Prepared in cooperation with the Fairbanks Soil and Water Conservation District

Occurrence of Selected Nutrients, Trace Elements, and Organic Compounds in Streambed Sediment in the Lower Chena River Watershed near Fairbanks, Alaska, 2002–03

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

Cover: Photograph of Chena Slough. View is southeast, upstream towards community of North Pole. Photograph by B.W. Kennedy, U.S. Geological Survey, September 13, 2003.

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KEN SALAZAR, Secretary

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Conversion Factors

Multiply	By	To obtain
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	0.00156	square mile (mi^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
gallon (gal)	0.003785	cubic meter (m3)
cubic foot (ft^3)	0.02832	cubic meter (m3)
	Flow rate	
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)

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

°C=(°F-32)/1.8.

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

°F=(1.8x°C)+32.

Concentrations of chemical constituents in sediment are given either in milligrams per kilogram (mg/kg), equivalent to parts per million, (ppm), or micrograms per kilogram (μg/kg), equivalent to parts per billion (ppb).

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 1927 (NAD 27).

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

Abbreviations and Acronyms

ADEC	Alaska Department of Environmental Conservation
ATSDR	Agency for Toxic Substances and Disease Registry
CB-PEC	consensus-based probable effect concentrations
EWI	equal-width-increments
GFAA	graphite furnace atomic absorption
LRL	laboratory reporting level
MRL	minimum reporting level
N	nitrogen
NAWQA	National Water-Quality Assessment
NWQL	National Water Quality Laboratory
NWIS	National Water Information System
P	phosphorus
PEL	probable effect level
SQG	sediment-quality guidelines
TMDL	total maximum daily load
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

cm	centimeter
mg	milligram
mm	millimeter
µg/g	microgram per gram
µm	micrometer, micron

Occurrence of Selected Nutrients, Trace Elements, and Organic Compounds in Streambed Sediment in the Lower Chena River Watershed near Fairbanks, Alaska, 2002–03

By Ben W. Kennedy, U.S. Geological Survey, and Cassidee C. Hall, Fairbanks Soil and Water Conservation District

Abstract

In 2002–03, the U.S. Geological Survey collected samples of streambed sediment at 18 sites in the lower Chena River watershed for analysis of selected nutrients, traces elements, and organic compounds. The purpose of the project was to provide Federal, State, and local agencies as well as neighborhood committees, with information for consideration in plans to improve environmental conditions in the watershed. The exploratory sampling program included analysis of streambed sediment from the Chena River and Chena Slough, a tributary to the Chena River. Results were compared to streambed-sediment guidelines for the protection of aquatic life and to 2001–02 sediment data from Noyes Slough, a side channel of the lower Chena River.

The median total phosphorus concentration in Chena Slough sediment samples, 680 milligrams per kilogram (mg/kg), was two orders of magnitude greater than median total phosphorus concentration in Chena River sediment samples of 5.2 mg/kg. Median concentrations of chloride and sulfate also were greater in Chena Slough samples. Low concentrations of nitrate were detected in most of the Chena Slough samples; nitrate concentrations were below method reporting limits or not detected in Chena River sediment samples.

Streambed-sediment samples were analyzed for 24 trace elements. Arsenic, nickel, and zinc were the only trace elements detected in concentrations that exceeded probable-effect levels for the protection of aquatic life. Concentrations of arsenic in Chena Slough samples ranged from 11 to 70 mg/kg and concentrations in most of the samples exceeded the probable-effect guideline for arsenic of 17 mg/kg. Arsenic concentrations in samples from the Chena River ranged from 9 to 12 mg/kg. The background level for arsenic in the lower Chena River watershed is naturally elevated because of significant concentrations of arsenic in local bedrock and ground water. Sources of elevated concentrations of zinc in one sample, and of nickel in two samples, are unknown. With the exception of elevated arsenic levels in samples from Chena Slough, the occurrence and concentration of trace elements in the streambed sediments of Chena Slough and Chena River were similar to those in Noyes Slough sediment.

Sediment samples were analyzed for 78 semivolatile organic compounds and 32 organochlorine pesticides and polychlorinated biphenyls (PCBs). Low concentrations of dimethylnaphthalene and *p*-Cresol were detected in most Chena Slough and Chena River sediment samples. The number of semivolatile organic compounds detected ranged from 5 to 21 in most Chena Slough sediment samples. In contrast, three or fewer semivolatile organic compounds were detected in Chena River sediment samples, most likely because chemical-matrix interference resulted in elevated reporting limits for organochlorine compounds in the Chena River samples. Low concentrations of fluoranthene, pyrene, and phenanthrene were detected in Chena Slough sediment. Relatively low concentrations of DDT or its degradation products, DDD and DDE, were detected in all Chena Slough samples. Concentrations of total DDT (DDT+DDD+DDE) in two Chena Slough sediment samples exceeded the effects-range median aquatic-life criteria of 46.1 micrograms per kilogram (µg/kg). DDT concentrations in Chena River streambed-sediment samples were less than 20 µg/kg. Low concentrations of PCB were detected in two Chena Slough streambed-sediment samples. None of the concentrations of the polychlorinated biphenyls or semivolatile organic compounds for which the samples were analyzed exceeded available guidelines for the protection of aquatic life. With the exception of elevated total DDT in two Chena Slough samples, the occurrence and concentration of organochlorine compounds in Chena Slough and Chena River sediment were similar to those in samples collected from Noyes Slough in 2001–02.

Introduction

During 2002–03, the U.S. Geological Survey (USGS) completed an assessment of selected nutrient, trace-element, and organic compound concentrations in streambed sediments for the lower Chena River watershed (fig. 1). Since the mid-1990s, the Alaska Department of Environmental Conservation (2008) has designated much of the lower Chena River watershed as Section 303(d) high priority Category 5 Waterbodies – Impaired by petroleum products and sediment for one or more designated uses.

Previous studies by the USGS on the Noyes Slough subreach of the lower Chena River watershed dealt with (1) hydraulic analysis and implications for restoration of Noyes Slough (Burrows and others, 2000), and (2) assessment of fish habitat, water quality, and selected contaminants in streambed sediments (Kennedy and others, 2004). Environmental managers and the public were concerned low-level concentrations of arsenic, lead, and zinc, as well as PCBs and pesticides such as dichlorodiphenyltrichloroethane (DDT) in Noyes Slough sediment possibly were indicative of greatly elevated contaminant levels upstream in the Chena River or Chena Slough. Residents were particularly concerned there may be elevated levels of trace elements, pesticides, and PCBs as a consequence of improper disposal of waste material from nearby industrial sites or military installations—Eielson Air Force Base near North Pole and Fort Wainwright Army Base near Fairbanks. In response to public and agency concerns, the USGS, in cooperation with the Fairbanks Soil and Water Conservation District, completed an exploratory streambed sediment sampling program at 18 sites to characterize streambed-sediment quality for the Chena Slough and the lower Chena River.

Purpose and Scope

The purpose of this report is to present and summarize the results of analyses of the streambed-sediment samples collected in Chena Slough and Chena River. Objectives of the study were to:

1. Describe the occurrence, distribution, and concentration of selected nutrients, trace elements, semivolatile organic compounds (SVOCs), and organochlorine compounds in streambed sediment from the lower Chena River watershed; and

2. Summarize and compare the selected streambed-sediment sample concentrations with published sediment-quality guidelines (SQGs) for the protection of aquatic life and with previously published USGS streambed-sediment data for Noyes Slough.

The study was intended to provide environmental managers with quantitative information to assist in developing focused restoration and protection solutions for the watershed. The intended audience for this report includes land- and water-resource managers, regulators, policy makers, and the general public. Some of the data used in the preparation of this report is available on the Internet by linking to the USGS Water Resources of Alaska home page (currently http://alaska.usgs.gov).

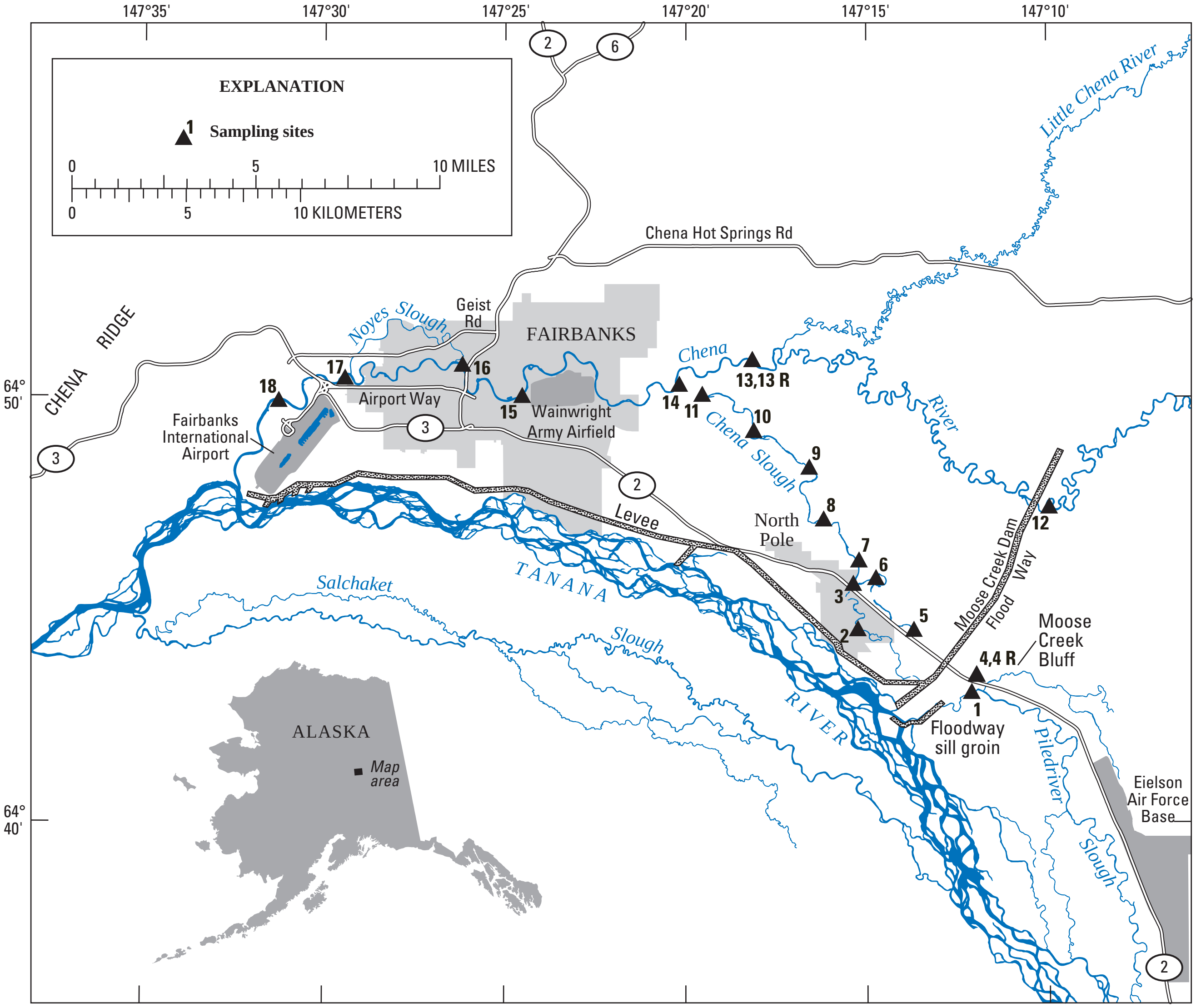
Description of Study Area

The study area is located on the Chena River-Tanana River alluvial plain near Fairbanks, Alaska, and includes a complex of overflow channels (sloughs) of the two rivers. The main waterways in the study area, in downstream order, are Chena Slough, Chena River, and Noyes Slough (fig. 1). The hydrology of the study area was described in detail in recent studies by Burrows and others (2000) and Kennedy and others (2004). These reports provide a comprehensive hydrologic history of the lower Chena River and Fairbanks area. A brief overview of hydrologic characteristics of the study area, provided here for reference, was largely summarized from Kennedy and others (2004).

