unvegetated channel-margin bar are shown. Channel A is along the braid plain margin and channels B and C are away from the braid plain margin.

The mean annual flow of the Matanuska River is 110 m³/s at Palmer, based on records from 1949–2008 (U.S. Geological Survey, 2008). Peak flows ranging from 420 to 2,300 m³/s typically occur in June or July and often are associated with glacial runoff. The mainstem of the river is turbid from spring through autumn, when glacial runoff is greatest, and is relatively clear beneath an ice cover in winter. Tributaries, the largest of which are Kings and Chickaloon Rivers, originate in the Chugach and Talkeetna Mountains and join the Matanuska along its entire confined length. Lakes occupy less than 1 percent of the Matanuska River's basin (Curran and others, 2003) and are distributed as lakes and ponds 0.5 km² or less in area along the Matanuska Valley bottom.

Five species of Pacific salmon, including Chinook salmon (*Oncorhynchus tshawytscha*), sockeye salmon (*O. nerka*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), and pink salmon (*O. gorbuscha*), spawn and rear in the Matanuska River and its tributaries. Matanuska River salmon contribute to commercial fisheries in Upper Cook Inlet as well as supporting a small sport fishery in the Matanuska River. In 2008, migration of chum, coho, and sockeye salmon into the Matanuska River lasted from July 22 to September 20. In 2008, detections of 263 radio-tagged salmon that were tracked to spawning sites indicated that 90 percent of chum salmon (42 of 46), 98 percent of sockeye salmon (81 of 82), and 45 percent of coho salmon (61 of 135) spawned in the braid plain (Anderson and Bromaghin, 2009).

Methods of Study and Data Collection

Determinations of Channel Distribution, Geomorphic Characteristics, and Salmon Use of Side Channels

Clearwater side channels are defined here as channels that convey water from a non-mainstem source through the braid plain to the turbid mainstem. Thus, the existence of such channels requires a primary water source from a tributary or spring and a mainstem connection at the distal end. For this study of the Matanuska River, where side channels were joined by a slough of the mainstem, the side channel designation was dropped if that slough overwhelmed the volume of the side channel. The presence or absence of fish was not a factor in defining side channels, but the channels needed to be accessible to fish by virtue of a connection to the mainstem.

A true-color orthophotograph derived from 1:24,000-scale aerial photographs taken in October 2006 for a USGS bank erosion study (U.S. Geological Survey, 2006) provided shadow-free base imagery for mapping side channels. Side channels were digitized at a scale of 1:2,300 using

heads-up digitizing in a Geographic Information System (GIS) (appendix A). Additional orthophotographs from 1949 and 1962 aerial photographs provided a comparison of the historical distribution of side channels in the Matanuska River braid plain, and true-color orthophotography from 2004 (below Chickaloon) and satellite imagery from 2005 (above Chickaloon) provided coverage outside the mainstem corridor ([table 1](#)). Orthophotography from additional dates between those of the primary full-river orthophotographs ([table 1](#)) was used to confirm observations and allowed for decadal-scale analysis of side channel persistence downstream from Palmer. In true-color photographs, side channels were detectable as those with bluish (clear) water, and the turbid mainstem and sloughs appeared gray or brown ([fig. 2](#)). In black and white photographs, the clearwater side channels appeared much darker than those carrying turbid water. In areas where historical photography was difficult to interpret, known water sources and patterns of clearwater side channels visible in 2004/2005 and 2006 color aerial orthophotographs were used to verify channel presence. In the lower resolution historical photography, the downstream connection to the mainstem was not always visible but was inferred from the size and position of the channels.

Table 1. Orthophotography and satellite orthoimagery used to determine location, turbidity, braid plain characteristics, and historical conditions of clearwater side channels, Matanuska River, Alaska.

[Abbreviations: m, meter; USGS, U.S. Geological Survey; N/A, not available]

Date(s)	Type	Media	Source	Extent (downstream to upstream location)	Aerial photograph scale	Pixel resolution (m)
08-10-1949, 08-14-1949, 08-15-1949	Orthophotograph mosaic	Black and white	USGS	Mouth of Matanuska River to Matanuska Glacier	1:50,000	0.6096
06-06-1960 ¹ , 05-24-1962	Orthophotograph mosaic	Black and white	USGS	Mouth of Matanuska River to Matanuska Glacier	1:24,000 (1960), 1:40,000 (1962)	0.6096
08-25-1978	Orthophotograph mosaic	Color infrared	Matanuska-Susitna Borough	Mouth of Matanuska River to Palmer	1:64,000	2
09-21-1985	Orthophotograph mosaic	True color	Matanuska-Susitna Borough	Mouth of Matanuska River to Palmer	1:36,000	2
07-19-1990, 08-12-1991	Orthophotograph mosaic	True color	USGS	Mouth of Matanuska River to Palmer	1:40,000	0.6096
1996	Orthophotograph mosaic	True color	Matanuska-Susitna Borough	Mouth of Matanuska River to Palmer	1:24,000	2
06-2004	Orthophotograph mosaic	True color	Natural Resources Conservation Service	Mouth of Matanuska River to Chickaloon	1:24,000	1
2005	DigitalGlobe satellite data	True color	Matanuska-Susitna Borough	Chickaloon to Matanuska Glacier	N/A	1
10-14-2006	Orthophotograph mosaic	True color	USGS	Mouth of Matanuska River to Matanuska Glacier	1:24,000	0.3

¹ 1960 photography was used to create the orthophotograph in a small area near the river mouth that was not covered by the 1962 photography.

Side channels in an active braid plain are by nature ephemeral, so the 2006 condition was used as a baseline. Ground observations and low-elevation aerial surveys confirmed the presence of clear water, thus providing calibration of the process of delineation from the orthophotography. Field observations of clearwater side channels during the first spring and early summer following the October 2006 photography, before river flows could alter channels, provided the most robust confirmation of side channel locations.

For reference, a braid plain centerline was drawn and used to generate braid plain kilometer numbers, starting at the river mouth (at its confluence with the Knik River; [fig. 3](#)). For comparison and discussion purposes, the Matanuska River was divided into six geomorphic reaches on the basis of channel and braid plain characteristics.

Each side channel was assigned attributes in a GIS database describing the type of alluvial surface it flowed through and its position within the braid plain, the water source for the side channel, and the degree of turbidity (clear or semi-turbid) (see appendix A). Channel position, water source, and qualitative turbidity level were assigned on the basis of ground observations, aerial flight reconnaissance, and examination of orthophotographs. The alluvial surface containing the side channel was categorized as either a bar attached to the braid plain margin (channel-margin bar), a mid-channel bar (island), or a flood plain. Most surfaces within the braid plain have been part of the channel within the historical record (57 years from aerial photography plus an estimated 30–50 years from vegetation patterns, or roughly a century) and can be considered bars with ground cover ranging from unvegetated to forested. Flood plains were considered to be indistinctly bounded areas where flooding can occur without lateral migration of the channel and a braid plain cannot be defined. Side channel position was categorized as being either along the braid plain margin or away from the margin, and water source was described as tributary, spring, or a mix of those sources. Where mainstem water joined the side channel, the turbidity descriptor was identified as semi-turbid.

The presence or absence of salmon was determined on the basis of a comprehensive aerial survey on September 13, 2007. For side channels that were not observed during the survey, presence/absence data are noted as “not determined” rather than absent.

Selection of Field Reconnaissance, Intensive-Survey, and Monitoring Sites

A total of 34 field sites ([fig. 3](#)) were identified on the basis of an initial field reconnaissance guided by aerial imagery, existing information about salmon spawning locations, and information that was emerging from a concurrent study of fish distribution being conducted by USFWS. All sites were selected for reconnaissance-level observations and measurements. Seven of the sites were selected for one-time intensive surveys and six of the sites were selected for monitoring. Two monitoring sites, T3 and T4, represent the same tributary, Moose Creek, and are considered a single site for streamwise analyses. [Table 2](#) provides a summary of the data collection activities performed at each site, and appendix A includes a shapefile of field site locations.

The reconnaissance investigation focused on clearwater side channel systems that were identified on aerial imagery or were anecdotally reported by federal and state agencies and others familiar with the area, and on tributaries anecdotally known to contain salmon spawning sites. Field site selection criteria included evidence of use by spawning salmon, primarily the presence of live adult salmon, carcasses, or redds (gravel nests). Preliminary results of concurrent tracking of radio-tagged fish by USFWS (Anderson and Bromaghin, 2009) assisted the site selection process. Reconnaissance-level observations extended from the Matanuska Glacier to the river mouth (braid plain kilometer 101-0) and resulted in the selection of 34 reconnaissance sites along 73 km of river (65 braid plain kilometers) from above Chickaloon to near the river mouth ([fig. 3](#)). Sites included 19 clearwater side channel systems, 4 springs at the heads or margins of side channels, 5 tributaries (1 site at Eska Creek, a tributary to Wolverine Creek, and 2 unnamed creeks, and 2 sites at Moose Creek), and 5 locations at mainstem channels near side channel sites. All sites were reached by short hikes from the road system or by raft.

Following reconnaissance, seven sites were identified for one-time intensive surveys of selected characteristics ([table 2](#)). Intensive survey sites consisted of a reach with salmon redds and at least some areas without redds at selected side channels and tributaries.

Monitoring sites ([fig. 4](#)) were selected for their longitudinal and lateral geographic distribution along the river, representation of water sources, and convenience of access. These sites were intended for repeat measurements or for continuous logging of data. Monitoring sites were assigned USGS site identification numbers for entry into the National Water Information System (NWIS) database ([table 2](#)).

Figure 3. Locations of reconnaissance measurement, survey, and monitoring sites in clearwater side channels, tributaries, springs, and mainstem channels of the Matanuska River, Alaska, 2007–09.

8 Salmon Spawning Habitats in Clearwater Side Channels, Matanuska River, Southcentral Alaska

Table 2. Map numbers, location data, and activities at field sites in clearwater side channels, springs, tributaries, and mainstem channels of the Matanuska River, Alaska, 2007–09.

[Map No.: Shown in [figure 3](#). **Braid plain kilometer:** Sites near tributary mouths were given braid plain kilometer of confluence. **Abbreviations:** USGS, U.S. Geological Survey; N/A, not applicable]

Map No.	Braid plain kilometer	Activities						USGS site identification No.
		Reconnaissance	Intensive survey		Monitoring			
		Surface water attributes	Channel and surface water	Intergavel temperature	Surface water temperature	Intergavel temperature	Streamflow	
Side channel sites								
SC1	72	X						
SC2	67	X		X				
SC3	48	X						
SC4	47	X						
SC5	46	X		X	X	X		614414148410300
SC6	46	X						
SC7	44	X						
SC8	37	X						
SC9	33	X						
SC10	31	X						
SC11	31	X						
SC12	31	X						
SC13	24	X						
SC14	24	X						
SC15	21	X						
SC16	19	X						
SC17	19	X		X				
SC18	15	X		X	X	X	X	613653149045600
SC19	7	X	X	X	X	X	X	613339149062400
Spring sites								
SPR1	48	X						
SPR2	46	X						
SPR3	15	X						
SPR4	8	X						
Tributary sites								
T1	N/A	X						
T2	N/A	X						
T3 ¹	N/A	X				X		614104149031500
T4 ¹	24	X	X		X		X	614024149021600
T5	N/A	X		X	X	X		613928148585500
T6	17	X						
Mainstem sites								
MC1	48	X						
MC2	32	X						
MC3	24	X						
MC4	15	X						
MC5	8	X						

¹T3 and T4 are located on Moose Creek and are considered a single site for the purpose of analysis.