Bedrock in the Fairbanks area is part of the Yukon-Tanana terrane, a complex assemblage of metasedimentary and metaigneous rocks that are intruded by Mesozoic and Cenozoic granitic rocks and minor amounts of intermediate and mafic rocks (Foster and others, 1994). Because of the broad assemblage of rock types found in the Fairbanks area, substantial concentrations of trace elements, including antimony, arsenic, barium, chromium, copper, nickel, vanadium, and zinc, are readily available through physical and chemical weathering (Hawkins, 1982; Newberry, 1996; McCoy and others, 1997; Mueller and others, 2001). Many placer and hard-rock gold mines have operated near the Fairbanks area since the early 1900s. Stream channels in the lower Chena River watershed flow through alluvial deposits of the Tanana and Chena Rivers, collectively referred to as the Chena Alluvium (Péwé and others, 1976).

Chena Slough

Chena Slough is a 16-mi long perennial, ground-water fed, low-gradient stream, flowing in a wide shallow channel with prolific summer growth of emergent and submergent aquatic plants. The slough provides critical spawning and rearing habitat for grayling and other fish and is a popular recreation area for fishing and canoeing. Adjacent wetlands provide habitat for beavers, muskrat, and waterfowl. Area residents and agencies have expressed concern that the slough is deteriorating as a clean, free flowing waterway due to the influx of nutrients and contaminants associated with urban development (Scharfenberg, 2004).



Basemap modifed from USGS and City of Fairbanks, AK digital datasets, various scales. Projection: UTM, Zone 1N, central meridian 147.5°W; North American Datum 1983

Figure 1. Location of the lower Chena River watershed study area near Fairbanks, Alaska, 2002–03.

Prior to 1940, Chena Slough was a major side channel of the glacier-fed, sediment-laden Tanana River. The slough flowed northwest approximately 30 mi from the Tanana River to the confluence with the Chena River, about 7 mi east of Fairbanks (fig. 1). Over the past 50 years, flow in the slough has decreased due to construction of flood-control structures on the Tanana and Chena Rivers. Mean annual flow in Chena Slough is currently about 50 ft^3/s and varies with ground water level. The wide, low-gradient Chena Slough channel previously carried mean annual flows of 1,000–2,000 ft^3/s and now is oversized for the present-day reduced flows. In many reaches, the slough has extensive backwater impounded behind road crossings with undersized or perched culverts (Wuttig, 1997). Consequently, the physical character of much of the slough is similar to a series of long shallow lakes interconnected by culverts. Because of the low gradient and lack of surface tributaries there are no seasonal floods; annual water levels typically vary by 1 to 2 ft, and winter ice and snow melt in place. Chena Slough does not freeze to the streambed during winter, an effect of high ground-water levels in the area. Organic rich fine-grained sediments accumulate in Chena Slough because of the road crossing impoundments and flow velocities that are not high enough to flush the fines downstream.

Benthic algae, rooted aquatic plant growth, and excessive accumulation of organic fines are appreciably degrading the aquatic environment of Chena Slough. Depth of the water table below land surface typically is about 5 to 15 ft. Many homeowners bury their septic systems 10–12 ft below the surface to avoid seasonal frost conditions (Nelson, 1978).

Consequently, in many areas, septic systems are below or near the water table, increasing the likelihood of continual or seasonal contamination of the shallow aquifer. Water quality studies by Krumhardt (1982) and Scharfenberg (2004) confirmed that urban development had adversely affected the quality of local surface water and ground water. Furthermore, the fine-grained, organic-rich sediments in Chena Slough likely act as a storage bank for nutrients. Analysis of macronutrient concentrations in bed-sediment samples may help resource managers verify if accelerated eutrophication of the slough, in part, is an effect of internal nutrient loading and recycling, similar to nutrient recycling that occurs in some lakes.

The Agency for Toxic Substances and Disease Registry (ATSDR) (2006) evaluated public exposure to maximum measured concentrations of PCBs and pesticides (DDD, DDE, and DDT) in fish in surface water on and off Eielson Air Force Base near the headwaters of Chena Slough, and concluded contaminant levels were below health guidelines for people eating up to six fish per year. Trace elements and organochlorine compounds generally are hydrophobic and therefore tend to adsorb to soil and sediment. Thus, streambed-sediment quality is an environmental concern because the streambed sediment may act as a sink for watershed contaminants as well as a source of contaminants to aquatic life in the watershed.

Chena River

The Chena River originates in upland areas about 90 mi east of the city of Fairbanks and is a clear-water, non-glaciated tributary to the Tanana River. The river flows southwest from its headwaters, continues through downtown Fairbanks and joins the Tanana River about 3 mi southwest of the city center (fig. 1). Inflows are from surface-water tributaries and ground water. Seasonally, high flows occur in summer, from May through September, while low flows occur from November through April. The river is ice covered in winter, with the primary contribution to flow coming from ground water. Flow diminishes to a minimum in March or April. Above freezing temperatures in April or May result in breakup of the ice cover.

Mean annual flow for the Chena River at Fairbanks is about 1,400 ft^3/s; however, because flow has been regulated by Moose Creek Dam since 1981, no more than 12,000 ft^3/s now flows through Fairbanks (U.S. Army Corps Engineers, 1997). In the event of a major flood on the Chena River, water is impounded behind the Moose Creek Dam and diverted into the Tanana River. During lesser floods, water is impounded behind the dam without spilling into the Tanana River and is regulated down the Chena River at levels below flood stage until the impounded flood water drains. Because flows greater than 12,000 ft^3/s no longer occur, and surface-water input from the glacial-fed Tanana River has been cut off, sediment influx to Chena River has been reduced. Sediment influx to the Chena River is now primarily from the uplands east of Fairbanks and re-suspension and transport of alluvial bank material during high flows. As a consequence of this decreased sediment supply, sections of the Chena River main channel have been down cutting, which further limits seasonal flow to side channels such as Noyes Slough.

The Chena River is a popular winter recreation area for skiing, snowmobiling, dog mushing, and fishing. Summer recreation activities include boating, fishing, hunting, camping, wildlife viewing, sunbathing, and swimming. Chinook and chum salmon use the Chena River for spawning, rearing, and migration. Alaska Department of Fish and Game has established catch-and-release regulations for protection of arctic grayling in the Chena River.

The Agency for Toxic Substances and Disease Registry (2003), Public Health Assessment of Fort Wainwright Army Base, identified several possible contaminant situations. In particular,

> "A variety of contaminated sites are located near the Chena river on Fort Wainwright; most are controlled and not currently affecting the river water quality. Limited sampling has identified metals and volatile organic compounds (VOCs) in river water and sediment. Sampling results suggest VOC and semivolatile organic compounds (SVOCs) contaminants levels are not likely to cause health concerns for local fish consumers. Insufficient sampling data is available to identify if metals, especially arsenic, exist at levels that could indicate a concern for fish consumption."

The ATSDR supports additional sampling of the lower Chena River to identify any metals present in the river at concentrations that could affect the health of fish consumers (Agency for Toxic Substances and Disease Registry, 2003). Of additional concern, petroleum hydrocarbon and solvent-based contamination of subsurface waters from industrial and commercial activity in Fairbanks have been documented near the Chena River (Lilly and others, 1996).

Noyes Slough

Noyes Slough is a 5.5-mi-long overflow channel of the Chena River within the city limits of Fairbanks (fig. 1). The slough is located north of the Chena River, and is surrounded by mixed urban and suburban developments. The State of Alaska (1999) classified the slough as an anadromous stream, providing rearing areas for juvenile salmon and habitat for grayling and other fish species. Over the past 50 years, flow in the slough channel has declined because of the flood-control structures on the Chena and Tanana Rivers. Surface water flows through Noyes Slough intermittently and only during open-water season.

Local residents have been concerned for years that the slough is deteriorating from being a free flowing, clean waterway. Some reaches of the slough have become catchments for storm runoff that introduces non-point source pollution. In spite of intermittent cleanup efforts, some reaches of the slough contain urban refuse. Beaver dams in Noyes Slough further impede surface-water inflow from the Chena River (Kennedy and others, 2004). Beaver management programs have not been effective in removing beaver dams. The relative magnitude of sediment influx to Noyes Slough varies in response to water-level changes in the Chena River. When water levels are high, suspended sediment and other contaminants can be transported by surface water from the Chena River and deposited in the slough. Bed sediments within the slough typically are reworked during high flows. Urban runoff during storms and spring snowmelt contribute additional sediment and urban contaminants to the slough. At low water levels, the slough acts as a drain for local ground water and any associated trace elements and chemical compounds in solution. In winter, sections of the slough, including the inlet, are completely frozen and filled with ice and snow.

Methods of Data Collection and Laboratory Analytical Techniques

Field Methods

Streambed-sediment samples were collected at 11 sites in Chena Slough during October and November 2002 and at 7 sites in Chena River in June 2003 (table 1, fig. 1). Three sediment samples were collected in pre-1940 channels of Chena Slough. One sample (#1) was collected upstream of Moose Creek Dike, in the Chena Slough channel identified as Piledriver Slough following construction of the Moose Creek dike in the 1940s. Two samples, #2 and #3, were collected downstream of the dike in a pre-1940s overflow channel of Chena Slough, locally known as Beaver Springs. Eight samples collected in the mainstem of Chena Slough, downstream of Moose Creek Dike, were numbered sequentially in downstream order, #4 through #11. The Chena River sites were numbered consecutively from upstream to downstream, #12 through #18. Distance between sampling sites varied (fig. 1).

Table 1. Location of streambed-sediment sampling sites in the lower Chena River watershed near Fairbanks, Alaska, 2002–03.

[**Sediment-sample site No.**: Location of sites are shown in figure 1; R, replicate sample. **Latitude** and **Longitude**: North American Datum 1927 (NAD27 Alaska)]

Sediment-sample site No.	USGS site identification No.	Sample date (mm–dd–yy)	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Site name
1	644306147141500	11–07–02	644306	1471415	Chena Slough–Piledriver Slough 0.4 mile below Moose Creek, near North Pole, Alaska
2	644435147203100	11–07–02	644435	1472031	Chena Slough–Beaver Springs 850 feet below refinery entrance road, near North Pole, Alaska
3	644539147204600	10–22–02	644539	1472046	Chena Slough–Beaver Springs at Doughchee Avenue, near North Pole, Alaska
4	644330147135800	11–05–02	644330	1471358	Chena Slough 0.8 mile above flood levee, near North Pole, Alaska
4R	644331147135900	11–05–02	644331	1471359	Chena Slough 0.8 mile above flood levee, near North Pole, Alaska
5	644434147172600	11–07–02	644434	1471726	Chena Slough at Spruce Branch Drive, near North Pole, Alaska
6	644547147193100	10–23–02	644547	1471931	Chena Slough at Outside Hurst Boulevard, near North Pole, Alaska
7	644612147202700	10–22–02	644612	1472027	Chena Slough at Airway Drive, near Fairbanks, Alaska
8	644710147222400	10–22–02	644710	1472224	Chena Slough at Brock Road, near Fairbanks, Alaska
9	644823147231100	10–22–02	644823	1472311	Chena Slough at Bradway Road, near Fairbanks, Alaska
10	15512000	10–22–02	644915	1472615	Chena Slough at Peede Road, near Fairbanks, Alaska
11	645006147290600	10–22–02	645006	1472906	Chena Slough at Persinger Road, near Fairbanks, Alaska
12	644727147095600	06–24–03	644727	1470956	Chena River 0.6 mile above Moose Creek Dam, near North Pole, Alaska
13	645055147262000	06–24–03	645055	1472620	Chena River 2 miles below Nordale Road, near North Pole, Alaska
13R	645055147262000	06–24–03	645055	1472620	Chena River 2 miles below Nordale Road, near North Pole, Alaska
14	645020147302200	06–24–03	645020	1473022	Chena River 0.7 miles above Dennis Road, near North Pole, Alaska
15	645004147390400	06–25–03	645004	1473904	Chena River at River Road, at Fairbanks, Alaska
16	645048147422200	06–25–03	645048	1474222	Chena River at Wendell Street, at Fairbanks, Alaska
17	645029147485200	06–26–03	645029	1474852	Chena River at University Avenue, at Fairbanks, Alaska
18	644957147523200	06–25–03	644957	1475232	Chena River at Ravenwood Avenue, at Fairbanks, Alaska

Collection and field processing of streambed-sediment samples followed established National Water-Quality Assessment (NAWQA) Program protocols (Shelton and Capel, 1994). In the Chena River, sediments were collected from depositional zones selected to represent various streamflow regimes. Chena Slough samples were collected through ice cover in October and November utilizing an ice auger to access the streambed. Variations in thickness and distribution of sediments collected in Chena Slough channel cross-sections were dependent on control structures such as beaver dams and road crossings with culverts. Samples collected near road crossings were collected upstream of the crossing. Sampling was confined to the upper 2–10 cm of streambed sediment. At each sampling site, five subsamples were collected, composited in a glass bowl, and passed through a 2-mm sieve. Samples were chilled in the field and shipped overnight to the USGS National Water Quality Laboratory (NWQL) in Lakewood , Colorado, for analyses of organic constituents and to Severn Trent Laboratories (STL) in Arvada, Colorado, for analyses of nutrient and trace-element concentrations.

Field Methods Quality Assurance

Collection of quality-control samples is necessary to evaluate the quality of data. Quality-control samples are collected, usually at the field site, in order to identify, quantify, and document bias and variability in data resulting from the collection, processing, shipping, and handling of samples by field and laboratory personnel (Wilde and others, 1998).

The field quality-assurance methods for this project included the collection of two replicate sediment samples; sample #4R, collected from the Chena River, and sample #13R, collected from the Chena Slough. Field replicates are separate samples identically collected and processed, as close as possible to the same point in space and time, as the original environmental sample. The replicate samples are used to detect heterogeneity within the environmental samples and provide a check that the samples are reproducible. Replicate samples are referenced with "R" and are presented in the tables with the environmental results for comparability.

Laboratory Methods

Streambed-sediment samples were analyzed for selected organic contaminants at the NWQL using standard techniques described by Wershaw and others (1987). Trace elements and metals were analyzed at the Severn Trent Laboratory (2002, 2003) using standard techniques described in Arbogast (1996), Briggs and Meier (1999), and Taggart (2002). Severn Trent Laboratories completed nutrients analyses using methods described by Fishman and Friedman (1989). Links to STL quality-assurance and analytical procedures are available at http://www.stl-inc.com/.

Laboratory reporting levels vary for different sediment samples because of variations in sample mass, sample matrix, and analytical interferences. STL analytical results for nutrients and trace elements were expressed as concentrations when they exceeded the Minimum Reporting Level (MRL), as below (B) when they were less than the MRL but exceeded the Method Detection Level (MDL), and as not detected (ND) when they were less than the MDL. The Method Detection Level is the minimum concentration of a substance STL measured and reported with 99-percent confidence that the analyte concentration is greater than zero. The MDL is determined from the analysis of a sample in a given matrix containing the analyte (U.S. Environmental Protection Agency, 1997).

NWQL analytical results for SVOC, PCB, and pesticide analytes were reported as concentrations when they exceeded the method reporting level (MRL) and as less than the method reporting level (<MRL) when not detected. The MRL is the smallest measured concentration of a constituent that NWQL reliably reported using a given analytical method. Reported non-detection (<MRL) of a particular analyte means the analyte was not present in the sample at a detectable concentration; the analyte may be absent, present at a concentration less than the reporting MRL, or present at a concentration greater than the MRL but matrix interferences prevented detection. In some cases, the NWQL reported an analyte concentration as an estimated (E) value. Estimated values indicate the analyte was detected but can not be reported with the same level of confidence as other quantitative values because of low concentrations or analytical interferences. Concentrations of trace element and organic compounds were reported on a dry weight basis.

Laboratory Methods Quality Assurance

Links to NWQL quality-assurance and analytical procedures are available at the NWQL Web page (http://wwwnwql.cr.usgs.gov/USGS/USGS_srv.html). Links to STL quality-assurance and analytical procedures are available at http://www.stl-inc.com/.

Laboratory quality-control methods are rigorous for both laboratories and include analysis of blank and spiked samples to quantify analytical accuracy of the reported concentrations. Laboratory blank samples are artificial samples that do not contain the chemical constituents being measured in the environmental samples. The blank samples are used to determine if target compounds or other interferences are present in the laboratory environment, reagents, or apparatus. Laboratory spiked samples have a small quantity of a know concentration of analyte stock solution added to the sample. The spiked samples are analyzed exactly like an environmental sample and are used to monitor the various analytical methods for bias and variability in the recovery of target compounds.

Results and Discussion

Analysis of streambed-sediment samples for chemical constituents and organic compounds provides a reliable means for assessing the occurrence, concentration, and distribution of contaminants in an aquatic system. Most trace elements and many anthropogenic organic compounds are known to associate with fine-grained sediments (Van Metre and Callender, 1997). Consequently, even though the water may contain only small quantities of these constituents, their concentration in suspended sediment and bed sediment may be relatively large (Shelton and Capel, 1994). Accordingly, sampling and analysis of streambed-sediment material increases the likelihood that contaminants will be detected and that the spatial distribution of contaminants in the aquatic environment can be evaluated.

Analytical results for streambed-sediment samples collected from 11 sites in Chena Slough and 7 sites in Chena River were summarized for concentrations of nutrients, trace elements, and organic compounds. The concentrations of trace element and organic compounds in the sediments were compared to guidelines for protection of aquatic life as well as to analytical results for sediment samples collected from Noyes Slough in 2001 and 2002. Sediment data for the interconnected waterways of Chena Slough, Chena River, and Noyes Slough are intended to provide environmental managers and the public with information required to make informed choices for improving sediment and surface-water quality of these impaired waterways. Although sediment-quality guidelines are provided for comparative purposes, no interpretations of analytical results or recommendations for remedial actions were offered as they may differ considerably between various agencies and stakeholders.

No official Federal or State of Alaska standards for protection of aquatic organisms have been established for concentrations of nutrients, trace-elements, or organic-compounds in freshwater streambed sediments. However, sediment-quality guidelines for a select number of elements and compounds have been proposed by several agencies and organizations to assess potential effects of sediment contamination on aquatic life. For bulk bed-sediment samples, the Canadian Council of Ministers of the Environment (2002) published probable effect levels (PELs), above which adverse effects to aquatic biota are likely to occur. MacDonald and others (2000) compiled sediment-quality guidelines (SQG) and data from several sources and developed consensus-based probable effect concentration (CB-PECs) guidelines for freshwater ecosystems. Gilliom and others (1998) summarized aquatic-life criteria from various agencies and compiled national median values based on streambed-sediment data collected at 198 nonrandom sites by the USGS NAWQA Program. The U.S. Environmental Protection Agency (1994) designated nine priority trace-element pollutants; arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. Probable effect levels (PELs) for the nine priority trace elements were summarized by Buchman (2008).

Aquatic-life criteria and national datasets are useful for comparison purposes. They provide perspective for evaluation of the streambed-sediment data, but should be used only as indicators of potential sediment-quality problems that may warrant further examination. However, the absence of criteria for a particular contaminant, or the presence of contaminants at concentrations that do not exceed one or more criteria, does not necessarily imply that there are no environmental issues of concern at that site. Mixtures of contaminants found at some sites could behave synergistically to cause adverse biological effects that are not indicated by criteria developed for individual contaminants (U.S. Geological Survey, 1999).

Field Quality Assurance

Agreement between reported nutrient concentrations and trace-element concentrations in replicate bed-sediment samples collected at Chena Slough site #4 and Chena River site #13 varied. Differences in reported trace-element concentrations between the #4 and #4R samples were less than 10 percent, except for reported concentrations near or below the minimum reporting level. For example, reported sodium concentrations of 420 and 190 mg/kg and thallium concentrations of 2.4 and 3.4 mg/kg differ by more than 10 percent but are near or below method reporting levels for the respective element.

Concentrations of trace elements in sample #13, compared to those in sample #13R, are within 35 percent for reported concentrations above the minimum reporting level. The sample variance may be the result of the incomplete mixing of the composite sample or due to analytical interferences.

Analytical results for organic compounds indicated that non-target interfering compounds were present in the sample matrix material of the Chena River samples collected during the summer of 2003. In an attempt to reduce the effects of matrix interference, samples were analyzed at relatively large dilutions and many of the target analyte minimum reporting limits were elevated due to the dilution.

There were no extreme variations in reported concentrations of organic compounds in the Chena Slough #4 and replicate #4R samples. Moderate differences of about 30 percent or less exist for concentrations reported as estimates. For example, *p*-Cresol concentrations for samples #4 (E67 µg/kg) and #4R (E78 µg/kg) differ by approximately 17 percent. Most of the sample concentration variability probably is due to actual differences in sample composition. Sample extraction procedures and subsequent chemical analysis introduce additional variation. Many of the reported organic-compound concentrations were near or below method reporting levels. The resulting increase in analytical uncertainty contributes to variation in the data. There were similar differences in reported estimated concentrations for replicate Chena River samples #13 and #13R. However, method reporting levels for Chena River sample concentrations were much higher than reporting levels for Chena Slough samples, possibly because of sample-matrix interference problems associated with elevated chlorophyll levels. Most SVOC analyte concentrations for Chena River sample #13 were reported at less than 350 µg/kg, compared to less than 500 µg/kg for replicate sample #13R. Because of elevated method reporting levels for Chena River SVOC analytes, it is difficult to compare the Chena River sample concentrations with low SVOC concentrations reported for Chena Slough samples and the relatively low SVOC sample concentrations for Noyes Slough reported in Kennedy and others (2004).

Laboratory Quality Assurance

Laboratory methods and quality-control procedures for Severn Trent Laboratories are summarized in Kennedy and others (2004). Laboratory quality-control Certification/Accreditation/Approvals for Severn Trent Laboratories are available at http://www.stl-inc.com/Labs/Denver/Denver_index.ht. Generally, there was good agreement between reported replicate bed-sediment sample concentrations for nutrients and trace elements. Data from laboratory quality-control analyses suggest that the reported analyte concentrations generally have an estimated uncertainty of from 10 to 35 percent for analyte concentrations greater than laboratory reporting limits.

Streambed-sediment samples were analyzed for 78 semivolatile organic compounds (SVOCs) and 32 organochlorine pesticides and polychlorinated biphenyls (PCBs). The National Water Quality Laboratory (NWQL) deleted analyses of 12 SVOCs, primarily phenol isomers. Reported analytical results for five SVOC analytes—*bis*(2-ethylhexyl)phthalate, di-*n*-butyl phthalate, butylbenzyl phthalate, phenol, and diethyl phthalate—include laboratory contamination at measurable concentrations in laboratory blanks. These data were not included in the count of SVOCs analytes detected. Lopes and Furlong (2001) corrected for laboratory SVOC contamination by subtracting the 95th-percentile concentration of laboratory blank samples, analyzed between 1992 and 1995, from the concentration detected in environmental samples with differences that were less than 50 µg/kg censored. Using this generalized correction scheme yields no substantial change in the number of SVOCs reported as detected for this study. Only two occurrences of low concentration butylbenzyl phthalate would be included in the detection count, sample #4R (E66 µg/kg) and sample #11 (E96 µg/kg). However, inclusion of these two samples as SVOCs detections is not warranted given the analytical uncertainty associated with the low concentration estimated values as well as the uncertainty associated with the correction method of subtracting the 95th-percentile laboratory blank concentrations from the environmental sample concentrations.