Figure 4. Locations of monitoring sites in clearwater side channels and tributaries of the Matanuska River, Alaska.

Measurements and Monitoring of Surface Water and Channel Characteristics

Field measurements of surface water and channel characteristics were made during reconnaissance, intensive survey, and monitoring activities in 2007–09. Reconnaissance and intensive surveys included measurements of the pH, temperature, conductivity, dissolved oxygen, and turbidity of the water, referred to collectively as water-quality field parameters, as well as measurements of channel depth, width, substrate, and water velocity. Surface-water monitoring included continuous recording of water temperatures and discrete measurements of water-quality field parameters and stream discharge.

Field measurements were made at all reconnaissance sites between April and September 2007 or between March and October 2008. Selected sites were visited on multiple dates for an informal inspection of the temporal variability of water and channel characteristics. Measurements of water-quality field parameters typically consisted of three point readings with a YSI multi-parameter sonde made while wading along a transect across side channels and tributaries, and single point readings at springs and mainstem channels. Instrument calibration and field measurement of water-quality parameters generally followed procedures described in Chapter A6 of the USGS National Field Manual for the Collection of Water-Quality Data (Wilde, variously dated). Water velocity was measured with a Price AA meter, and depth was noted on the wading rod. Channel substrate at reconnaissance sites was qualitatively categorized on the basis of visual observations of the presence of silt, sand, gravel, or cobbles.

Summary statistics were calculated from the reconnaissance data to generally characterize surface-water and channel characteristics in Matanuska River clearwater side channels. Point data were considered to be sufficiently distributed so as to avoid overweighting a particular site, so no transect or site averaging was applied. Data collection was not extensive enough to draw statistically significant comparisons between single transects and areas, between different seasons at a single site, or between different reaches of the river.

Intensive surveys for channel and surface-water characteristics consisted of a single field visit to make more densely spaced measurements of characteristics measured at reconnaissance sites, as well as to make measurements of water-surface gradient and particle size. Site T4 and two reaches at SC19 were surveyed within a 1-week period in August 2007. A reach 60–120 m long containing areas with and

without salmon redds was identified at each site. Measurement points within each reach included all redds observed and a grid of three points along transects spaced about a channel width apart. Measurement locations and reach water-surface elevations were surveyed with a total station surveying instrument. Water-quality parameters and stream velocity and depth were measured using the same methods as for the reconnaissance sites. The median substrate particle size (D_{50}) was visually estimated to the nearest 5 mm, or noted as sand or silt for particles less than 2 mm (Platts and others, 1983).

Surface-water temperature monitoring focused on a single winter period—from September 2008 to May 2009—but included an extended record at one site that documented temperature variability for 2 years. Deployment of the surface-water temperature loggers generally coincided with deployment of the intergravel water temperature loggers (described in a following section) to provide a comparison between surface and subsurface waters. Surface water temperature at each site was monitored with a single continuously recording Onset Hobo Pro v2 thermistor fastened to a steel rod. The thermistors were positioned near the bed so that they would not be exposed to air because of low flows and low water stages, but shallow channel depths and sparse, short deciduous streamside vegetation could have exposed them to the thermal influence of sunlight. The temperature data were collected and processed in general accordance with procedures described in Wagner and others (2006). Field checks of thermistor performance consisted of comparison of temperature indicated by the deployed thermistor to temperatures recorded by a hand held thermistor housed in a hollow steel probe held adjacent to the surface water loggers.

Streamflow monitoring consisted of several discrete measurements of discharge in 2007 and 2008 at side channel monitoring sites SC18 and SC19 and at tributary monitoring site T4. These measurements were opportunistic assessments of flow conditions at the time of site visits for reconnaissance work and were intended as an exploration of streamflow quantity and patterns in the side channels. Water-quality field measurements were made at all six monitoring sites (SC5, SC18, SC19, T3, T4, and T5) along a single transect using the procedures referred to above.

All data collected at monitoring sites, including water-quality field parameters, surface-water temperature, and stream discharge measurements, are stored in the USGS NWIS database and can be accessed at <http://waterdata.usgs.gov/nwis> (see [table 2](#) for site identification numbers).

Measurements and Monitoring of Intergravel Water Temperature

Intergravel water temperatures were mapped over a short reach at intensive survey sites selected for general characterization of the clearwater side channels and tributaries. Single visits were made to side channel sites SC2, SC5, SC17, SC18, and SC19, and to tributary site T5 between September 12 and October 2, 2008. Measurements were made along a 100-m transect that followed the centerline of the channel rather than the thalweg because a thalweg was generally not prominent. At every 10 to 25 m, depending on stream size and desired resolution, measurements were made, perpendicular to the transect, at evenly spaced points (0.5 to 2.5 m apart, again depending on stream size) on each side of the centerline. Measurements of intergravel water temperature were made using an electronic thermistor (Barnant LogR, thermistor data logger, model 600-1075) housed in a slightly flexible steel rod. The rod was inserted to 35 cm, a documented redd depth of sockeye and chum salmon (Montgomery and others, 1996; DeVries, 1997). Where gravel penetration to 35 cm was not possible, the maximum depth of penetration was recorded; 77 percent of the measurement depths were either 30 or 35 cm. Temperature readings were allowed to stabilize before being recorded.

At monitoring sites selected as representative of spawning habitat in the clearwater side channels and tributaries (SC5, SC18, SC19, T3, and T5), temperature data loggers (Onset TidbiT v2 water temperature data loggers) were installed adjacent to redds, at a 35-cm intergravel depth, to document temperatures during the incubation period for observed spawning salmon. Loggers recorded temperature every 15 minutes from September 12, 2008, until April 27, 2009. Field visits to check thermistor performance consisted of comparison of the temperatures indicated by the deployed thermistor to temperatures recorded by a hand held thermistor housed in a hollow steel probe pushed to the depth of the buried loggers. In addition to the data loggers, small containers

called “freeze vials” were installed along right and left banks near data logger locations to determine depth of freeze within the substrate. Freeze vials consisted of a series of four glass vials, filled with water, and secured at 0, 10, 20, and 30 cm within a tube of plastic mesh. Depth of freezing was determined based on breakage of the vials. When retrieved, the data were downloaded from temperature data loggers, and accumulated thermal units (ATUs) were calculated for each intergravel location. ATUs are the sum of mean daily temperature values above freezing and are used to track the development of incubating salmon eggs and embryos (Crisp, 1988). To calculate ATU, only positive mean daily temperatures were summed from date of installation to date of retrieval.

Distribution and Persistence of Side Channels and Their Use by Salmon

In 2006, the Matanuska River contained 105.8 km of clearwater side channels detectable from the 2006 orthophotograph and field observations ([fig. 5](#)). Of these, 42 channel sub-systems with at least one channel longer than 150 m could be identified. Some of these sub-systems consisted of a single channel and others consisted of a network with many small headwater channels that coalesced to form a single larger mainstem. Although the channels occurred in every geomorphic reach of the Matanuska River, they were most abundant in the wide braid plain of the lower river below the Old Glenn Highway bridge (reach 1), at 1.5 km/km², and least common in the single-thread channel of the river near Chickaloon (reach 4), at 0.3 km/km² ([table 3](#)). The sum of side channel lengths in 1 km-long segments of the braid plain correlates well to the braid plain width measured at 1 km transects ([fig. 6](#)).

Table 3. Length, distribution, and density of side channels in six geomorphic reaches of the Matanuska River, Alaska, 2006.

[Reach locations are shown in [figure 5](#). Abbreviations: km, kilometer; km², square kilometer; km/km², kilometer per square kilometer]

Reach	Braid plain kilometer	Reach area (km ²)	Cumulative side channel length (km)	Side channel density (km/km ²)
1	0–14	35.6	53.8	1.5
2	14–25	11.1	.9	.9
3	25–51	13.7	16.2	1.2
4	51–61	1.5	.5	.3
5	61–94	20.5	23.8	1.2
6	94–101	1.4	.7	.5
Study area	0–101	83.8	104.8	1.3

Most side channels in the braid plain are on channel-margin bars (91.7 km) with relatively few on islands (11.8 km) or flood plain (2.3 km) surfaces ([table 4](#)). Side channels most frequently occur away from the braid plain margin (83.4 km) as opposed to along the braid plain margin (22.4 km). The right braid plain (as defined by the area to the right of the main channel's thalweg, viewed in a downstream direction) had more abundant side channels (72.2 km) than did the left braid plain (33.6 km). Much of this length (46.9 km) can be accounted for in the wide, lower part of the braid plain (braid plain kilometers 0–8). Springs were the main water source for clearwater side channels (78.1 km), with only 2.6 km of side channels originating solely from tributaries, and 25.1 km of side channels containing a mixture of tributary and spring water ([table 4](#)). Aerial and ground surveys confirmed the presence of clearwater side channels for 35 percent of the length of side channels delineated from orthophotography ([table 4](#)).

Decadal scale analysis in reaches of the Matanuska River with frequent migration of the mainstem channel shows mainstem channels moving over a period of years to decades, with the relative abundance of side channels remaining fairly stable within a specific reach. Two study areas were selected to examine the process of side channel generation and the persistence of side channel sites over time in areas where the mainstem reoccupied an existing side channel site. The first reach includes a large spring-fed system including site SC19 near Palmer that was analyzed with the aid of comparative orthophotography from 1949, 1978, 1985, and 1996 ([fig. 7](#)). The second reach includes a tributary-influenced site near Sutton that includes T1, a stream locally known as Yellow Creek, that was compared in 1949 and 2006 orthophotography ([fig. 8](#)).

Table 4. Summary of selected attributes of clearwater side channels of the Matanuska River, Alaska, 2006.

[Abbreviation: km, kilometer]

Category	Side channel length (km)	Side channel length (percent)
Type of surface containing the side channel		
Channel-margin bar	91.7	87
Island	11.8	11
Flood plain	2.3	2
Position of side channel within braid plain		
Along margin	22.4	21
Away from margin	83.4	79
Water source		
Spring	78.1	74
Tributary	2.6	2
Tributary and spring	25.1	24
Field check of side channel presence		
Aerial	18.6	17
Aerial and ground	5.0	5
Ground	13.7	13
Not checked	68.6	65
Salmon observations on September 13, 2007		
Present	14.7	14
Not present	.6	1
Not determined	90.5	85

Figure 5. Locations of side channels delineated from 2006 orthophotography, Matanuska River, Alaska.

Figure 6. Total length of side channels in 1 kilometer-long polygons and braid plain width at 1 kilometer transects, Matanuska River, Alaska. Inverse square smoothing was applied to both curves.

Active mainstem channels in the Palmer area occupied the entire extent of the braid plain in 1949, with the main channel against the left braid plain margin and an older vegetated flood plain surface extending beyond that. Clearwater side channels were identified on sparsely vegetated bars along the right braid plain margin (see location A, [fig. 7](#)) and on the flood plain surface (see location B, [fig. 7](#)). In 1978, some of the mainstem channels shifted toward the right bank, inundating the side channel area at location A. Other mainstem channels began a substantial shift in course onto the flood plain surface at location B and additional side channels appeared in this area. In 1985, mainstem channels appear to be consolidating into more discrete courses, with additional vegetated bars, and side channels appear along the right margin of the right bank at location C. By 1996, the mainstem channels have all shifted toward the left bank and onto the flood plain surface, creating a new braid plain at location B. The side channels at location A return ([fig. 7](#), location A) and a network of clearwater side channels develops on a stabilized bar surface along the right bank at location C. These conditions persisted in 2004 and 2006 imagery and were consistent with field observations in 2007 and 2008.

In the Yellow Creek area, active mainstem channels flowed against the left bank in 1949 and a clearwater side channel system fed by the Yellow Creek tributary extended for more than 2 km against the right braid plain margin on a sparsely vegetated surface ([fig. 8](#)). By 2006, the mainstem channels migrated toward the right bank and occupied most of the side channel system on the right bank. On the left bank, a new side channel system has developed on a sparsely vegetated bar and is fed by an unnamed tributary that emptied directly into mainstem channels at the braid plain margin in 1949.

In the two areas examined, side channel abundance was maintained primarily by creation of new side channels in recently abandoned braid plain areas. In the Palmer area, a particular location supported a side channel whenever not occupied by the mainstem. Coupled with the observation of clearwater side channels throughout the study area, this suggests that side channels formed readily under the channel migration regime of the past six decades and that springs and tributaries were persistent water sources for the side channels whenever not inundated by the mainstem.

A reconnaissance assessment of salmon use from an aerial flight survey on September 13, 2007, showed that salmon were generally distributed in side channels across most of the study area. The survey was conducted prior to delineation of channels from orthophotography and made observations of only channels readily detectable from an airplane flying at low altitude. The survey identified 14.7 km of side channels with salmon present and less than 1 km of side channels with no salmon present ([table 4](#), [fig. 9](#)). The additional 90.5 km of side channels detected later from orthophotography were beyond the survey area, were tributaries to the aerially-surveyed reaches, or were missed during the aerial survey. Shallow depths and clear water created good conditions for visibly detecting fish in the side channels from the air or from the ground ([fig. 10](#)). Ground observations of fish showed that sockeye and chum salmon were the most common species in the side channels and often were together; coho salmon occupied some side channels but were more common in tributaries. Based on the trapping results of Anderson and Bromaghin (2009), the aerial survey occurred after most salmon would have migrated into spawning reaches (which, in 2009, was on September 10). It is possible that some fish had already spawned and left spawning sites, but ground surveys indicated that fish were still present in all sites visited on foot.

Figure 7. Clearwater side channels and mainstem from braid plain kilometer 3–9 in 1949, 1978, 1985, and 1996, Matanuska River, Alaska. Over the time period shown, location A cycles from a clearwater side channel to mainstem and back to a clearwater side channel. Location B transitions from a flood plain to braid plain and has varying amounts of clearwater side channels. Location C transitions from mainstem to an abandoned braid plain with long clearwater side channels.

Figure 8. Clearwater side channels and tributaries from braid plain kilometers 37–40 in 1949 and 2006, Matanuska River, Alaska.

Figure 9. Salmon presence/absence survey limits and results, Matanuska River, Alaska, September 13, 2007.

Figure 10. Salmon in a clearwater side channel of the Matanuska River, Alaska. (Photograph taken by Christian Zimmerman, U.S Geological Survey, August 28, 2007.)

Hydrologic, Physical, and Water-Quality Characteristics of Side Channels

Measurements of surface water flow and quality, intergravel temperature, and channel characteristics provided data for (1) generally characterizing the clearwater side channels, (2) comparing the water-quality characteristics of surface water in side channels to surface water at their sources (tributaries and springs within the braid plain) and in the mainstem, (3) contrasting surface water and channel characteristics at sites selected by salmon for spawning to those not selected for spawning within the same reach, and (4) comparing intergravel water temperature to surface water temperature, and comparing intergravel water temperature between side channels and tributaries, during salmon spawning and incubation periods. The characterization and comparisons in items 1 and 2 drew from the reconnaissance data collected as point measurements at 19 sites over 65 braid plain kilometers (fig. 3) and from additional measurements at 6 of those sites designated as monitoring sites (fig. 4). Salmon spawning site selection analysis drew from intensive survey data collected at two locations at side channel site SC19 near Palmer and at a single location at tributary site T4, Moose

Creek (fig. 4). Intergravel water temperature analysis drew from intensive survey data collected at 6 sites and monitoring at 5 sites.

Side channel reconnaissance point measurements were made when spawning salmon were present in August and September of 2007 and 2008, while measurements at springs and tributaries were made in spring (March, April, or May) and autumn (August, September, or October) of those years. Surface water and channel characteristics measured at these sites are presented in table 5 and summarized in table 6 for comparison. Care should be taken in interpreting seasonally-affected variables, such as water temperature, as the periods for measurement varied between types of stream listed in the summary tables. Summary statistics shown in table 6 are average values, except that for pH, which is presented as the median of the pH values to show the distribution of values (rather than the true average computed as the negative logarithm of the average of the hydrogen ion concentrations), and turbidity, which is represented by median values to account for the wide range and multimodal distribution of the values for this property. Additional water-quality field parameter data collected at monitoring sites along the Matanuska River in April, August, and September 2007 and in February and March of 2008 can be accessed at <http://waterdata.usgs.gov/nwis>.

Table 5. Surface water and channel characteristic reconnaissance data for clearwater side channels, springs, tributaries, and mainstem streams, Matanuska River, Alaska, 2007–08.

[Shading indicates transect grouping. **Abbreviations:** m, meter; m/s, meter per second; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; NTU, nephelometric turbidity units; GW, groundwater; main, mainstem; trib, tributary; org. mat., organic material; coho, coho salmon; sockeye, sockeye salmon; <, less than; – not available; N/A, not applicable]

Point identifier	Map No.	Date	Depth (m)	Wetted width (m)	Velocity (m/s)	Temperature (°C)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	pH	Turbidity (NTU)	Water source	Particle size	Fish species observed
Side Channels													
LongLakeXS1WP215	SC1	09-26-2007	0.17	3.5	<0.03	6.2	483	10.3	8.2	<1.0	GW	gravel, cobble	coho
LongLakeXS1WP216	SC1	09-26-2007	.17		<0.03	6.2	483	10.5	8.2	<1.0			
LongLakeXS1WP217	SC1	09-26-2007	.08		<0.03	6.3	483	10.5	8.2	<1.0			
RileyCreekXS1WP278.1	SC2	09-30-2008	.15	–	.09	–	–	–	–	–	GW	–	–
RileyCreekXS1WP278.2	SC2	09-30-2008	.15		.20	–	–	–	–	–			
RileyCreekXS2WP285.1	SC2	09-30-2008	.17	3.5	.09	–	–	–	–	–	GW	–	–
RileyCreekXS2WP285.2	SC2	09-30-2008	.15		<.03	–	–	–	–	–			
PinnacleXS1WP181	SC3	09-06-2007	.24	8.7	.22	9.5	353	11.5	6.6	22	GW, main	sand, gravel, cobble	chum, sockeye
PinnacleXS1WP182	SC3	09-06-2007	.26		.09	9.2	359	11.5	6.7	22			
PinnacleXS1WP180	SC3	09-06-2007	.09		.10	9.9	338	11.2	6.7	29			
PinnacleXS2WP185	SC3	09-06-2007	.09	2.1	.18	6.5	386	9.7	6.4	10	GW, main	sand, gravel	–
PinnacleXS2WP183	SC3	09-06-2007	.09		.14	6.2	386	10.4	6.4	55			
OppositePinnacleXS1WP3.1	SC4	09-05-2007	.09	2.5	.12	8.7	381	10.5	7.5	–	GW	silt, gravel	–
OppositePinnacleXS1WP3.2	SC4	09-05-2007	.09		.14	6.8	400	10.8	7.4	–			
OppositePinnacleXS2WP3.3	SC4	09-05-2007	.15	2.3	<.03	7.8	387	11.6	7.6	–	GW	silt, gravel	coho
OppositePinnacleXS2WP3.4	SC4	09-05-2007	.15		<.03	7.6	388	11.9	7.5	–			
OppositePinnacleXS3WP3.5	SC4	09-05-2007	.12	5.1	.05	8.1	387	10.8	7.4	–	GW	–	sockeye
OppositePinnacleXS3WP3.6	SC4	09-05-2007	.18		<.03	8.0	387	10.9	7.4	–			
OppositePinnacleXS3WP3.7	SC4	09-05-2007	.30		<.03	8.0	386	10.8	7.4	–			
PinnacleDSXS1WP169	SC5	09-06-2007	.11	3.8	.18	8.3	406	7.7	6.9	3	GW	gravel	chum, sockeye
PinnacleDSXS1WP168	SC5	09-06-2007	.12		.21	7.4	403	8.6	6.7	4			
PinnacleDSXS1WP167	SC5	09-06-2007	.12		.11	6.8	403	8.7	6.8	5			
PinnacleDSXS2WP172	SC5	09-06-2007	.09	4.0	.19	8.6	406	7.6	6.4	2	GW	gravel	chum
PinnacleDSXS2WP171	SC5	09-06-2007	.09		.18	7.2	402	8.3	6.3	3			
PinnacleDSXS2WP170	SC5	09-06-2007	.09		.20	6.6	401	8.8	6.4	14			
PinnacleDSXS3WP173	SC5	09-06-2007	.09	4.1	<.03	5.9	399	8.8	6.3	3	GW	–	chum, sockeye
PinnacleDSXS3WP174	SC5	09-06-2007	.12		.16	5.8	398	8.8	6.2	6			
PinnacleDSXS3WP175	SC5	09-06-2007	.12		.17	5.8	396	8.6	6.3	8			
PinnacleDSXS4WP176	SC5	09-06-2007	.12	3.5	.12	5.7	397	8.9	6.3	3	GW	–	chum, sockeye
PinnacleDSXS4WP178	SC5	09-06-2007	.12		.14	5.8	398	8.4	6.4	3			
PinnacleDSXS4WP177	SC5	09-06-2007	.09		<.03	5.7	397	8.7	6.3	7			
PinnacleDSXS1WP328	SC5	08-28-2008	.19	3.9	–	10.5	441	6.0	6.7	<1.0	GW	gravel, cobble	chum, sockeye, Dolly Varden
PinnacleDSXS1WP329	SC5	08-28-2008	.34		–	10.5	442	5.6	6.7	<1.0			
PinnacleDSXS1WP330	SC5	08-28-2008	.41		–	10.5	443	5.4	6.7	<1.0			
PinnacleDSXS2WP332	SC5	08-28-2008	.13	7.3	–	9.8	439	5.8	7.0	<1.0	GW	sand, gravel, cobble	chum, sockeye
PinnacleDSXS2WP333	SC5	08-28-2008	.24		–	10.8	439	5.2	7.0	<1.0			
PinnacleDSXS2WP331	SC5	08-28-2008	.10		–	9.3	443	6.1	7.0	<1.0			

Table 5. Surface water and channel characteristic reconnaissance data for clearwater side channels, springs, tributaries, and mainstem streams, Matanuska River, Alaska, 2007–08.—Continued

[Shading indicates transect grouping. **Abbreviations:** m, meter; m/s, meter per second; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; NTU, nephelometric turbidity units; GW, groundwater; main, mainstem; trib, tributary; org. mat., organic material; coho, coho salmon; chum, chum salmon; sockeye, sockeye salmon; <, less than; – not available; N/A, not applicable]