Environmental Samples

Nutrients

Streambed-sediment samples collected from Chena Slough and Chena River were analyzed for the nutrients orthophosphate, total phosphorus, nitrate, and ammonia as well as for chloride, fluoride, and sulfate anion concentrations. Analytical results and summary statistics for nutrient and anion data are summarized in table 2.

The median concentration of total phosphorus in streambed samples was much greater in Chena Slough (680 mg/kg) than in the Chena River (5.2 mg/kg). Nitrate concentrations were below method reporting limits or were not detected in Chena River sediment samples; low level concentrations of nitrate were detected in five Chena Slough samples. Ammonia was detected in most Chena Slough and Chena River sediment samples. Median concentrations of chloride and sulfate were greater in Chena Slough samples than in samples from Chena River (table 2).

No sediment-quality guidelines have been established for the macronutrients phosphorus or nitrogen because these nutrients are not considered toxic to aquatic organisms. In excess quantities, however, macronutrients can promote nuisance aquatic plant and algae growth in streams and lakes, causing eutrophication (Hem, 1985). Natural sources of nutrients include precipitation, rock weathering, and biochemical processes such as decomposition of organic matter. Sources of nitrogen include precipitation, nitrogen fixation in the water and the sediment, and inputs from surface water and ground water.

Significant contributors of phosphorus may include: phosphate-based detergents, lawn and garden fertilizers, improperly sited and maintained septic systems, waterfowl, agricultural drainage, urban storm runoff, wastewater-treatment effluent, animal wastes, road deicers, and atmospheric deposition. Typically, nitrogen supplies to fresh waters are augmented more readily from external sources than are those of phosphorus (Wetzel, 2001). Phosphorus availability generally is believed to be a critical factor in eutrophication of water bodies, as the nutrient in shortest supply will tend to be the control on production rates (Hem, 1985). Depending on redox conditions, phosphorus may form insoluble precipitates (particles) with calcium, iron, manganese, and aluminum. In hard water areas, precipitates of calcium carbonate absorb phosphorus, reducing the overall phosphorus concentration as well as aquatic plant growth. Aquatic plants with roots in the bed sediment still obtain phosphorus from sediments. Plants take up sediment-bound phosphorus through their roots, releasing it in small amounts to the water column throughout their life cycles, and in large amounts when they die and begin to decompose (Hem, 1985). Hard water lakes commonly have clear water with relatively low phosphorous concentrations, but may have excess rooted aquatic plant growth associated with sediment-bound phosphorus.

Table 2. Summary of anion and nutrient concentrations in streambed sediment at selected sites in the lower Chena River watershed near Fairbanks, Alaska, 2002–03.

[**Sediment-sample site No.**: Location of sites are shown in figure 1; R, replicate sample. **Concentrations**: B, below method reporting limit; J, blank contains analyte at measurable level; Q, high analyte level. ND, not detected]

Sediment-sample site No.	USGS site identification No.	Sample date	Concentration (milligrams per kilogram, dry weight)						
			Chloride, as Cl	Sulfate as SO_4	Fluoride as F	Phosphorus, total	Orthophosphate, phosphorus	Nitrate, as N	Ammonia, as N
1	644306147141500	11–07–02	21 B, J	300 J	2.6 B	830 J, Q	ND	13	1.3 B, J
2	644435147203100	11–07–02	22 B, J	310 J	2.5 B	610 J, Q	ND	ND	2.9 J
3	644539147204600	10–22–02	79 B, J	1,100	10 B	1,600 Q	ND	ND	3.6 B, J
4	644330147135800	11–05–02	22 B, J	500 J	2.3 B	640 J, Q	ND	13	4.3 J
4R	644331147135900	11–05–02	24 B, J	1,100 J, Q	2.4 B	730 J, Q	3.3 B	ND	4.3 J
5	644434147172600	11–07–02	36 B, J	650 J	3.3 B	710 J, Q	ND	ND	6.0 J
6	644547147193100	10–23–02	52 B, J	470	6.4 B	600 Q	ND	ND	1.5 B, J
7	644612147202700	10–22–02	66 B, J	740	8.4 B	1,000 Q	ND	ND	2.6 B, J
8	644710147222400	10–22–02	27 B, J	250	3.3 B	430 Q	ND	5 B	1.6 B, J
9	644823147231100	10–22–02	19 B, J	80	2.4 B	380 Q	ND	ND	1.2 B, J
10	15512000	10–22–02	51 B, J	230	7.3 B	890 Q	ND	9.7 B	2.4 B, J
11	645006147290600	10–22–02	43 B, J	95 B	5.5 B	650 Q	ND	11 B	12.0 J
12	644727147095600	06–24–03	14 B, J	43 B, J	3.7 B, J	2.4 B	ND	2.7 B	2.4
13	645055147262000	06–24–03	15 B, J	19 B, J	3.9 B, J	5.5 B	3.4 B, J	2.6 B	5.6
13R	645055147262000	06–24–03	17 B, J	22 B, J	4.2 B, J	3.1 B	3.2 B, J	ND	5.5
14	645020147302200	06–24–03	21 B, J	17 B, J	4.3 B, J	39	ND	2.5 B	4.9
15	645004147390400	06–25–03	14 B, J	34 B, J	3.9 B, J	2 B	ND	2.7 B	3.1
16	645048147422200	06–25–03	18 B, J	20 B, J	4.5 B, J	33	ND	2.8 B	6.4
17	645029147485200	06–26–03	16 B, J	18 B, J	5.4 B, J	ND	2.1 B, J	2.7 B	5.3
18	644957147523200	06–25–03	27 B, J	18 B, J	3.8 B, J	5.2 B	ND	2.6 B	5.4
	Summary statistics	Count				19	4	12	
		Median	22	163	4	600	3	3	4
	Chena Slough	Count[1]	12	12	12	12	1	5	12
		Maximum	79	1,100	10	1,600	3.3	13	12
		Minimum	19	80	2.3	380	3.3	5	1.2
		Median	31.5	390	3.3	680	3.3	11	2.75
	Chena River	Count[1]	8	8	8	7	3	7	8
		Maximum	27	43	5.4	39	3.4	2.8	6.4
		Minimum	14	17	3.7	2	2.1	2.5	2.4
		Median	16.5	19.5	4.05	5.2	3.2	2.7	5.35

[1] Count includes replicate values (R) as well as reported values below (B) reporting limit.

Some interment of nitrogen also results from permanent sedimentation loss of inorganic and organic nitrogen-containing compounds to the sediments. However, little correlation has been found between concentrations of total or organic forms of nitrogen in sediments and general productivity (Wetzel, 2001).

Trace Elements

Streambed-sediment samples were analyzed for 24 selected trace elements. Analytical results and summary statistics for trace-element data are summarized in table 3.

Table 3. Summary of trace-element concentrations in streambed sediment at selected sites in the lower Chena River watershed near Fairbanks, Alaska, 2002–03.

[**Sediment-sample site No.**: Location of sites are shown in figure 1; R, replicate sample. **Concentrations:** B, concentration is below minimum reporting limit; G, reporting limit is elevated due to matrix interference; ND, not detected. N/A, not available]

Sediment-sampling site No.	USGS site identification No.	Sample date	Concentration (milligrams per kilogram, dry weight)											
			Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead
1	644306147141500	11–07–02	14,000	ND	26	200	0.21	ND G	6,900	23	11	20	34,000	7.9
2	644435147203100	11–07–02	14,000	ND	10	200	0.11	ND	12,000	29	14	53	24,000	15
3	644539147204600	10–22–02	12,000	ND	170	300	ND	ND	12,000	23	26	51	86,000	23
4	644330147135800	11–05–02	14,000	ND	22	170	ND	ND	10,000	24	18	33	31,000	10
4R	644331147135900	11–05–02	14,000	ND	20	170	0.08	ND	9,900	23	17	34	30,000	10
5	644434147172600	11–07–02	16,000	ND	21	180	ND	ND	15,000	26	20	40	34,000	11
6	644547147193100	10–23–02	11,000	ND	58	430	ND	ND	13,000	24	28	26	40,000	12
7	644612147202700	10–22–02	11,000	ND	52	170	ND	ND	18,000	22	27	34	55,000	14
8	644710147222400	10–22–02	7,800	ND	15	120	ND	ND	6,900	15	13	16	20,000	7.7
9	644823147231100	10–22–02	8,100	ND	11	120	0.068	ND	6,300	14	9.8	16	17,000	4.6
10	15512000	10–22–02	13,000	ND	27	250	ND	ND	8,100	16	18	20	55,000	8.1
11	645006147290600	10–22–02	10,000	ND	16	240	ND	ND	47,000	20	16	25	32,000	11
12	644727147095600	06–24–03	12,000	ND	9	110	ND	0.22	4,100	20	9.1	18	20,000	7.6
13	645055147262000	06–24–03	12,000	0.56	11	130	ND	0.35	5,100	21	9.7	19	23,000	7
13R	645055147262000	06–24–03	11,000	ND	12	110	0.19	0.44	6,000	17	8.2	16	23,000	6.3
14	645020147302200	06–24–03	9,400	0.49	10	110	ND	0.14	4,200	15	7.3	13	20,000	4.5
15	645004147390400	06–25–03	13,000	0.43	10	130	ND	0.27	5,200	21	10	19	24,000	7.2
16	645048147422200	06–25–03	13,000	ND	11	130	0.21	0.28	5,300	21	10	20	26,000	7.5
17	645029147485200	06–26–03	12,000	ND	11	120	ND	0.31	5,800	20	9.5	17	25,000	7.1
18	644957147523200	06–25–03	14,000	0.51	11	140	ND	0.30	5,900	23	11	21	23,000	8.4
	Summary statistics[1]	**Count**	**20**	**4**	**20**	**20**	**6**	**8**	**20**	**20**	**20**	**20**	**20**	**20**
		Median	**12,000**	**0.5**	**13.5**	**155**	**0.15**	**0.29**	**6,900**	**21**	**12**	**20**	**25,500**	**8**
	Chena Slough	Count[2]	12	0	12	12	4	0	12	12	12	12	12	12
		Maximum	16,000	0	170	430	0.21	0	47,000	29	28	53	86,000	23
		Minimum	7,800	0	10	120	0.068	0	6,300	14	9.8	16	17,000	4.6
		Median	12,500	N/A	**21.5**	190	0.095	N/A	**11,000**	23	17.5	29.5	33,000	10.5
	Chena River	Count[2]	8	4	8	8	2	8	8	8	8	8	8	8
		Maximum	14,000	0.56	12	140	0.21	0.44	6,000	23	11	21	26,000	8.4
		Minimum	9,400	0.43	9	110	0.19	0.14	4,100	15	7.3	13	20,000	4.5
		Median	12,000	**0.5**	11	125	**0.2**	0.29	5,250	20.5	9.6	18.5	23,000	7.15

[1]Summary statistics calculated for trace elements with count (*n*) greater than or equal to 2.

[2]Count includes replicate (R) values and values that are below the minimum reporting limit.