Point identifier	Map No.	Date	Depth (m)	Wetted width (m)	Velocity (m/s)	Temperature (°C)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	pH	Turbidity (NTU)	Water source	Particle size	Fish species observed
Side Channels—Continued													
PinnacleDSXS3WP334	SC5	08-28-2008	.29	14.9	–	7.8	437	7.0	7.1	2	GW	org. mat., silt, sand, gravel	sockeye
PinnacleDSXS3WP335	SC5	08-28-2008	.32	–	–	7.9	436	6.7	7.1	5			
PinnacleDSXS3WP336	SC5	08-28-2008	.54	–	–	8.5	437	6.0	7.2	5			
PinnacleDSXS5WP338	SC6	08-28-2008	0.21	4.6	–	8.2	278	13.1	7.5	380	GW, main	gravel, cobble	none
PinnacleDSXS5WP339	SC6	08-28-2008	.23	–	–	8.1	278	12.7	7.5	400			
PinnacleDSXS5WP340	SC6	08-28-2008	.24	–	–	8.2	278	12.8	7.5	402			
PinnacleDSXS6WP341	SC6	08-28-2008	.17	6.1	–	9.3	336	10.2	7.6	262	GW, main	gravel, cobble	chum, sockeye
PinnacleDSXS6WP343	SC6	08-28-2008	.23	–	–	9.3	332	10.6	7.6	263			
PinnacleDSXS6WP342	SC6	08-28-2008	.23	–	–	9.2	330	10.5	7.6	282			
KingsRiverXS1WP189	SC7	09-06-2007	.12	5.6	0.23	10.0	348	11.3	6.6	2	GW	sand, gravel	chum
KingsRiverXS1WP190	SC7	09-06-2007	.09	–	.20	9.9	345	11.4	6.6	2			
KingsRiverXS1WP188	SC7	09-06-2007	.17	–	.33	9.7	338	11.3	6.6	3			
KingsRiverXS2WP192	SC7	09-06-2007	.14	6.6	<.03	10.3	369	9.4	6.7	<1.0	GW	sand, gravel, cobble	sockeye
KingsRiverXS2WP193	SC7	09-06-2007	.22	–	<.03	10.3	371	9.1	6.7	6			
KingsRiverXS2WP191	SC7	09-06-2007	.12	–	<.03	8.5	371	8.4	6.7	14			
KingsRiverXS3WP194	SC7	09-06-2007	.11	3.0	.04	10.3	369	10.1	6.8	<1.0	GW	–	sockeye
KingsRiverXS3WP195	SC7	09-06-2007	.12	–	.09	10.9	370	10.9	6.8	1			
OppositeYCXS2WP4.4	SC8	09-05-2007	.14	14.8	.09	9.3	185	11.7	7.4	–	trib	–	sockeye
OppositeYCXS2WP4.3	SC8	09-05-2007	.18	–	.48	8.9	176	11.7	7.3	–			
OppositeYCXS2WP4.2	SC8	09-05-2007	.15	–	.33	9.1	179	11.7	7.4	–			
EskaCreekXS2WP206	SC9	09-12-2007	.11	3.5	.26	7.7	285	10.0	8.2	<1.0	GW	sand, gravel	chum
EskaCreekXS2WP205	SC9	09-12-2007	.09	–	.25	7.8	285	8.6	8.2	<1.0			
EskaCreekXS2WP207	SC9	09-12-2007	.14	–	.12	7.7	285	9.7	8.2	<1.0			
EskaCreekXS3WP17	SC9	09-11-2008	.15	3.0	–	8.3	280	10.5	9.3	<1.0	GW	sand, gravel, cobble	chum
EskaCreekXS3WP18	SC9	09-11-2008	.09	–	–	8.3	287	10.5	9.1	<1.0			
EskaCreekXS3WP19	SC9	09-11-2008	.11	–	–	8.2	286	10.3	9.0	<1.0			
EskaCreekXS4WP22	SC9	09-11-2008	.21	10.4	–	8.2	286	10.3	8.7	<1.0	GW	sand, gravel	chum, sockeye
EskaCreekXS4WP20	SC9	09-11-2008	.18	–	–	8.2	288	10.4	8.9	<1.0			
EskaCreekXS4WP21	SC9	09-11-2008	.18	–	–	8.1	286	10.4	8.8	<1.0			
EskaCreekXS3WP209	SC10	09-12-2007	.12	7.0	.38	7.4	96	12.8	7.9	8	trib	gravel	sockeye
EskaCreekXS3WP210	SC10	09-12-2007	.37	–	.48	7.4	96	12.5	7.8	8			
EskaCreekXS3WP211	SC10	09-12-2007	.46	–	.26	7.4	96	12.8	7.8	8			
EskaCreekXS1WP13	SC10	09-11-2008	.11	4.0	–	7.2	115	10.5	7.6	<1.0	trib	gravel, cobble	chum, coho, sockeye
EskaCreekXS1WP11	SC10	09-11-2008	.12	–	–	7.3	115	10.6	7.6	<1.0			
EskaCreekXS1WP12	SC10	09-11-2008	.15	–	–	7.2	115	10.8	7.6	<1.0			
EskaCreekXS2WP16	SC11	09-11-2008	.18	6.6	–	7.1	125	11.3	7.7	5	main, trib	gravel, cobble	coho, sockeye
EskaCreekXS2WP14	SC11	09-11-2008	.15	–	–	7.1	127	11.4	7.7	5			
EskaCreekXS2WP15	SC11	09-11-2008	.11	–	–	7.1	125	11.3	7.6	5			

Table 5. Surface water and channel characteristic reconnaissance data for clearwater side channels, springs, tributaries, and mainstem streams, Matanuska River, Alaska, 2007–08.—Continued

[Shading indicates transect grouping. **Abbreviations:** m, meter; m/s, meter per second; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; NTU, nephelometric turbidity units; GW, groundwater; main, mainstem; trib, tributary; org. mat., organic material; coho, coho salmon; chum, chum salmon; sockeye, sockeye salmon; <, less than; – not available; N/A, not applicable]

Point identifier	Map No.	Date	Depth (m)	Wetted width (m)	Velocity (m/s)	Temperature (°C)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	pH	Turbidity (NTU)	Water source	Particle size	Fish species observed
Side Channels—Continued													
EskCreekXS4WP212	SC12	09-12-2007	0.24	9.1	0.68	6.9	165	11.5	7.9	131	main, trib	–	sockeye
EskCreekXS4WP214	SC12	09-12-2007	.27		.59	6.9	164	11.9	7.9	135			
EskCreekXS4WP213	SC12	09-12-2007	.37		.60	6.9	163	11.6	7.9	136			
MooseCreekXS2WP5.1	SC13	08-29-2007	.17	–	.13	6.0	157	8.7	7.8	34	GW, main	–	–
MooseCreekXS2WP5.2	SC13	08-29-2007	.09		.14	7.6	238	9.6	7.7	55			
MooseCreekXS2WP5.3	SC13	08-29-2007	.11		.33	7.7	242	9.9	7.8	55			
MooseCreekXS3WP5.4	SC14	08-29-2007	.08	–	.09	7.3	250	8.2	7.7	<1.0	GW	–	–
MooseCreekXS3WP5.5	SC14	08-29-2007	.09		.09	6.2	298	8.5	7.7	<1.0			
WolCreekUSXS5WP215	SC15	09-24-2008	.12	5.6	.06	5.2	318	10.7	8.2	<1.0	GW	sand, gravel	chum, sockeye
WolCreekUSXS5WP216	SC15	09-24-2008	.18		.26	5.1	318	10.6	8.1	<1.0			
WolCreekUSXS5WP217	SC15	09-24-2008	.18		.17	5.1	319	10.5	8.1	<1.0			
WolCreekDSXS1WP206	SC16	09-24-2008	.12	10.2	<.03	9.4	301	10.5	8.1	<1.0	GW	sand, gravel, cobble	sockeye
WolCreekDSXS1WP204	SC16	09-24-2008	.15		<.03	8.1	318	9.5	8.1	<1.0			
WolCreekDSXS1WP205	SC16	09-24-2008	.18		<.03	9.5	308	10.5	8.1	<1.0			
WolCreekDSXS2WP207	SC17	09-24-2008	.09	2.3	–	6.8	346	8.1	8.3	<1.0	GW	sand, gravel	sockeye
WolCreekDSXS2WP208	SC17	09-24-2008	.09		–	6.7	347	7.8	8.2	<1.0			
WolCreekDSXS3WP209	SC17	09-24-2008	.24	3.7	.05	6.8	347	8.6	8.6	<1.0	GW	sand	sockeye
WolCreekDSXS3WP211	SC17	09-24-2008	.15		.15	6.8	347	8.3	8.3	<1.0			
WolCreekDSXS3WP210	SC17	09-24-2008	.21		.17	6.8	347	8.3	8.4	<1.0			
WolCreekDSXS4WP212	SC17	09-24-2008	.09	3.4	–	6.8	347	8.5	8.6	1	GW	sand, gravel	sockeye
WolCreekDSXS4WP213	SC17	09-24-2008	.09		–	6.8	348	8.5	8.5	1			
WolCreekDSXS4WP214	SC17	09-24-2008	.06		–	6.8	347	8.6	8.4	2			
LazyMountainXS1WP2	SC18	09-03-2008	.30	8.3	–	5.8	326	9.5	7.9	5	GW	gravel, cobble	chum, sockeye
LazyMountainXS1WP3	SC18	09-03-2008	.47		–	5.7	321	10.0	8.0	5			
LazyMountainXS1WP4	SC18	09-03-2008	.38		–	6.0	315	10.2	8.0	5			
LazyMountainXS2WP7	SC18	09-03-2008	.29	16.6	–	5.9	314	10.6	8.1	5	GW	silt, gravel, cobble	chum, sockeye
LazyMountainXS2WP6	SC18	09-03-2008	.47		–	5.9	319	9.9	8.0	6			
LazyMountainXS2WP5	SC18	09-03-2008	.36		–	6.0	329	9.0	7.9	7			
RiverBendXS1WP240	SC19	09-25-2008	.26	10.1	.23	5.4	337	12.8	8.0	<1.0	GW	sand, gravel, cobble	sockeye
RiverBendXS1WP238	SC19	09-25-2008	.24		.23	5.4	338	12.4	8.0	<1.0			
RiverBendXS1WP241	SC19	09-25-2008	.21		<.03	5.3	338	12.8	8.0	<1.0			
RiverBendXS1WP242	SC19	09-25-2008	.15		.23	5.3	338	12.8	8.0	<1.0			
RiverBendXS1WP243	SC19	09-25-2008	.09		.35	5.3	337	13.2	8.0	<1.0			
RiverBendXS2WP246	SC19	09-25-2008	.18	13.4	.34	5.5	337	13.4	8.0	<1.0	GW	sand, gravel, cobble	sockeye
RiverBendXS2WP248	SC19	09-25-2008	.18		.22	5.4	337	13.3	8.0	<1.0			
RiverBendXS2WP244	SC19	09-25-2008	.15		.09	5.7	337	13.7	8.0	<1.0			
RiverBendXS2WP245	SC19	09-25-2008	.20		.25	5.6	336	13.3	8.0	<1.0			
RiverBendXS2WP247	SC19	09-25-2008	.15		.32	5.5	337	13.3	8.0	<1.0			

Table 5. Surface water and channel characteristic reconnaissance data for clearwater side channels, springs, tributaries, and mainstem streams, Matanuska River, Alaska, 2007–08.—Continued

[Shading indicates transect grouping. **Abbreviations:** m, meter; m/s, meter per second; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; NTU, nephelometric turbidity units; GW, groundwater; main, mainstem; trib, tributary; org. mat., organic material; chum, coho salmon; sockeye, sockeye salmon; <, less than; – not available; N/A, not applicable]

Point identifier	Map No.	Date	Depth (m)	Wetted width (m)	Velocity (m/s)	Temperature (°C)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	pH	Turbidity (NTU)	Water source	Particle size	Fish species observed
Side Channels—Continued													
RiverBendXS3WP249	SC19	09-25-2008	0.09	17.0	0.07	5.8	336	13.9	8.0	<1.0	GW	sand, gravel, cobble	sockeye
RiverBendXS3WP250	SC19	09-25-2008	.18		.11	5.8	336	13.8	8.0	<1.0			
RiverBendXS3WP252	SC19	09-25-2008	.21		.14	5.7	338	13.7	8.0	<1.0			
RiverBendXS3WP251	SC19	09-25-2008	.18		.13	5.7	337	13.8	8.0	<1.0			
RiverBendXS3WP253	SC19	09-25-2008	.24		.09	5.6	338	13.6	8.0	<1.0			
Springs													
PinnacleWP015	SPR1	05-03-2007	–	–	–	2.1	415	9.9	7.4	<1.0	N/A	N/A	N/A
PinnacleWP2.1_1	SPR1	09-06-2007	–	–	–	7.2	384	7.3	6.3	1	N/A	N/A	N/A
PinnacleWP2.1_2	SPR1	09-06-2007	–	–	–	7.3	383	7.5	6.4	2	N/A	N/A	N/A
PinnacleDSWP035	SPR2	05-03-2007	–	–	–	3.1	426	9.9	7.5	<1.0	N/A	N/A	N/A
LazyMountainWP8_1	SPR3	09-03-2008	–	–	–	5.5	355	5.9	7.8	–	N/A	N/A	N/A
LazyMountainWP8_2	SPR3	09-03-2008	–	–	–	5.8	355	6.2	7.7	–	N/A	N/A	N/A
RiverBendWP002	SPR4	04-23-2007	–	–	–	3.0	312	9.5	7.8	<1.0	N/A	N/A	N/A
Tributaries													
YellowCreekXS1WP197	T1	09-06-2007	0.27	4.3	0.04	10.8	347	10.3	6.7	2	N/A	org. mat., gravel, cobble	sockeye
YellowCreekXS1WP198	T1	09-06-2007	.21		<.03	10.9	347	10.2	6.7	3			
YellowCreekXS1WP196	T1	09-06-2007	.24		<.03	10.9	349	10.6	6.8	3			
YellowCreekXS2WP199	T1	09-06-2007	.15	2.1	.13	10.9	347	11.1	6.8	2	N/A	gravel	sockeye
YellowCreekXS2WP201	T1	09-06-2007	.15		.16	10.9	346	10.6	6.7	3			
YellowCreekXS2WP200	T1	09-06-2007	.15		.15	10.9	347	10.7	6.8	5			
EskaCreekXS1WP204	T2	09-12-2007	.37	6.2	.98	7.1	94	12.1	7.9	8	N/A	gravel	sockeye
EskaCreekXS1WP202	T2	09-12-2007	.15		.53	7.1	94	12.1	7.9	8			
EskaCreekXS1WP203	T2	09-12-2007	.35		.75	7.1	94	12.2	7.9	9			
EskaCreekXS6WP26	T2	09-11-2008	.15	9.1	–	7.1	99	13.4	8.4	1	N/A	gravel, cobble	none
EskaCreekXS6WP25	T2	09-11-2008	.18		–	7.1	99	13.4	8.4	3			
EskaCreekXS6WP24	T2	09-11-2008	.12		–	7.1	99	13.4	8.4	7			
MooseCreekXS1WP313	T3	10-09-2008	.58	10.4	.41	.8	115	14.2	7.8	<1.0	N/A	gravel, cobble	coho
MooseCreekXS1WP311	T3	10-09-2008	.40		.60	.8	115	14.3	7.8	<1.0			
MooseCreekXS1WP312	T3	10-09-2008	.58		.68	.8	115	14.2	7.8	<1.0			
MooseCreekXS1WP309	T3	10-09-2008	.21		.48	.7	115	14.3	7.8	<1.0			
MooseCreekXS1WP310	T3	10-09-2008	.37		.43	.8	115	14.3	7.8	1			
MooseCreekXS2WP315	T3	10-09-2008	.34	12.6	.66	.8	115	14.2	7.9	<1.0	N/A	cobble, gravel	coho
MooseCreekXS2WP318	T3	10-09-2008	.15		.34	.9	115	14.2	7.9	<1.0			
MooseCreekXS2WP314	T3	10-09-2008	.40		.88	.8	115	14.3	7.9	<1.0			
MooseCreekXS2WP316	T3	10-09-2008	.27		.72	.8	115	14.2	7.9	<1.0			
MooseCreekXS2WP317	T3	10-09-2008	.24		.66	.8	115	14.2	7.9	<1.0			

Table 5. Surface water and channel characteristic reconnaissance data for clearwater side channels, springs, tributaries, and mainstem streams, Matanuska River, Alaska, 2007–08.—Continued

[Shading indicates transect grouping. **Abbreviations:** m, meter; m/s, meter per second; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; NTU, nephelometric turbidity units; GW, groundwater; main, mainstem; trib, tributary; org. mat., organic material; coho, coho salmon; chum, chum salmon; sockeye, sockeye salmon; <, less than; – not available; N/A, not applicable]

Point identifier	Map No.	Date	Depth (m)	Wetted width (m)	Velocity (m/s)	Temperature (°C)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	pH	Turbidity (NTU)	Water source	Particle size	Fish species observed
Tributaries—Continued													
MooseCreekXS1WP228	T4	03-20-2008	–	5.9	–	0.1	150	14.1	8.7	<1.0	N/A	gravel, cobble, boulder	–
MooseCreekXS1WP229	T4	03-20-2008	–	–	–	.1	150	14.1	8.4	<1.0			
MooseCreekXS1WP230	T4	03-20-2008	–	–	–	.1	150	14.1	8.3	<1.0			
MooseCreekXS1WP231	T4	03-20-2008	–	–	–	.1	150	14.1	8.2	<1.0			
MooseCreekXS1WP232	T4	03-20-2008	–	–	–	.1	150	14.1	8.1	<1.0			
WolverineXS1WP300	T5	10-02-2008	0.21	4.4	0.15	4.9	154	12.6	8.6	<1.0	N/A	sand, gravel, cobble	coho
WolverineXS1WP299	T5	10-02-2008	.15	–	.20	4.9	154	12.6	8.6	<1.0			
WolverineXS1WP301	T5	10-02-2008	.27	–	.10	4.9	154	12.6	8.6	<1.0			
WolverineXS2WP16.1	T5	10-02-2008	.18	3.4	.23	4.9	154	12.7	8.6	1	N/A	sand, gravel	–
WolverineXS2WP16.2	T5	10-02-2008	.15	–	.37	4.9	154	12.7	8.6	1			
WolverineXS2WP16.3	T5	10-02-2008	.18	–	.09	4.9	154	12.7	8.6	2			
WolverineXS3WP303	T5	10-02-2008	.12	3.3	.35	4.9	154	12.8	8.7	<1.0	N/A	gravel, cobble	–
WolverineXS3WP304	T5	10-02-2008	.21	–	.10	5.0	154	12.8	8.7	<1.0			
WolverineXS3WP302	T5	10-02-2008	.12	–	.24	4.9	154	12.8	8.7	<1.0			
LazyMountainWP046	T6	05-04-2007	–	–	–	1.9	104	14.5	7.6	17	N/A	–	–
Mainstem													
PinnacleWP019	MC1	05-03-2007	–	–	–	1.8	377	14.8	7.8	136	N/A	–	–
EskaCreekMatRWP208	MC2	09-12-2007	–	–	–	5.1	251	15.6	8.2	610	N/A	–	–
MooseCreekMatRWP6.1	MC3	08-29-2007	–	–	–	9.5	218	10.1	7.6	100	N/A	–	–
LazyMountainWp9	MC4	09-03-2008	–	–	–	7.7	298	11.7	8.2	–	N/A	–	–
RiverBendMatRWP013	MC5	04-23-2007	–	–	–	.9	308	14.4	7.9	168	N/A	–	–

Table 6. Summary statistics for spring-autumn surface water and channel characteristic reconnaissance data for side channels and source waters, Matanuska River, Alaska.

[**Abbreviations:** m, meter; m/s, meter per second; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; NTU, nephelometric turbidity unit; – not available; <, less than]

Stream type	Number of measurements	Mean wetted width (m)	Mean depth (m)	Mean velocity (m/s)	Mean spring-autumn temperature (°C)	Mean specific conductance (µS/cm)	Mean dissolved oxygen (mg/L)	Median pH	Median turbidity (NTU)
Side channels									
Groundwater-fed	103	7.0	0.17	0.13	7.4	352	10.0	7.7	<1
Tributary-fed	15	8.3	.21	.43	7.6	136	11.6	7.7	7.5
Source waters									
Springs	7	–	–	–	4.9	376	8.0	7.5	<1
Tributaries	37	6.8	0.25	0.37	4.4	164	13.0	7.9	<1

Physical Characteristics and Riparian Vegetation

The physical characteristics of clearwater side channels were similar over the length of the study area. Most were wide and shallow (averaging 7.6 m wide and 0.18 m deep and a width/depth ratio of 40), with few bedforms such as pools or bars. Tributary-fed side channels averaged more than a meter wider than the groundwater-fed side channels (table 6). Substrates consisted of gravel with differing amounts of cobbles, sand, or silt. Sand and silt were commonly present as a drape over the gravelly bed, which observations suggest is likely the result of bioturbation during construction of redds. Short riffles interrupted long runs in many of the channels. Large woody debris, such as logs or trees with root wads, was scarce. Surveyed water-surface gradients of 0.0013 and 0.00018 at intensive survey sites SC19 (a) and SC19 (b), respectively, confirmed observations that side channel gradients were typically relatively gentle. Flow velocities in the side channels were low, regardless of whether fed by a tributary or a spring, with only one measurement exceeding 0.6 m/s. For comparison, similarly-sized tributaries with spawning sites had, on average, a width/depth ratio of 27, more and deeper pools, and steeper slopes (for example, the surveyed water surface gradient at T4 was 0.0058) than did the side channels, and tributaries, on average, had higher velocities than groundwater-fed side channels (table 6).

Riparian vegetation in the braid plain ranged from a sparse cover of small low-lying shrubs on young gravel bars to small shrubs and patches of taller shrubs including alders, willow, and cottonwoods on older bars. On the oldest vegetated surfaces in the braid plain, the vegetation consisted of mature stands of cottonwood and spruce trees. The side channel margins commonly supported a narrow vegetated corridor in which plants were denser than on the surrounding vegetated surface and included cottonwood, alder, and willow saplings, as well as horsetails, sedges, and moss. By contrast,

the vegetation bordering Matanuska River tributary streams commonly consisted of a stable mature forest with large cottonwoods and willows lining the banks. A subcanopy of tall alder shrubs densely covered the tributary banks, with fewer low sedges and mosses lining the banks than on the braid plain surfaces.