Table 3. Summary of trace–element concentrations in streambed sediment at selected sites in the lower Chena River watershed near Fairbanks, Alaska, 2002–03.—Continued

[**Sediment-sample site No.**: Location of sites are shown in figure 1; R, replicate sample. **Concentrations:** B, concentration is below minimum reporting limit; G, reporting limit is elevated due to matrix interference; ND, not detected. N/A, not available]

Sediment sampling site No.		Concentration (milligrams per kilogram, dry weight)											
		Magne–sium	Man–ganese	Mercury	Molyb–denum	Nickel	Potas–sium	Selen–ium	Silver	Sodium	Thallium	Vana–dium	Zinc
1		5,900	620	0.031	ND	22	1,300	ND	0.29	250	1.1	43	55
2		6,400	580	0.04	1.9	32	1,600	ND	0.26	240	1.6	46	66
3		6,200	2,600	0.025	13	31	1,600	3.1	1.4	450	8.3	38	650
4		7,500	2,900	0.024	6.2	31	1,700	ND	0.62	420	2.4	43	61
4R		7,400	2,900	ND	5.9	30	1,700	1	0.67	190	3.4	42	59
5		8,300	3,900	0.021	6.3	37	2,100	ND	0.82	550	3.6	47	77
6		5,800	27,000	ND	2.8	44	1,500	ND	5	360	8.6	36	72
7		6,400	7,200	0.031	9.3	33	1,600	ND	1.9	ND	15	38	180
8		4,400	6,200	ND	2.3	21	880	ND	1.3	210	7.7	28	52
9		4,700	900	ND	0.5	18	770	ND	0.3	300	2.3	28	34
10		8,600	2,900	ND	12	23	1,000	ND	1	260	7.1	35	62
11		6,000	5,100	0.011	1	24	1,200	ND	1.4	ND	8.8	32	60
12		5,100	230	0.016	0.54	22	1,100	1.6	0.42	ND	ND	32	86
13		5,200	250	0.014	0.71	22	1,100	1.5	0.44	ND	ND	36	76
13R		4,800	220	0.013	ND	18	820	1.3	0.43	ND	ND	30	64
14		4,400	200	ND	ND	16	780	ND	0.33	ND	ND	30	53
15		5,600	280	ND	ND	23	1,100	1.2	0.41	ND	ND	38	74
16		5,600	270	0.029	ND	23	1,100	ND	0.44	ND	ND	35	79
17		5,500	300	0.010	ND	21	960	ND	0.45	ND	ND	38	67
18		5,600	300	0.025	ND	23	1,100	ND	0.45	ND	ND	37	69
Summary statistics[1]	Count[2]	**20**	**20**	**13**	**13**	**20**	**20**	**6**	**20**	**10**	**12**	**20**	**20**
	Median	**5,700**	**760**	**0.024**	**2.8**	**23**	**1,100**	**1.4**	**0.45**	**280**	**5.35**	**36.5**	**66.5**
Chena Slough	Count[2]	12	12	7	11	12	12	2	12	10	12	12	12
	Maximum	8,600	27,000	0.04	13	44	2,100	3.1	5	550	15	47	650
	Minimum	4,400	580	0.011	0.5	18	770	1	0.26	190	1.1	28	34
	Median	6,300	**2,900**	0.025	**5.9**	30.5	1,550	2.05	0.91	**280**	**5.35**	38	61.5
Chena River	Count[2]	8	8	6	2	8	8	4	8	0	0	8	8
	Maximum	5,600	300	0.029	0.71	23	1,100	1.6	0.45	0	0	38	86
	Minimum	4,400	200	0.01	0.54	16	780	1.2	0.33	0	0	30	53
	Median	5,350	260	0.015	0.625	22	1,100	1.4	0.435	N/A	N/A	35.5	71.5

Sixteen of the 24 selected trace elements were detected in bed sediment from all 18 sample sites. Median concentrations for aluminum, chromium, magnesium, vanadium, and zinc were within ±20 percent for both waterways. Concentrations of four trace elements—antimony, beryllium, mercury, and selenium—were relatively low and were reported either as not detected (ND) or below (B) reporting limits for most sample sites. The spatial distribution of other trace-element occurrence and concentration were varied. The median concentrations of arsenic, barium, cobalt, copper, iron, lead, nickel, and potassium in Chena Slough samples were 39 to 95 percent greater than median concentrations in Chena River samples. Median concentrations of calcium, manganese and silver in Chena Slough samples were more than 100 percent greater than Chena River median concentrations for the same elements (table 3). Sodium and thallium were detected in most Chena Slough samples but were not detected in Chena River sediment samples. Conversely, antimony and cadmium were detected in Chena River bed sediments but were not detected in any Chena Slough samples.

Natural background levels for a particular trace element may change substantially with changes in sediment-source geology. Chena Slough sediments primarily were derived from sediment source areas along the north side of the Alaska Range with transport and deposition of sediment by the Tanana River prior to construction of flood control structures in the 1940s. Chena River streambed-sediment samples reflect influx of sediment from local upland source areas east of Fairbanks. Urban runoff from suburban and high-traffic areas in the study area may contribute to variability in trace-element concentrations in some locations. According to the Alaska Department of Environmental Conservation (2008), urban contaminants have had adverse effects on both the Chena Slough and the Chena River waterways.

Aquatic-Life Criteria Trace Elements

Sediment-quality guidelines have been established by the U.S. Environmental Protection Agency (1994) for nine priority pollutants; arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc (table 4). The USEPA has not established sediment-quality guidelines for selenium. However, concentrations equal to or greater than 4.0 mg/kg in sediment are a concern for fish and wildlife because of the potential for bioaccumulation (Lemly and Smith, 1987).

Table 4. Summary of streambed-sediment quality guidelines for nine priority-pollutant trace elements in streambed sediment at selected sites in the lower Chena River watershed near Fairbanks, Alaska, 2002–03.

[**Concentrations**: B, below reporting limit; NG, no guideline. **Noyes Slough median:** Noyes Slough median values provided for comparison (see Kennedy and others, 2004). **NAWQA national median**: National median concentrations from NAWQA sampling sites (Gilliom and others, 1998). **Canada PEL**: Probable Effect Level (PEL) (Canadian Council of Ministers of the Environment, 2002). **CB-PEC**: Consensus Based Probable Effect Concentration (CB-PEC) (MacDonald and others, 2000). mg/kg, milligram per kilogram; NAWQA, National Water-Quality Assessment]

Constituent	Concentration (mg/kg, dry weight)						Sediment sample concentration (mg/kg, dry weight)	
	Chena Slough median	Chena River median	Noyes Slough median	NAWQA national median	Canada PEL	CB-PEC	Greater than PEL	Greater than CB-PEC
Arsenic	21.5	11	12.6	6.35	17	33	Sample #1; 26 Sample #3; 170 Sample #4; 21 Sample #5; 21 Sample #6; 58 Sample #7; 52 Sample #10; 27	Sample #3; 170 Sample #6; 58 Sample #7; 52
Cadmium	B	B	B	0.4	3.53	4.98	None	None
Chromium	23	20.5	27.4	62	90	111	None	None
Copper	29.5	18.5	30.4	26	197	149	None	None
Lead	10.5	7.15	13.7	24.3	91.3	128	None	None
Mercury	B	B	B	0.06	0.486	1.06	None	None
Nickel	30.5	22	26.1	25	36	48.6	Sample #5; 37 Sample #6; 44	None None
Selenium[1]	3.1 (one sample)	B	B	0.7	NG	NG	NG	NG
Zinc	61.5	71.5	97.8	110	315	459	Sample #3; 650	Sample #3; 650

[1] Selenium concentrations; Lemly and Smith (1987) recommend streambed sediment selenium concentration less than 4.0 mg/kg.

None of the Chena River streambed sediment trace-element concentrations exceeded probable-effect level (PEL) or consensus-based probable-effect concentration (CB-PEC) sediment-quality guidelines for the protection of aquatic life. However, one or more Chena Slough sediment samples contained arsenic, nickel, or zinc concentrations that exceeded CB-PEC or PEL sediment-quality guidelines. Concentrations of arsenic in seven Chena Slough sediment samples were greater than the PEL (17 mg/kg) guideline; only three concentrations exceeded the CB-PEC (33 mg/kg) arsenic guideline recommended by MacDonald and others (2000). The background concentration of arsenic in Chena Slough appears to be naturally elevated, based on the median concentration of 21.5 mg/kg (table 4). Elevated arsenic concentrations in Chena Slough streambed sediment are expected because significant concentrations of arsenic are present in local bedrock (Newberry, 1996), in local bed-sediments (Hawkins, 1982), and in local ground-water wells (Mueller and others, 2002). Arsenic concentrations in Chena River streambed-sediment samples—the median was 11 mg/kg—were consistently less than arsenic concentrations in Chena Slough streambed sediment. The concentration of nickel in Chena Slough samples #5 (37 mg/kg) and #6 (44 mg/kg) exceeded the PEL guideline (36 mg/kg) by less than 25 percent. The source(s) of the elevated nickel concentrations are uncertain. The median concentration of nickel in Chena Slough was 30.5 mg/kg. Reported zinc concentration in Chena Slough sediment sample #3 (650 mg/kg) was approximately 100 percent greater than the PEL guideline of 315 mg/kg and 42 percent greater than the CB-PEC guideline of 459 mg/kg (table 4). The median zinc concentration for Chena Slough samples was 61.5 mg/kg (table. 3). The source(s) of the elevated zinc concentration are unknown. Nevertheless, elevated zinc concentration an order of magnitude greater than the median zinc concentration at a single site in Chena Slough suggests local enrichment.

Median concentrations of arsenic, copper, and nickel in Chena Slough samples were greater than the NAWQA National median (table 4). Arsenic concentrations ranged from 10 to 170 mg/kg, copper concentrations from 16 to 53 mg/kg, and nickel concentrations from 18 to 44 mg/kg.

Cadmium and mercury concentrations in sediment from Chena Slough, Chena River, and Noyes Slough generally were below reporting limits or were not detected. Median nickel concentrations were similar in all three streams and ranged from 22 to 30.5 mg/kg. Median concentrations of chromium, copper, lead, and zinc in Chena River and Chena Slough were less than those in Noyes Slough. The median concentration of arsenic in Chena Slough (21.5 mg/kg) was somewhat elevated compared to that in Chena River (11 mg/kg) and Noyes Slough (12 mg/kg). Elevated concentrations of trace elements in streambed sediment may represent enrichment from natural or anthropogenic sources.

Organic Compounds

Semivolatile Organic Compounds

Of the 78 semivolatile organic compounds (SVOCs) for which samples were analyzed, 21 were detected at levels that could be estimated or reported by the laboratory (table 5). More than 10 SVOCs were detected in Chena Slough samples #8 and #9 (table 5). The number of SVOCs detected in sample #8 (21) was greater than in other Chena Slough samples. However, most analytes detected in Chena Slough sample #8 and in other Chena Slough samples, were present at low concentrations and reported as estimated. Two SVOC compounds, *p*-Cresol and 2,6-dimethylnaphthalene, were detected in most Chena River and Chena Slough samples. Relatively low concentrations of common urban contaminants such as fluoranthene, phenanthrene, and pyrene, were reported in most of Chena Slough samples but were not detected in most Chena River samples, probably because of matrix interference in sample analysis and subsequent increased laboratory detection levels. The median organic-carbon concentration of Chena Slough and Chena River samples (table 5) were the same, 25 (g/kg). Median inorganic-carbon concentration of Chena Slough samples (3 g/kg) was an order of magnitude greater than the median concentration of inorganic carbon in Chena River samples (0.3 g/kg).

Several phthalates, including *bis*(2-ethylhexyl), butylbenzyl, PAHs, including fluoranthene, phenanthrene, pyrene, *p*-Cresol, naphthalene and 1,6-dimethylnaphthalene were detected in Chena Slough samples. Contamination of laboratory blanks varied for phthalates and may contribute to the reported low-level phthalate concentrations (table 5). Phthalates are a family of chemical compounds that were developed in the past century. Most of these compounds are used as “plasticizers”—they make plastics flexible without sacrificing strength or durability. Except for data on the most widely used phthalate, di-2-ethylhexyl phthalate (DEHP), much of the human-exposure and reproductive-toxicity data now available are preliminary (Raloff, 2000). Because of their persistence in the environment, phthalates are commonly found in ground water, rivers, and drinking water (Jobling and others, 1995).

Low concentrations of *p*-Cresol were detected in most sediment samples (table 5). Cresols are widely occurring natural and anthropogenic products. They are natural components of crude oil and coal tar. Low concentrations of cresols are constantly emitted to the atmosphere in the exhaust from motor vehicle engines using petroleum based-fuels (Agency for Toxic Substances and Disease Registry, 1992). Fluoranthene, phenanthrene, and pyrene were detected in relatively low concentrations (<150 µg/kg) in most of the Chena Slough sediment samples. Fluoranthene, phenanthrene, and pyrene are polycyclic aromatic hydrocarbons (PAHs).