Surface Water Characterization and Comparison to Source Waters

Water temperatures during the August and September reconnaissance visits to the side channels averaged 7.5 °C. Despite the lack of vegetative cover and shallow depths, recorded water temperatures at reconnaissance sites never exceeded 11 °C. Data from the continuously logging thermistor at site SC19, a side channel near Palmer, show the maximum temperature over the summers of 2007 and 2008 was 12.1 °C (fig. 11). Relatively warm winter water temperatures noticeably distinguished the side channels from most mainstem channels and from tributaries. Unlike the mainstem and tributaries, side channels rarely froze over completely (fig. 12); site SC19 was observed to be ice-free even after several weeks of air temperatures below -18 °C. Temperature loggers recorded the coldest surface-water temperatures in December through February, with an average over that period ranging from 0.5 to 2.4 °C for the three side channel monitoring sites.

The specific conductance of water can be used to indicate its ionic content, or the concentration of dissolved solids. In the clearwater channels of the Matanuska River, specific conductance varied consistently with the source of the water. Specific conductance of the water averaged 352 µS/cm in groundwater-fed side channels, but was much less, an average of 136 µS/cm, in tributary-fed side channels (table 6). For comparison, specific conductance of water near the margins of mainstem Matanuska River channels averaged 290 µS/cm.

Figure 11. Maximum, mean, and minimum daily surface water temperatures at side channel monitoring site SC19, Matanuska River, Alaska, 2007–09.

Figure 12. Lack of ice cover typical of winter conditions in clearwater side channels, site SC18, Matanuska River, Alaska. (Photograph taken by Janet Curran, U.S. Geological Survey, February 10, 2009.)

Dissolved oxygen and pH are important factors for the health of aquatic life and can be critical factors to some organisms. In the clearwater side channels, dissolved oxygen concentration averaged 11 mg/L. The pH of the side channels ranged from 6.2 to 9.3, but median pH was similar for side channels, tributaries, and springs ([table 6](#)).

The side channels, by definition, contain clear water, and turbidity measurements supported the visual observations of water clarity. The turbidity of water in groundwater-fed side channels was typically less than 1 nephelometric turbidity unit (NTU) and ranged from less than 1 to 136 NTU in channels with a tributary water source. Side channels downstream of a confluence with a similarly small turbid channel had turbidities as high as 402 NTU. Turbidities in mainstem channels of the Matanuska River ranged from 100 to greater than 600 NTU ([table 5](#)).

Trends in the reconnaissance data show that the water in the side channels retains the chemical characteristics of its source water. The strongest evidence for this is shown in the

specific conductance values of the water in the side channels, which correlated closely with those of the primary source of the water ([fig. 13](#)). Specific conductance commonly is higher in groundwater than in rainwater, snowmelt, or glacial meltwater because of its longer contact time with rock and (or) soils. The average specific conductance of the springs that provide source waters for the side channels was 376 $\mu\text{S}/\text{cm}$, more than twice the average specific conductance of water in the tributaries, and similar to the average specific conductance in the groundwater-fed side channels. Concentrations of dissolved oxygen also varied slightly between groundwater-fed and tributary-fed side channels. Turbidity was generally higher in tributary-fed side channels than in those fed by groundwater. The low median turbidity in the tributaries, however ([table 6](#)), is probably a consequence of not transect-averaging or site-averaging the data and reporting the median instead of the mean value; tributaries often appeared slightly turbid, depending on recent weather conditions.

Figure 13. Specific conductance in side channels and spring, mainstem, and tributary source waters along the Matanuska River, Alaska, 2007–08.

Side-channel discharge appears to be relatively constant throughout the year, particularly in groundwater-fed systems. Visual observations of mossy channel margins, which generally would be eroded away by high flows, and lack of fine-grained or debris overbank deposits suggests that the channels do not receive enough snowmelt or rainfall runoff to generate the large spring and summer flows typical in a similarly sized tributary channel. Measured discharge at side channel site SC19 and tributary site T4 near the mouth of Moose Creek on the same day or consecutive days in different seasons ([table 7](#)) illustrate this difference. The 35 percent decrease in discharge from August 28, 2007, to March 20, 2008, in the side channel contrasts sharply with the near order-of-magnitude decrease in Moose Creek discharge from August 29, 2007, to March 20, 2008.

Table 7. Discharge measurements in side channel sites for the Matanuska River (sites SC18 and SC19) and the Moose Creek tributary (site T4), Matanuska River, Alaska, 2007–08.

[Locations of discharge measurements are shown in [figure 4](#). **Abbreviations:** m³/s, cubic meter per second; USGS, U.S. Geological Survey]

USGS site No.	Map No.	Date	Discharge, in (m ³ /s)
613653149045600	SC18	05-04-2007	0.309
613339149062400	SC19	04-23-2007	.329
613339149062400	SC19	08-23-2007	.402
613339149062400	SC19	08-28-2007	.402
613339149062400	SC19	03-20-2008	.261
614024149021600	T4	08-29-2007	2.46
614024149021600	T4	03-20-2008	.348

Reach-Scale Spawning Site Selection

Intensive surveys provided a reach-scale assessment of variability and an opportunity to examine the relation of surface water characteristics to spawning site locations. Point measurements from intensive surveys at two locations along side channel site SC19 near Palmer and at one location at tributary site T4 on Moose Creek are presented in [table 8](#). These surveys consisted of measurement points on a regular grid as well as measurements at all redds observed. [Table 9](#) summarizes surface water and channel characteristics for measurements at grid points and at chum and sockeye salmon redds.

Reconnaissance and intensive survey data showed that variability of individual surface water-quality parameters was generally minor within reaches on the order of 100 m long. Distribution of water-quality parameters at the 100-m-long intensively surveyed reaches showed no distinct patterns and no correlation to position within the channel. However, at confluences of clearwater side channels with tributaries or another branch of a side channel, lateral variability of water-quality field parameters persisted for at least 100 m downstream, suggesting that mixing lengths are greater than this distance.

Table 8. Surface water and channel characteristic intensive survey data for a Matanuska River clearwater side channel (site SC19) near Palmer and Moose Creek (site T4), Alaska.

[Locations of sites are shown in [figure 3](#). **Abbreviations:** m, meter; m/s, meter per second; mm, millimeter; °C, degrees Celsius; mg/L, milligram per liter; µS/cm, microsiemens per centimeter; NTU, nephelometric turbidity unit; –, not available; N/A, not applicable]

Point identifier	Map No.	Date	Description	Depth (m)	Velocity (m/s)	Median substrate diameter (mm)	Temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH	Turbidity (NTU)
RiverBendCH10082807	SC19(a)	08-28-2007	Chum salmon redd	0.17	0.02	10	8.3	9.9	312	7.8	1.8
RiverBendCH11082807	SC19(a)	08-28-2007	Chum salmon redd	.20	.05	10	8.0	10.2	312	7.9	2.3
RiverBendCH12082807	SC19(a)	08-28-2007	Chum salmon redd	.18	.15	20	8.2	10.3	313	7.9	2.7
RiverBendCH13082807	SC19(a)	08-28-2007	Chum salmon redd	.26	.05	30	7.8	10.4	311	7.9	1.5
RiverBendCH14082807	SC19(a)	08-28-2007	Chum salmon redd	.18	.07	40	7.9	10.3	312	7.9	1.7
RiverBendCH15082807	SC19(a)	08-28-2007	Chum salmon redd	.20	.14	10	8.2	10.3	313	7.9	2.0
RiverBendCH17082807	SC19(a)	08-28-2007	Chum salmon redd	.17	.06	35	7.9	10.3	312	7.9	2.5
RiverBendCH18082807	SC19(a)	08-28-2007	Chum salmon redd	.20	.11	5	8.1	10.3	313	7.9	1.4
RiverBendCH20082807	SC19(a)	08-28-2007	Chum salmon redd	.27	.05	30	7.7	10.2	312	7.9	2.4
RiverBendCH21082807	SC19(a)	08-28-2007	Chum salmon redd	.30	.07	40	7.5	10.4	311	7.9	1.9
RiverBendCH22082807	SC19(a)	08-28-2007	Chum salmon redd	.14	.05	40	7.8	10.5	312	7.9	2.9
RiverBendCH23082807	SC19(a)	08-28-2007	Chum salmon redd	.18	.05	30	7.5	10.4	312	7.9	1.3
RiverBendCH24082807	SC19(a)	08-28-2007	Chum salmon redd	.30	.05	15	7.4	10.4	312	7.9	1.3
RiverBendCH26082807	SC19(a)	08-28-2007	Chum salmon redd	.26	.02	25	8.2	10.2	314	7.9	3.8
RiverBendCH27082807	SC19(a)	08-28-2007	Chum salmon redd	.29	.07	15	7.4	10.4	312	7.9	3.3
RiverBendCH5082807	SC19(a)	08-28-2007	Chum salmon redd	.15	.37	15	8.1	10.3	312	7.9	6.4
RiverBendCH6082807	SC19(a)	08-28-2007	Chum salmon redd	.23	.33	30	8.1	10.3	312	7.9	3.4
RiverBendCH7082807	SC19(a)	08-28-2007	Chum salmon redd	.15	.33	25	8.2	10.4	312	7.8	14.0
RiverBendCH8082807	SC19(a)	08-28-2007	Chum salmon redd	.18	.40	35	7.9	10.3	312	7.9	1.9
RiverBendCH9082807	SC19(a)	08-28-2007	Chum salmon redd	.18	.04	10	8.3	10.1	313	7.9	2.8
RiverBendG10082807	SC19(a)	08-28-2007	Grid point	.11	.18	20	8.1	10.4	312	7.9	1.6
RiverBendG1082807	SC19(a)	08-28-2007	Grid point	.09	.25	<2	8.0	10.8	313	7.8	1.8
RiverBendG11082807	SC19(a)	08-28-2007	Grid point	.12	.20	10	8.1	10.3	313	7.9	1.7
RiverBendG12082807	SC19(a)	08-28-2007	Grid point	.09	.34	10	8.0	10.4	312	7.9	2.1
RiverBendG13082807	SC19(a)	08-28-2007	Grid point	.12	.51	20	8.1	10.4	312	7.9	2.2
RiverBendG14082807	SC19(a)	08-28-2007	Grid point	.12	.20	40	8.1	10.3	312	7.8	3.6
RiverBendG15082807	SC19(a)	08-28-2007	Grid point	.09	.30	50	8.0	10.4	312	7.9	7.0
RiverBendG16082807	SC19(a)	08-28-2007	Grid point	.12	.23	45	8.0	10.4	312	7.8	3.0
RiverBendG17082807	SC19(a)	08-28-2007	Grid point	.18	.10	<.0625	8.2	10.3	312	7.9	2.1
RiverBendG18082807	SC19(a)	08-28-2007	Grid point	.15	.05	<.0625	8.3	10.3	312	7.9	1.7
RiverBendG19082807	SC19(a)	08-28-2007	Grid point	.11	.20	30	7.9	10.5	312	7.9	1.5
RiverBendG20082807	SC19(a)	08-28-2007	Grid point	.15	.12	30	7.9	10.3	312	7.9	1.8
RiverBendG2082807	SC19(a)	08-28-2007	Grid point	.12	.33	5	7.6	10.7	312	7.8	2.7
RiverBendG21082807	SC19(a)	08-28-2007	Grid point	.17	.10	<2	7.9	10.4	312	7.9	1.9
RiverBendG22082807	SC19(a)	08-28-2007	Grid point	.14	.10	<.0625	8.2	10.2	312	7.9	2.9
RiverBendG23082807	SC19(a)	08-28-2007	Grid point	.24	.07	30	7.8	10.2	311	7.9	1.9
RiverBendG24082807	SC19(a)	08-28-2007	Grid point	.17	.09	<2	7.8	10.2	311	7.9	1.7
RiverBendG25082807	SC19(a)	08-28-2007	Grid point	.20	.06	<.0625	7.8	10.3	312	7.9	1.9
RiverBendG26082807	SC19(a)	08-28-2007	Grid point	.30	.08	<.0625	7.8	10.2	312	7.9	3.3
RiverBendG27082807	SC19(a)	08-28-2007	Grid point	.41	.04	30	7.5	10.2	312	7.9	5.6
RiverBendG28082807	SC19(a)	08-28-2007	Grid point	.30	.05	<2	7.3	10.4	311	7.9	–
RiverBendG29082807	SC19(a)	08-28-2007	Grid point	.44	.04	<.0625	7.5	10.3	310	7.9	–
RiverBendG30082807	SC19(a)	08-28-2007	Grid point	.11	.07	5	7.9	10.3	312	7.9	2.1
RiverBendG3082807	SC19(a)	08-28-2007	Grid point	.08	.33	50	8.0	10.6	312	7.9	1.7
RiverBendG31082807	SC19(a)	08-28-2007	Grid point	.32	.10	<.0625	7.3	10.5	311	7.9	2.0
RiverBendG4082807	SC19(a)	08-28-2007	Grid point	.06	.24	35	7.6	10.6	312	7.9	–
RiverBendG5082807	SC19(a)	08-28-2007	Grid point	.09	.41	30	7.8	10.6	312	7.9	1.5
RiverBendG6082807	SC19(a)	08-28-2007	Grid point	.06	.31	25	7.6	10.6	312	7.9	4.0
RiverBendG7082807	SC19(a)	08-28-2007	Grid point	.12	.26	25	8.0	10.6	312	7.9	2.8
RiverBendG8082807	SC19(a)	08-28-2007	Grid point	.15	.19	<.0625	7.6	10.4	312	7.9	1.4
RiverBendG9082807	SC19(a)	08-28-2007	Grid point	.14	.30	25	7.7	10.6	312	7.9	8.4
RiverBendSK1082807	SC19(a)	08-28-2007	Sockeye salmon redd	.18	.20	15	7.7	10.4	312	7.9	1.8
RiverBendSK16082807	SC19(a)	08-28-2007	Sockeye salmon redd	.24	.05	20	7.8	10.5	312	7.9	1.9

Table 8. Surface water and channel characteristic intensive survey data for a Matanuska River clearwater side channel (site SC19) near Palmer and Moose Creek (site T4), Alaska.—Continued

[Locations of sites are shown in [figure 3](#). **Abbreviations:** m, meter; m/s, meter per second; mm, millimeter; °C, degrees Celsius; mg/L, milligram per liter; µS/cm, microsiemens per centimeter; NTU, nephelometric turbidity unit; –, not available; N/A, not applicable]

Point identifier	Map No.	Date	Description	Depth (m)	Velocity (m/s)	Median substrate diameter (mm)	Temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH	Turbidity (NTU)
RiverBendSK19082807	SC19(a)	08-28-2007	Sockeye salmon redd	0.27	0.08	25	7.9	10.2	312	7.9	2.3
RiverBendSK2082807	SC19(a)	08-28-2007	Sockeye salmon redd	.17	.26	25	7.6	10.4	311	7.9	1.5
RiverBendSK25082807	SC19(a)	08-28-2007	Sockeye salmon redd	.26	.05	25	7.9	10.3	311	7.9	—
RiverBendSK3082807	SC19(a)	08-28-2007	Sockeye salmon redd	.18	.41	20	7.2	10.4	310	7.9	2.0
RiverBendSK4082807	SC19(a)	08-28-2007	Sockeye salmon redd	.20	.16	20	8.0	10.2	287	7.9	2.1
RiverBendCH10082307	SC19(b)	08-23-2007	Chum salmon redd	.12	.22	30	6.8	12.8	334	8.0	<1.0
RiverBendCH11082307	SC19(b)	08-23-2007	Chum salmon redd	.27	.10	10	6.5	12.5	333	7.9	<1.0
RiverBendCH12082307	SC19(b)	08-23-2007	Chum salmon redd	.27	.07	10	6.7	12.6	334	7.9	<1.0
RiverBendCH14082307	SC19(b)	08-23-2007	Chum salmon redd	.15	<.015	25	5.8	12.2	329	7.9	<1.0
RiverBendCH2082307	SC19(b)	08-23-2007	Chum salmon redd	.21	<.015	35	6.2	12.1	328	7.9	<1.0
RiverBendCH3082307	SC19(b)	08-23-2007	Chum salmon redd	.32	<.015	50	6.5	12.4	332	7.9	<1.0
RiverBendCH4082307	SC19(b)	08-23-2007	Chum salmon redd	.34	<.015	50	6.6	12.6	332	7.9	<1.0
RiverBendCH5082307	SC19(b)	08-23-2007	Chum salmon redd	.38	<.015	60	6.3	12.4	332	7.9	<1.0
RiverBendCH6082307	SC19(b)	08-23-2007	Chum salmon redd	.30	<.015	35	7.5	12.3	329	8.0	<1.0
RiverBendCH7082307	SC19(b)	08-23-2007	Chum salmon redd	.24	.17	25	7.7	12.7	331	8.1	<1.0
RiverBendCH8082307	SC19(b)	08-23-2007	Chum salmon redd	.17	.11	25	6.6	12.5	334	7.9	<1.0
RiverBendCH9082307	SC19(b)	08-23-2007	Chum salmon redd	.23	.12	10	6.8	12.7	334	7.8	<1.0
RiverBendG10082307	SC19(b)	08-23-2007	Grid point	.16	.17	5	6.9	12.9	333	8.0	<1.0
RiverBendG1082307	SC19(b)	08-23-2007	Grid point	.14	.21	20	7.5	13.0	331	8.1	<1.0
RiverBendG11082307	SC19(b)	08-23-2007	Grid point	.15	.20	10	7.5	12.9	331	8.1	<1.0
RiverBendG12082307	SC19(b)	08-23-2007	Grid point	.16	.22	2	7.5	13.0	332	8.1	<1.0
RiverBendG13082307	SC19(b)	08-23-2007	Grid point	.15	.26	5	6.9	12.9	333	8.0	<1.0
RiverBendG14082307	SC19(b)	08-23-2007	Grid point	.14	.17	2	6.7	12.6	334	7.9	<1.0
RiverBendG15082307	SC19(b)	08-23-2007	Grid point	.12	.28	25	6.7	12.6	334	7.9	<1.0
RiverBendG16082307	SC19(b)	08-23-2007	Grid point	.07	.27	30	7.0	12.9	332	8.0	<1.0
RiverBendG17082307	SC19(b)	08-23-2007	Grid point	.13	.34	20	7.5	12.9	332	8.1	<1.0
RiverBendG2082307	SC19(b)	08-23-2007	Grid point	.20	.26	2	7.2	13.0	332	8.0	<1.0
RiverBendG3082307	SC19(b)	08-23-2007	Grid point	.21	.13	2	6.7	12.7	333	7.8	<1.0
RiverBendG4082307	SC19(b)	08-23-2007	Grid point	.20	.07	2	6.7	12.7	333	7.9	<1.0
RiverBendG5082307	SC19(b)	08-23-2007	Grid point	.21	.17	2	7.2	13.0	332	8.0	<1.0
RiverBendG6082307	SC19(b)	08-23-2007	Grid point	.18	.11	2	7.6	12.7	331	8.1	<1.0
RiverBendG7082307	SC19(b)	08-23-2007	Grid point	.18	.03	2	7.7	12.5	330	8.1	<1.0
RiverBendG8082307	SC19(b)	08-23-2007	Grid point	.37	.21	2	7.2	12.9	332	8.0	<1.0
RiverBendG9082307	SC19(b)	08-23-2007	Grid point	.52	.02	2	6.8	12.7	334	8.0	<1.0
RiverBendSK1082307	SC19(b)	08-23-2007	Sockeye salmon redd	.16	.23	25	7.2	13.0	332	8.0	<1.0
RiverBendSK13082307	SC19(b)	08-23-2007	Sockeye salmon redd	.23	.24	25	6.9	12.9	333	8.0	<1.0
MooseCreekCH1082907	T4	08-29-2007	Chum salmon redd	.27	.55	35	9.6	11.5	99	7.6	1.0
MooseCreekCH2082907	T4	08-29-2007	Chum salmon redd	.27	.67	30	9.7	11.4	100	7.6	1.9
MooseCreekCH3082907	T4	08-29-2007	Chum salmon redd	.21	.46	30	9.7	11.4	100	7.6	1.3
MooseCreekCH4082907	T4	08-29-2007	Chum salmon redd	.32	.94	50	9.8	11.4	100	7.6	<1.0
MooseCreekCH6082907	T4	08-29-2007	Chum salmon redd	.24	.37	60	9.9	11.5	100	7.7	1.3
MooseCreekCH7082907	T4	08-29-2007	Chum salmon redd	.73	.41	25	9.9	11.4	100	7.7	1.3
MooseCreekG10082907	T4	08-29-2007	Grid point	.82	.43	100	9.8	11.4	100	7.6	1.3
MooseCreekG1082907	T4	08-29-2007	Grid point	.46	1.10	200	9.5	11.6	102	—	1.5
MooseCreekG11082907	T4	08-29-2007	Grid point	.21	.40	75	9.8	11.4	100	7.6	3.2
MooseCreekG12082907	T4	08-29-2007	Grid point	.15	.84	100	9.8	11.4	100	7.6	1.2
MooseCreekG13082907	T4	08-29-2007	Grid point	.18	.83	70	9.8	11.5	100	7.6	1.0
MooseCreekG14082907	T4	08-29-2007	Grid point	.30	1.12	500	9.9	11.5	100	7.6	1.0
MooseCreekG15082907	T4	08-29-2007	Grid point	.30	.65	500	9.9	11.4	99	7.7	1.0
MooseCreekG16082907	T4	08-29-2007	Grid point	.12	.19	200	9.9	11.4	100	7.7	1.2

Table 8. Surface water and channel characteristic intensive survey data for a Matanuska River clearwater side channel (site SC19) near Palmer and Moose Creek (site T4), Alaska.—Continued

[Locations of sites are shown in [figure 3](#). **Abbreviations:** m, meter; m/s, meter per second; mm, millimeter; °C, degrees Celsius; mg/L, milligram per liter; µS/cm, microsiemens per centimeter; NTU, nephelometric turbidity unit; –, not available; N/A, not applicable]

Point identifier	Map No.	Date	Description	Depth (m)	Velocity (m/s)	Median substrate diameter (mm)	Temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH	Turbidity (NTU)
MooseCreekG2082907	T4	08-29-2007	Grid point	0.24	0.63	100	9.5	11.6	101	–	1.3
MooseCreekG3082907	T4	08-29-2007	Grid point	.12	.42	75	9.5	11.6	100	–	1.6
MooseCreekG4082907	T4	08-29-2007	Grid point	.61	.90	200	9.6	11.6	100	–	<1.0
MooseCreekG5082907	T4	08-29-2007	Grid point	.37	1.06	150	9.6	11.5	100	–	<1.0
MooseCreekG6082907	T4	08-29-2007	Grid point	.27	.51	25	9.7	11.5	101	7.6	<1.0
MooseCreekG7082907	T4	08-29-2007	Grid point	.56	1.10	100	9.7	11.5	100	7.6	1.1
MooseCreekG8082907	T4	08-29-2007	Grid point	.29	.97	75	9.8	11.4	100	7.6	1.3
MooseCreekG9082907	T4	08-29-2007	Grid point	.34	1.01	200	9.8	11.4	100	7.6	<1.0
MooseCreekSK5082907	T4	08-29-2007	Sockeye salmon redd	.62	.59	15	9.7	11.4	100	7.6	2.3

Table 9. Descriptive statistics for surface water and channel characteristic intensive survey data for Matanuska River side channel sites SC19(a) and SC19(b) and Moose Creek tributary site T4, Alaska.