Table 5. Summary of semivolatile organic compounds and carbon concentrations in streambed sediment at selected sites in the lower Chena River watershed near Fairbanks, Alaska, 2002–03.

[**Sediment sample site No.**: See table 1 for full site name. NWIS, U.S. Geological Survey National Water Data Storage and Retrieval System; mi, mile; µg/kg, microgram per kilogram, dry weight; <, less than; E, estimated; M-D, method deleted; U-DELETE, unable to determine]

Semivolatile organic compound	NWIS Code	Method detection level (µg/kg)	Concentration (µg/kg, dry weight)					
			Sediment sample site No.					
			1	2	3	4	4R	5
Hexachlorobenzene	49343	50	<80	<80	<150	<80	<80	<100
Dibutylphthalate[1]	49381	50	E26	E32	E79	E29	E38	E41
Dioctylphthalate[1]	49382	50	E26	E27	E75	E37	<80	<100
Diethylphthalate[1]	49383	50	E8	E13	E23	E7	E10	E12
Dimethylphthalate	49384	50	<80	<80	<150	<80	<80	<100
Pyrene	49387	50	E20	E17	E42	E14	<80	<100
1-Methylpyrene	49388	50	<80	<80	<150	<80	<80	<100
Benzo[*a*]pyrene	49389	50	<80	<80	<150	<80	<80	<100
1-Methyl-indeno[*1,2,3-cd*]pyrene	49390	50	<80	<80	<150	<80	<80	<100
2,2'-Biquinoline	49391	50	<80	<80	<150	<80	<80	<100
Quinoline	49392	50	<80	<80	<150	<80	<80	<100
Phenanthridine	49393	50	<80	<80	<150	<80	<80	<100
Isoquinoline	49394	50	<80	<80	<150	<80	<80	<100
2,4-Dinitrotoluene	49395	50	<80	<80	<150	<80	<80	<100
2,6-Dinitrotoluene	49396	50	<80	<80	E110	E46	E52	<100
Benzo[*k*]fluoranthene	49397	50	<80	<80	<150	<80	<80	<100
1-Methyl 9H-fluorene	49398	50	<80	<80	<150	<80	<80	<100
9H-Fluorene	49399	50	<80	<80	<150	<80	<80	<100
Isophorone	49400	50	<80	<80	<150	<80	<80	<100
bis(2-chloroethoxy)methane	49401	50	<80	<80	<150	<80	<80	<100
Naphthalene	49402	50	<80	<80	<150	<80	<80	<100
1,2-Dimethylnaphthalene	49403	50	<80	<80	<150	<80	<80	<100
1,6-Dimethylnaphthalene	49404	50	E11	E20	E65	E27	E24	E27
2,3,6-Trimethylnaphthalene	49405	50	<80	<80	<150	<80	<80	<100
2,6-Dimethylnaphthalene	49406	50	E45	84	440	250	200	170
2-Chloronaphthalene	49407	50	<80	<80	<150	<80	<80	<100
Benzo[*g,h,i*]perylene	49408	50	<80	<80	<150	<80	<80	<100
Phenanthrene	49409	50	E10	E12	E20	E8	E8	E10
1-Methylphenanthrene	49410	50	E8	E8	<150	<80	<80	<100
4H-Cyclopenta[*def*]phenanthrene	49411	50	<80	<80	<150	<80	<80	<100
Phenol[1]	49413	50	<80	<80	<150	<80	E50	<100
2,4,6-Trichlorophenol	49415	50	M-D	M-D	M-D	M-D	M-D	M-D
Mesitol	49416	50	M-D	M-D	M-D	M-D	M-D	M-D
2,4-Dichlorophenol	49417	50	M-D	M-D	M-D	M-D	M-D	M-D
2,4-Dinitrophenol	49418	50	M-D	M-D	M-D	M-D	M-D	M-D
2-Methyl-4,6-phenol	49419	50	M-D	M-D	M-D	M-D	M-D	M-D
o-Nitrophenol	49420	50	M-D	M-D	M-D	M-D	M-D	M-D
3,5-Xylenol	49421	50	<80	<80	<150	<80	<80	<100
4-Chloro-*m*-cresol	49422	50	<80	<80	<150	<80	<80	<100
m-Nitrophenol	49423	50	M-D	M-D	M-D	M-D	M-D	M-D
C8-Alkylphenol	49424	50	<80	<80	<150	<80	<80	<100
Pentachlorophenol	49425	50	M-D	M-D	M-D	M-D	M-D	M-D
bis(2-ethylhexyl)phthalate[1]	49426	50	E75	E54	U-DELETED	<130	<130	<150
Butylbenzylphthalate[1]	49427	50	E82	U-DELETED	U-DELETED	E100	E130	U-DELETED
Acenaphthylene	49428	50	<80	<80	<150	<80	<80	<100
Acenaphthene	49429	50	<80	<80	<150	<80	<80	<100
Acridine	49430	50	<80	<80	<150	<80	<80	<100

Table 5. Summary of semivolatile organic compounds and carbon concentrations in streambed sediment at selected sites in the lower Chena River watershed near Fairbanks, Alaska, 2002–03.—Continued

[**Sediment sample site No.**: See table 1 for full site name. NWIS, U.S. Geological Survey National Water Data Storage and Retrieval System; mi, mile; µg/kg, microgram per kilogram, dry weight; <, less than; E, estimated; M-D, method deleted; U-DELETE, unable to determine]

Semivolatile organic compound	NWIS Code	Method detection level (µg/kg)	Concentration (µg/kg, dry weight)					
			Sediment sample site No.					
			1	2	3	4	4R	5
n-Nitrosodipropylamine	49431	50	<80	<80	<150	<80	<80	<100
n-Nitrosodiphenylamine	49433	50	<80	<80	<150	<80	<80	<100
Anthracene	49434	50	E15	E16	<150	<80	<80	<100
2-Methylanthracene	49435	50	<80	<80	<150	<80	<80	<100
Benzo[*a*]anthracene	49436	50	<80	<80	<150	<80	<80	<100
9,10-Anthraquinone	49437	50	<80	<80	<150	<80	<80	<100
1,2,4-Trichlorobenzene	49438	50	<80	<80	<150	<80	<80	<100
o-Dichlorobenzene	49439	50	<80	<80	<150	<80	<80	<100
m-Dichlorobenzene	49441	50	<80	<80	<150	<80	<80	<100
p-Dichlorobenzene	49442	50	<80	<80	<150	<80	<80	<100
Azobenzene	49443	50	<80	<80	<150	<80	<80	<100
Nitrobenzene	49444	50	<80	<80	<150	<80	<80	<100
Pentachlorobenzene	49446	50	<80	<80	<150	<80	<80	<100
Hexachlorobutadiene	49448	50	M-D	M-D	M-D	M-D	M-D	M-D
Carbazole	49449	50	<80	<80	<150	<80	<80	<100
Chrysene	49450	50	<80	<80	<150	<80	<80	<100
p-Cresol	49451	50	E41	E42	<150	E67	E78	E43
Thiophene	49452	50	<80	<80	<150	<80	<80	<100
Hexachloroethane	49453	50	M-D	M-D	M-D	M-D	M-D	M-D
4-Bromophenylphenylether	49454	50	<80	<80	<150	<80	<80	<100
4-Chlorophenylphenylether	49455	50	<80	<80	<150	<80	<80	<100
bis(2-chloroethyl)ether	49456	50	<80	<80	<150	<80	<80	<100
bis(2-chloro-1-methylethyl)ether	49457	50	M-D	M-D	M-D	M-D	M-D	M-D
Benzo[*b*]fluoranthene	49458	50	<80	<80	<150	<80	<80	<100
Pentachloroanisole	49460	50	<80	<80	<150	<80	<80	<100
Dibenz[*a*,*h*]anthracene	49461	50	<80	<80	<150	<80	<80	<100
Fluoranthene	49466	50	E21	E17	E37	E13	<80	<100
o-Chlorophenol	49467	50	<80	<80	<150	<80	<80	<100
Benzo[*c*]cinnoline	49468	50	<80	<80	<150	<80	<80	<100
Hexachlorocyclopentadiene	49489	50	M-D	M-D	M-D	M-D	M-D	M-D
2-Ethylnaphthalene	49948	50	<80	<80	<150	<80	<80	<100
Number of SVOC analytes detected, includes remark code E (estimated). Excludes 5 phthalates with laboratory contamination—see footnote 1.			**8**	**8**	**5**	**7**	**5**	**4**
Inorganic carbon (g/kg)	49270	0.2	0.48	2.4	1.7	2.8	2.7	4.8
Organic carbon (g/kg)	49271	0.2	26	16	68	17	17	21
Maximum		50	8	84	440	250	200	170
Median Inorganic Carbon-Chena Slough	3							
Median Inorganic Carbon-Chena River	0.3							
Median Organic Carbon-Chena Slough	25							
Median Organic Carbon-Chena River	25							

[1]Reported value for this analyte includes contamination in laboratory blank at measurable concentrations.

Table 5. Summary of semivolatile organic compounds and carbon concentrations in streambed sediment at selected sites in the lower Chena River watershed near Fairbanks, Alaska, 2002–03.—Continued

[**Sediment sample site No.**: See table 1 for full site name. NWIS, U.S. Geological Survey National Water Data Storage and Retrieval System; mi, mile; µg/kg, microgram per kilogram, dry weight; <, less than; E, estimated; M-D, method deleted; U-DELETE, unable to determine]

Semivolatile organic compound	NWIS Code	Concentration (µg/kg, dry weight)							
		Sediment sample site No.							
		6	7	8	9	10	11	12	13
Hexachlorobenzene	49343	<100	<100	<80	<100	<150	<100	<300	<350
Dibutylphthalate[1]	49381	E46	E61	E30	E47	E68	E41	<300	<350
Dioctylphthalate[1]	49382	<100	E55	E36	E48	<150	E22	<300	<350
Diethylphthalate[1]	49383	E14	E17	E13	E16	E19	E10	<300	<350
Dimethylphthalate	49384	<100	<100	<80	<100	<150	<100	<300	<350
Pyrene	49387	E23	E25	E64	E49	<150	E12	<300	<350
1-Methylpyrene	49388	<100	<100	E20	<100	<150	<100	<300	<350
Benzo[*a*]pyrene	49389	E27	<100	E43	E34	<150	<100	<300	<350
1-Methyl-indeno[*1,2,3-cd*]pyrene	49390	<100	<100	E47	<100	<150	<100	<300	<350
2,2’-Biquinoline	49391	E62	<100	<80	<100	<150	<100	<300	<350
Quinoline	49392	<100	<100	<80	<100	<150	<100	<300	<350
Phenanthridine	49393	<100	<100	<80	<100	<150	<100	<300	<350
Isoquinoline	49394	E59	<100	<80	<100	<150	<100	<300	<350
2,4-Dinitrotoluene	49395	<100	<100	<80	<100	<150	<100	<300	<350
2,6-Dinitrotoluene	49396	E57	<100	E48	<100	E91	E43	<300	<350
Benzo[*k*]fluoranthene	49397	<100	<100	E18	<100	<150	<100	<300	<350
1-Methyl 9H-fluorene	49398	<100	<100	<80	<100	<150	<100	<300	<350
9H-Fluorene	49399	<100	<100	E14	E22	<150	<100	<300	<350
Isophorone	49400	<100	E43	<80	<100	<150	<100	<300	<350
bis(2-chloroethoxy)methane	49401	<100	<100	<80	<100	<150	<100	<300	<350
Naphthalene	49402	<100	<100	<80	E20	<150	<100	<300	<350
1,2-Dimethylnaphthalene	49403	<100	<100	<80	<100	<150	<100	<300	<350
1,6-Dimethylnaphthalene	49404	E24	E46	E14	E22	E39	E17	<300	<350
2,3,6-Trimethylnaphthalene	49405	<100	<100	<80	<100	<150	<100	<300	<350
2,6-Dimethylnaphthalene	49406	160	320	87	100	320	150	<300	E58
2-Chloronaphthalene	49407	<100	<100	<80	<100	<150	<100	<300	<350
Benzo[*g,h,i*]perylene	49408	<100	<100	E31	<100	<150	<100	<300	<350
Phenanthrene	49409	E12	<100	E10	E30	<150	E6	<300	<350
1-Methylphenanthrene	49410	<100	<100	E9	<100	<150	<100	<300	<350
4H-Cyclopenta[*def*]phenanthrene	49411	<100	<100	E6	<100	<150	<100	<300	<350
Phenol[1]	49413	E60	<100	<80	<100	<150	<100	<300	<350
2,4,6-Trichlorophenol	49415	M-D	M-D	M-D	M-D	M-D	M-D	M-D	M-D
Mesitol	49416	M-D	M-D	M-D	M-D	M-D	M-D	M-D	M-D
2,4-Dichlorophenol	49417	M-D	M-D	M-D	M-D	M-D	M-D	M-D	M-D
2,4-Dinitrophenol	49418	M-D	M-D	M-D	M-D	M-D	M-D	M-D	M-D
2-Methyl-4,6-phenol	49419	M-D	M-D	M-D	M-D	M-D	M-D	M-D	M-D
o-Nitrophenol	49420	M-D	M-D	M-D	M-D	M-D	M-D	M-D	M-D
3,5-Xylenol	49421	<100	<100	<80	<100	<150	<100	<300	<350
4-Chloro-*m*-cresol	49422	<100	<100	<80	<100	<150	<100	<300	<350
m-Nitrophenol	49423	M-D	M-D	M-D	M-D	M-D	M-D	M-D	M-D
C8-Alkylphenol	49424	<100	<100	<80	<100	<150	<100	<300	<350
Pentachlorophenol	49425	M-D	M-D	M-D	M-D	M-D	M-D	M-D	M-D
bis(2-ethylhexyl)phthalate[1]	49426	<100	110	95	100	E110	E88	<300	<350
Butylbenzylphthalate[1]	49427	U-DELETED	<100	U-DELETED	<100	U-DELETED	E160	<300	<350
Acenaphthylene	49428	<100	<100	<80	<100	<150	<100	<300	<350
Acenaphthene	49429	<100	<100	<80	<100	<150	<100	<300	<350
Acridine	49430	<100	<100	<80	<100	<150	<100	<300	<350

Table 5. Summary of semivolatile organic compounds and carbon concentrations in streambed sediment at selected sites in the lower Chena River watershed near Fairbanks, Alaska, 2002–03.—Continued

[**Sediment sample site No.**: See table 1 for full site name. NWIS, U.S. Geological Survey National Water Data Storage and Retrieval System; mi, mile; µg/kg, microgram per kilogram, dry weight; <, less than; E, estimated; M-D, method deleted; U-DELETE, unable to determine]

Semivolatile organic compound	NWIS Code	Concentration (µg/kg, dry weight)							
		Sediment sample site No.							
		6	7	8	9	10	11	12	13
n-Nitrosodipropylamine	49431	<100	<100	<80	<100	<150	<100	<300	<350
n-Nitrosodiphenylamine	49433	<100	<100	E19	<100	<150	<100	<300	<350
Anthracene	49434	<100	<100	E22	E27	<150	<100	<300	<350
2-Methylanthracene	49435	<100	<100	<80	<100	<150	<100	<300	<350
Benzo[*a*]anthracene	49436	<100	<100	E39	E23	<150	<100	<300	<350
9,10-Anthraquinone	49437	<100	<100	<80	<100	<150	<100	<300	<350
1,2,4-Trichlorobenzene	49438	<100	<100	<80	<100	<150	<100	<300	<350
o-Dichlorobenzene	49439	<100	<100	<80	<100	<150	<100	<300	<350
m-Dichlorobenzene	49441	<100	<100	<80	<100	<150	<100	<300	<350
p-Dichlorobenzene	49442	<100	<100	<80	<100	<150	<100	<300	<350
Azobenzene	49443	<100	<100	<80	<100	<150	<100	<300	<350
Nitrobenzene	49444	<100	<100	<80	<100	<150	<100	<300	<350
Pentachlorobenzene	49446	<100	<100	<80	<100	<150	<100	<300	<350
Hexachlorobutadiene	49448	M-D	M-D	M-D	M-D	M-D	M-D	M-D	M-D
Carbazole	49449	<100	<100	<80	<100	<150	<100	<300	<350
Chrysene	49450	<100	<100	E25	E26	<150	<100	<300	<350
p-Cresol	49451	<100	E51	E42	E64	<150	E56	<300	E160
Thiophene	49452	<100	<100	<80	<100	<150	<100	<300	<350
Hexachloroethane	49453	M-D	M-D	M-D	M-D	M-D	M-D	M-D	M-D
4-Bromophenylphenylether	49454	<100	<100	<80	<100	<150	<100	<300	<350
4-Chlorophenylphenylether	49455	<100	<100	<80	<100	<150	<100	<300	<350
bis(2-chloroethyl)ether	49456	<100	<100	<80	<100	<150	<100	<300	<350
bis(2-chloro-1-methylethyl)ether	49457	M-D	M-D	M-D	M-D	M-D	M-D	M-D	M-D
Benzo[*b*]fluoranthene	49458	<100	<100	E41	<100	<150	<100	<300	<350
Pentachloroanisole	49460	<100	<100	<80	<100	<150	<100	<300	<350
Dibenz[*a,h*]anthracene	49461	<100	<100	E50	<100	<150	<100	<300	<350
Fluoranthene	49466	E20	E23	E64	E56	<150	E12	<300	<350
o-Chlorophenol	49467	<100	<100	<80	<100	<150	<100	<300	<350
Benzo[*c*]cinnoline	49468	<100	<100	<80	<100	<150	<100	<300	<350
Hexachlorocyclopentadiene	49489	M-D	M-D	M-D	M-D	M-D	M-D	M-D	M-D
2-Ethylnaphthalene	49948	<100	<100	<80	<100	<150	<100	<300	<350
Number of SVOC analytes detected, includes remark code E (estimated). Excludes 5 phthalates with laboratory contamination-see footnote 1.		9	6	21	12	3	7	0	2
Inorganic carbon (g/kg)	49270	9.9	5.1	3.2	1.6	1.6	17	<0.2	0.22
Organic carbon (g/kg)	49271	34	37	22	24	39	35	26	21
Maximum		160	320	95	100	320	150	0	2

[1]Reported value for this analyte includes contamination in laboratory blank at measurable concentrations.

Table 5. Summary of semivolatile organic compounds and carbon concentrations in streambed sediment at selected sites in the lower Chena River watershed near Fairbanks, Alaska, 2002–03.—Continued

[**Sediment sample site No.**: See table 1 for full site name. NWIS, U.S. Geological Survey National Water Data Storage and Retrieval System; mi, mile; µg/kg, microgram per kilogram, dry weight; <, less than; E, estimated; M-D, method deleted; U-DELETE, unable to determine]

Semivolatile organic compound	NWIS Code	Concentration (µg/kg, dry weight) Sediment sample site No.					
		13R	14	15	16	17	18
Hexachlorobenzene	49343	<500	<350	<650	<480	<300	<350
Dibutylphthalate[1]	49381	<500	<350	<650	<480	<300	<350
Dioctylphthalate[1]	49382	<500	<350	<650	<480	<300	<350
Diethylphthalate[1]	49383	<500	<350	<650	<480	<300	<350
Dimethylphthalate	49384	<500	<350	<650	<480	<300	<350
Pyrene	49387	<500	<350	<650	<480	<300	<350
1-Methylpyrene	49388	<500	<350	<650	<480	<300	<350
Benzo[a]pyrene	49389	<500	<350	<650	<480	<300	<350
1-Methyl-indeno[*1,2,3-cd*]pyrene	49390	<500	<350	<650	<480	<300	<350
2,2’-Biquinoline	49391	<500	<350	<650	<480	<300	<350
Quinoline	49392	<500	<350	<650	<480	<300	<350
Phenanthridine	49393	<500	<350	<650	<480	<300	<350
Isoquinoline	49394	<500	<350	<650	<480	<300	<350
2,4-Dinitrotoluene	49395	<500	<350	<650	<480	<300	<350
2,6-Dinitrotoluene	49396	<500	<350	<650	<480	<300	<350
Benzo[*k*]fluoranthene	49397	<500	<350	<650	<480	<300	<350
1-Methyl 9H-fluorene	49398	<500	<350	<650	<480	<300	<350
9H-Fluorene	49399	<500	<350	<650	<480	<300	<350
Isophorone	49400	<500	<350	<650	<480	<300	<350
bis(2-chloroethoxy)methane	49401	<500	<350	<650	<480	<300	<350
Naphthalene	49402	<500	<350	<650	<480	<300	<350
1,2-Dimethylnaphthalene	49403	<500	<350	<650	<480	<300	<350
1,6-Dimethylnaphthalene	49404	<500	<350	<650	<480	<300	<350
2,3,6-Trimethylnaphthalene	49405	<500	<350	<650	<480	<300	<350
2,6-Dimethylnaphthalene	49406	E87	E73	E120	E100	E92	E67.3
2-Chloronaphthalene	49407	<500	<350	<650	<480	<300	<350
Benzo[*g,h,i*]perylene	49408	<500	<350	<650	<480	<300	<350
Phenanthrene	49409	<500	<350	<650	<480	<300	<350
1-Methylphenanthrene	49410	<500	<350	<650	<480	<300	<350
4H-Cyclopenta[*def*]phenanthrene	49411	<500	<350	<650	<480	<300	<350
Phenol[1]	49413	<500	<350	<650	<480	<300	<350
2,4,6-Trichlorophenol	49415	M-D	M-D	M-D	M-D	M-D	M-D
Mesitol	49416	M-D	M-D	M-D	M-D	M-D	M-D
2,4-Dichlorophenol	49417	M-D	M-D	M-D	M-D	M-D	M-D
2,4-Dinitrophenol	49418	M-D	M-D	M-D	M-D	M-D	M-D
2-Methyl-4,6-phenol	49419	M-D	M-D	M-D	M-D	M-D	M-D
o-Nitrophenol	49420	M-D	M-D	M-D	M-D	M-D	M-D
3,5-Xylenol	49421	<500	<350	<650	<480	<300	<350
4-Chloro-*m*-cresol	49422	<500	<350	<650	<480	<300	<350
m-Nitrophenol	49423	M-D	M-D	M-D	M-D	M-D	M-D
C8-Alkylphenol	49424	<500	<350	<650	<480	<300	<350
Pentachlorophenol	49425	M-D	M-D	M-D	M-D	M-D	M-D
bis(2-ethylhexyl)phthalate[1]	49426	<500	<350	<650	<480	<300	<350
Butylbenzylphthalate[1]	49427	<500	<350	<650	<480	<300	<350
Acenaphthylene	49428	<500	<350	<650	<480	<300	<350
Acenaphthene	49429	<500	<350	<650	<480	<300	<350
Acridine	49430	<500	<350	<650	<480	<300	<350

Table 5. Summary of semivolatile organic compounds and carbon concentrations in streambed sediment at selected sites in the lower Chena River watershed near Fairbanks, Alaska, 2002–03.—Continued

[**Sediment sample site No.**: See table 1 for full site name. NWIS, U.S. Geological Survey National Water Data Storage and Retrieval System; mi, mile; µg/kg, microgram per kilogram, dry weight; <, less than; E, estimated; M-D, method deleted; U-DELETE, unable to determine]