[**Abbreviations:** m, meter; m/s, meter per second; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; NTU, nephelometric turbidity unit; mm, millimeter]

Type of point	Number of measurements	Mean depth (m)	Mean velocity (m/s)	Mean temperature (°C)	Mean specific conductance (µS/cm)	Mean dissolved oxygen (mg/L)	Median pH	Median turbidity (NTU)	Median substrate diameter (mm)
Grid point	64	0.21	0.33	8.1	264	11.3	7.9	1.4	20
Chum salmon redd	38	.24	.18	7.8	285	11.2	7.9	1.3	30
Sockeye salmon redd	10	.25	.23	7.8	292	11.0	7.9	1.9	23

Intergravel Water Temperature

Intergravel water temperature varied within and among selected side channels and tributaries of the Matanuska River. For most of the October–April monitoring period, intergravel water temperatures associated with redds were warmer and displayed less short-term fluctuation than did the temperatures in the overlying surface waters ([fig. 14](#)). On average, intergravel water temperatures in side channels were warmer than temperatures in tributaries, possibly because of the greater component of groundwater in the side channels.

Intergravel water temperature adjacent to redds at side channel sites SC5, SC18, and SC19 ([fig. 4](#)) varied among the sites and over time at the sites ([fig. 14](#)). In side channel study sites, intergravel water temperatures ranged from 0.2 to 10.0 °C ([table 10](#)). At-site variation of intergravel water temperature was low (that is, less than 2 °C), indicating only minor spatial variability within spawning sites when measured along 100-m transects ([fig. 15](#)).

Values for ATUs varied among all side channel locations, and were higher than those calculated from data recorded at locations on Moose Creek and on an unnamed tributary to Wolverine Creek ([table 10](#)). In all cases, intergravel ATU was greater than surface water ATU ([table 10](#)). Differences among sites, however, may reflect differences in the amount of time that loggers were in place, which is due to differences in spawning dates among locations ([table 10](#)). In spite of this variability in duration of data collection, our estimates of ATU roughly correspond to the period between spawning at a site and presence of emerging fry as determined by visual observation when thermistors were recovered. Relative to tributaries, side channel spawning habitats have higher ATU available for egg development, and thus would provide a higher quality habitat for spawning salmon, especially late spawning species such as chum salmon and coho salmon. All side channels monitored had ATU within the desired range needed to facilitate incubation and emergence of salmon. Chum salmon, for example, require 600–800 ATU to complete incubation and emergence (Wangaard and Burger, 1983). These values were achieved in all intergravel sites adjacent to redds but not in surface waters ([table 10](#)).

Figure 14. Surface and intergravel water temperature at monitoring sites on side channels and tributaries along Matanuska River, Alaska, September 2008–May 2009.

Table 10. Summary of intergravel and surface water temperature data and accumulated thermal units from monitoring sites at three clearwater side channels and two tributaries of the Matanuska River, Alaska.

[Abbreviations: °C, degrees Celsius; ATU, accumulated thermal unit; –, no data]

Location of temperature sensor	Date range	Days logged	Minimum temperature (°C)	Maximum temperature (°C)	Mean temperature (standard deviation of mean temperature) (°C)	ATU
SC5						
Intergravel #1	09-12-08 – 04-27-09	228	0.9	10	2.7 (2.4)	616
Intergravel #2	09-12-08 – 04-27-09	228	.8	9.1	2.9 (2.5)	668
Intergravel #3	09-12-08 – 04-27-09	228	1.2	9.7	3.6 (2.7)	811
Surface	10-23-08 – 04-27-09	187	.3	4	1.0 (0.9)	182
SC18						
Intergravel #1	09-17-08 – 04-28-09	224	1.4	4.6	3.1 (0.7)	691
Intergravel #2	09-17-08 – 04-28-09	224	1.3	5	2.4 (1.0)	543
Intergravel #3	09-17-08 – 04-28-09	224	1	6	2.5 (1.1)	553
Surface	09-17-08 – 04-28-09	224	.2	5.9	2.0 (1.3)	451
SC19						
Intergravel #1	Logger disturbed	–	–	–	–	–
Intergravel #2	09-25-08 – 04-27-09	215	2.7	6.6	4.0 (1.2)	865
Intergravel #3	Logger disturbed	–	–	–	–	–
Surface	09-25-08 – 04-27-09	215	.8	5.3	3.0 (1.1)	656
T3 (intergravel) and T4 (surface) (Moose Creek)						
Intergravel #1	10-09-08 – 04-27-09	201	0	2.8	0.3 (0.4)	51
Intergravel #2	10-09-08 – 04-27-09	201	-.1	2.8	.3 (0.4)	66
Intergravel #3	10-09-08 – 04-27-09	201	.1	3	1.0 (0.4)	193
Surface	10-09-08 – 04-27-09	201	-3	2.9	-.2 (0.8)	29
T5 (tributary to Wolverine Creek)						
Intergravel #1	10-02-08 – 04-28-09	209	0.1	5.3	0.9 (0.8)	190
Intergravel #2	10-02-08 – 04-28-09	209	.4	5.8	1.2 (0.9)	251
Intergravel #3	10-20-08 – 04-28-09	209	.3	5.6	1.1 (0.9)	226
Surface	10-29-08 – 04-28-09	182	0	1.5	.6 (0.4)	115

Intergravel water temperature adjacent to redds at Matanuska River tributaries Moose Creek (T3) and an unnamed tributary to Wolverine Creek (T5) (fig. 4) was variable between and within sites (fig. 14). At T3, intergravel water temperature was colder than at all other sampling locations (table 10). ATU varied between T3 and T5 and was the lowest recorded for all sites sampled along the Matanuska River (table 10). Temperatures approached freezing in all intergravel measurement sites, which indicates possible mortality associated with freezing (Reiser and Wesche, 1979). ATU at tributary sites was low relative to expected values needed to achieve emergence of salmon, suggesting that fish would have to spawn prior to the beginning of our monitoring date, when water

temperatures were warmer, to achieve the required thermal units for optimal spring emergence. Additionally, the early embryonic stage of juvenile salmon is highly susceptible to environmentally induced mortality until early epiboly (a stage of development) is reached (Bailey and Evans, 1971); this suggests that late spawning salmon may experience high levels of mortality and deformities as a result of incubation temperature near and below their thermal threshold (Bailey and Evans, 1971). Further work is needed to determine how salmon that spawn in Matanuska River tributaries respond to low intergravel water temperatures. It is possible that salmon at these sites are adapted to incubation in colder temperatures, but this would need to be evaluated with controlled laboratory experiments.

Figure 15. Longitudinal distribution of intergravel temperature within 100-m reaches at intensive survey sites on clearwater side channels and a tributary along Matanuska River, Alaska, September–October 2008.

Summary and Conclusions

Systematic mapping of clearwater side channels in the braid plain of the Matanuska River and collection of data on their hydrologic and water-quality characteristics provided new evidence to support prior, mostly anecdotal observations of clearwater habitats for spawning salmon in this turbid glacial river. Analysis of 2006 orthophotography resulted in delineation of 105.8 km of clearwater side channels in the Matanuska River and documented their distribution from the Matanuska Glacier to the river's mouth. Side channels occurred as individual channels or as a network of channels contained within broad abandoned river bar complexes at the margin of the river's braid plain; islands within the braid plain supported only a few clearwater channels. Side channel abundance correlated to braid plain width, especially in areas such as those downstream from Palmer, where the wide braid plain supported a large number of channels, and near Chickaloon, where side channels were nearly absent in the narrow braid plain.

Channel patterns identified on historical imagery and the presence of young vegetation surrounding many sites indicates that these channels persist, on average, for a period of from years to decades before the actively migrating channels of the mainstem re-occupy and re-work them. Small tributaries provided a direct water source for some side channels, but springs originating in the braid plain formed a more common water source. The distribution, age, and water source of the channels show that conditions favorable for clearwater side channels—a pre-existing channel form and a source of clear water—are relatively abundant under the present-day actively braiding conditions of the Matanuska River. Densities of side channels vary locally with braid plain width and availability of a water source. The extent to which springs feeding side channels originate in a local or regional alluvial aquifer, or an upland aquifer, was not investigated for this report, but many springs were observed to provide year-round flow in locations from tens to hundreds of meters from mainstem channels.

Wide, shallow, and gravel-bedded, these small side channels formed a common habitat for spawning salmon during the course of this study. Although the total length of delineated side channels that were used by salmon was not determined, spawning salmon or carcasses were observed at 19 sites spanning 65 braid plain kilometers that were selected for measurement of channel and water characteristics. Recent tracking of radio-tagged salmon indicated that more than 90 percent of chum salmon, 98 percent of sockeye salmon, and 44 percent of coho salmon spawning in the Matanuska River watershed selected spawning locations in clearwater side channels within the mainstem braid plain. On the basis of field measurements of surface water and channel characteristics and intergravel water temperatures, it is apparent that these habitats are viable salmon spawning (and likely rearing)

habitats. Given the dynamic nature of the Matanuska River braid plain, these habitats are likely to change, move, disappear, and reappear over time, and these natural cycles of disturbance are an important component of healthy habitats for Pacific salmon (Reeves and others, 1995). Previously virtually ignored as fish habitat, the Matanuska River is part of the focus of the Matanuska-Susitna Basin Salmon Habitat Partnership, and the results of this study will aid in defining the distribution of salmon habitats to aid land use and fisheries planning and management.

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Appendix A. Description of Matanuska River Clearwater Side Channel Geographic Information System Products

Table A1. Clearwater side channel Geographic Information System products from Matanuska River, Alaska.

[Shapefiles produced for this report are described below and are available for download at <http://pubs.usgs.gov/sir/2011/5102/>]

Shapefile name	Description
2006_sidechannels.shp	Arcs representing all clearwater side channels within the project boundary present in October 2006 orthoimagery, attributed with side channel water source, qualitative turbidity, type of surface occupied, position within the braid plain, field verification data, and fish observations from September 13, 2007, aerial survey.
Bndry.shp	Polygon defining the extent of the U.S. Geological Survey Matanuska River clearwater side channels project. The primary use of this boundary was for delineation of clearwater side channels and computation of side channel density.
FieldSites.shp	Points representing the 34 field sites used in the report. Activities at each site are summarized in table 2 .
IntensiveChannelSurvey.shp	Points representing surveyed grid points, salmon redds, edges of water, and survey markers at three intensively surveyed reaches of the Matanuska River and its tributary, Moose Creek.
ReconData.shp	Points representing all measurement locations used in this report, attributed with water quality field parameter data, physical channel characteristics, side channel water source, and fish observations from ground surveys.

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