Semivolatile organic compound	NWIS Code	Concentration (µg/kg, dry weight)					
		Sediment sample site No.					
		13R	14	15	16	17	18
n-Nitrosodipropylamine	49431	<500	<350	<650	<480	<300	<350
n-Nitrosodiphenylamine	49433	<500	<350	<650	<480	<300	<350
Anthracene	49434	<500	<350	<650	<480	<300	<350
2-Methylanthracene	49435	<500	<350	<650	<480	<300	<350
Benzo[*a*]anthracene	49436	<500	<350	<650	<480	<300	<350
9,10-Anthraquinone	49437	<500	<350	<650	<480	<300	<350
1,2,4-Trichlorobenzene	49438	<500	<350	<650	<480	<300	<350
o-Dichlorobenzene	49439	<500	<350	<650	<480	<300	<350
m-Dichlorobenzene	49441	<500	<350	<650	<480	<300	<350
p-Dichlorobenzene	49442	<500	<350	<650	<480	<300	<350
Azobenzene	49443	<500	<350	<650	<480	<300	<350
Nitrobenzene	49444	<500	<350	<650	<480	<300	<350
Pentachlorobenzene	49446	<500	<350	<650	<480	<300	<350
Hexachlorobutadiene	49448	M-D	M-D	M-D	M-D	M-D	M-D
Carbazole	49449	<500	<350	<650	<480	<300	<350
Chrysene	49450	<500	<350	<650	<480	<300	<350
p-Cresol	49451	E410	370	E310	1000	710	E297
Thiophene	49452	<500	<350	<650	<480	<300	<350
Hexachloroethane	49453	M-D	M-D	M-D	M-D	M-D	M-D
4-Bromophenylphenylether	49454	<500	<350	<650	<480	<300	<350
4-Chlorophenylphenylether	49455	<500	<350	<650	<480	<300	<350
bis(2-chloroethyl)ether	49456	<500	<350	<650	<480	<300	<350
bis(2-chloro-1-methylethyl)ether	49457	M-D	M-D	M-D	M-D	M-D	M-D
Benzo[*b*]fluoranthene	49458	<500	<350	<650	<480	<300	<350
Pentachloroanisole	49460	<500	<350	<650	<480	<300	<350
Dibenz[*a*,*h*]anthracene	49461	<500	<350	<650	<480	<300	<350
Fluoranthene	49466	<500	<350	<650	<480	<300	E55.1
o-Chlorophenol	49467	<500	<350	<650	<480	<300	<350
Benzo[*c*]cinnoline	49468	<500	<350	<650	<480	<300	<350
Hexachlorocyclopentadiene	49489	M-D	M-D	M-D	M-D	M-D	M-D
2-Ethylnaphthalene	49948	<500	<350	<650	<480	<300	<350
Number of SVOC analytes detected, includes remark code E (estimated). Excludes five phthalates with laboratory contamination—see footnote 1.		2	2	2	2	2	3
Inorganic carbon (g/kg)	49270	0.29	<0.2	0.36	0.29	0.26	0.43
Organic carbon (g/kg)	49271	32	12	35	25	14	25
Maximum	3	2	370	2	1,000	710	3

[1]Reported value for this analyte includes contamination in laboratory blank at measurable concentrations.

PAHs are a group of chemicals that are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances, such as tobacco and charbroiled meat; they generally occur as complex mixtures (for example, as part of combustion products such as soot), not as single compounds (Agency for Toxic Substances and Disease Registry, 1995). They also can be found in substances such as crude oil, coal, coal tar pitch, creosote, and roofing tar. They are present throughout the environment and can occur in the air, attached to dust particles, or as solids in soil or sediment. Because of their low solubility and high affinity for organic carbon, PAHs in aquatic systems primarily are found adsorbed to particles that either have settled to the bottom or are suspended in the water column (Eisler, 1987).

The number of SVOCs detected in sample #8 (21) was greater than in other Chena Slough samples. The organic-carbon content for sample #8 (22 g/kg) was approximately the same as the median organic-carbon content (about 25 g/kg) of other Chena Slough samples. Generally, organic compounds have an affinity for organic matter, and consequently, bed sediments that are rich in organic-carbon compounds adsorb more SVOCs than do bottom sediments that are mainly composed of inorganic matter (Miller and McPherson, 2001).

Aquatic-Life Criteria Semivolatile Organic Compounds

Aquatic-life criteria values for 18 common SVOCs, compiled by Gilliom and others (1998), and associated SVOC concentrations for Noyes Slough, Chena Slough, and Chena River sediment are presented in table 6. None of the SVOCs

Table 6. Summary of aquatic–life criteria for semivolatile organic compounds in streambed sediment at selected sites in the lower Chena River watershed near Fairbanks, Alaska, 2002–03.

[Modified from Gilliom and others (1998). **Noyes Slough median:** Noyes Slough median values provided for comparison (see Kennedy and others, 2004). **Type of criterion**: SQC, sediment–quality criterion; ER–M, effects range–median; SQAL, sediment–quality advisory level; PEL, probable effect level. USEPA, U.S. Environmental Protection Agency; µg/kg, micrograms per kilogram, dry weight; <, less than]

Compound	Chena Slough concentration range (µg/kg)	Chena River concentration range (µg/kg)	Noyes Slough concentration range (µg/kg)	Criterion (µg/kg, dry weight)	Type of criterion	Criterion reference
Polycyclic aromatic hydrocarbons (PAHs)						
Acenaphthene	<80–<150	<300–<650	<50–E85	1,300	USEPA SQC[2]	USEPA (1990)
Acenaphthylene	<80–<150	<300–<650	<50	640	ER-M	Long and others (1995)
Anthracene	E15–<150	<300–<650	<50–E54	1,100	ER-M	Long and others (1995)
Benzo[*a*]anthracene	E23–<150	<300–<650	<50–E94	693	Florida PEL	MacDonald (1994)
Benzo[*a*]pyrene	E20–<150	<300–<650	<50–E120	782	Canada PEL	Canadian Council of Ministers of the Environment (2002)
Chrysene	E25–<150	<300–<650	<50–230	862	Canada PEL	Canadian Council of Ministers of the Environment (2002)
Dibenzo[*a*,*h*]anthracene	E50–<150	<300–<650	<50–E100	260	ER-M	Long and others (1995)
Fluoranthene	E12–<150	E55.1–<650	<50–330	6,200	USEPA SQC[2]	USEPA (1996)
Naphthalene	E20–<150	<300–<650	<50–E60	470	USEPA SQC[2]	USEPA (1996)
Phenanthrene	E6–<150	<300–<650	<50–200	1,800	USEPA SQC[2]	USEPA (1996)
Pyrene	E12–<150	<300–<650	<50–300	1,398	Florida PEL	MacDonald (1994)
Phthalates						
Butylbenzylphthalate[1]	E82–E160	<300–<650	E57–173	11,000	USEPA SQC[2]	USEPA (1996)
Diethylphthalate[1]	E7–E19	<300–<650	<50	630	USEPA SQAL	USEPA (1996)
Di-*n*-butylphthalate[1]	E26–E68	<300–<650	<50–E89	11,000	USEPA SQC[2]	USEPA (1996)
bis(2-ethylhexyl)phthalate[1]	E54–<150	<300–<650	E95–2,560	2,650	Florida PEL	MacDonald (1994)
Other (semivolatile organic compounds)						
1,2-Dichlorobenzene	<80–<150	<300–<650	<50	340	USEPA SQC[2]	USEPA (1996)
1,4-Dichlorobenzene	<80–<150	<300–<650	<50	350	USEPA SQC[2]	USEPA (1996)
1,2,4-Trichlorobenzene	<80–<150	<300–<650	<50	9,200	USEPA SQC[2]	USEPA (1996)

[1] Concentrations in field samples are not corrected for contamination measured in laboratory blanks.

[2] Value assumes a 1–percent sediment organic carbon.

measured in Chena Slough streambed-sediment samples are at concentrations exceeding aquatic-life criteria, nor were any of the SVOC analytes detected at elevated concentrations. In contrast, because of the elevated reporting levels for Chena River sediment samples, it is unknown whether one or more SVOC aquatic-life criteria were exceeded. For example, most SVOC concentrations for Chena River sample #15 were reported as <650 µg/kg, which may exceed criterion for PAHs aceaphthylene (640 µg/kg), dibenzo[*a,h*]anthracene (260 µg/kg), and naphthalene (470 µg/kg) as well as one phthalate and two other SVOCs (table 6).

Pesticides and Polychlorinated Biphenyls

The pesticide DDT, metabolites DDD and DDE, and selected isomers, as well as PCB compounds were detected in sediment from Chena Slough sample sites #1 and #2. Low level concentrations of chlordane compounds (pesticide) also were detected in the Chena Slough sediment sample #1. Relatively low concentrations of total DDT, about 10 µg/kg or less were detected in all other Chena Slough sediment samples except in sample #9. Low concentrations of DDD and DDE were detected in Chena River sediment from only one sample site, #18. However, because non-target interfering compounds were present in the Chena River sample matrix material, many of the target analytes minimum reporting limits were elevated. Consequently, low concentrations of DDT or other contaminants may have been present in many of the Chena River samples but were not detected because contaminant concentrations were below elevated reporting limits (table 7).

Aquatic-Life Criteria Pesticides and Polychlorinated Biphenyls

Aquatic-life criteria values for six common pesticides and PCBs, compiled by Gilliom and others (1998), are presented in table 8. Criteria for total DDT, DDD, and DDE concentrations for bulk-sediment samples were obtained from Canadian sediment quality guideline summary tables (Canadian Council of Ministers of the Environment, 2002). Total DDT (DDT+DDD+DDE) concentration in two Chena Slough streambed-sediment samples, #1 (Total DDT > 120 µg/kg) and #2 (total DDT >70 µg/kg), exceeded the effects range-median (ER-M) of 46.1 µg/kg published by Long and others (1995). Low-level concentrations, typically less than 15.0 µg/kg total DDT were detected in most other Chena Slough samples (table 8). Chena River streambed-sediment sample #18 contained isomer *p,p*'-DDD at 6 µg/kg. The pesticide and PCB reporting levels for most Chena River samples were relatively high (<20 µg/kg).

For many years (1939–72), DDT was one of the most widely used pesticide chemicals in the United States (Agency for Toxic Substances and Disease Registry, 2002). Its popularity was due to its reasonable cost, effectiveness, persistence, and versatility. In 1972, DDT use was banned in the United States and many parts of the world. DDT was released into the environment primarily by spraying onto agricultural crops and forest lands and to control mosquitoes. DDT does not occur naturally in the environment. DDT and its metabolites, DDD and DDE, are virtually immobile in soil, becoming strongly absorbed onto the surface layer of soils. Likewise, as a consequence of their extremely low water solubility, DDT and its metabolites become adsorbed onto particulates in water and settle into sediments. There is continued dispersion of DDT to streambed sediments through erosion of contaminated soils. DDT also may attach to small particles and be carried by the wind. DDT, DDD and DDE are persistent, bioaccumulative, and toxic pollutants (U.S. Environmental Protection Agency, 2003).

Low concentrations of chlordane compounds were detected in the Chena Slough sediment sample #1. Chlordane is a man-made chemical that was used as a pesticide in the United States from 1948 to 1988. Because of concerns over cancer risk, evidence of human exposure and build up in body fat, persistence in the environment, and danger to wildlife, the USEPA canceled the use of chlordane on food crops and phased out other above-ground uses by 1988 (Agency for Toxic Substances and Disease Registry, 1994). In soil, chlordane attaches strongly to particles in the upper layers of soil and is unlikely to enter into ground water. In water, some chlordane attaches strongly to sediment and particles in the water. It is not known whether much breakdown of chlordane occurs in water or in sediment. Chlordane is known to remain in some soils for more than 20 years. The source of the chlordane is unknown; however, the spatial distribution appears to be limited to Chena Slough sample site #1.

Low concentrations of PCBs were detected in the Chena Slough sediment samples #1 and #2. Polychlorinated biphenyls (PCBs) are mixtures of as many as 209 individual chlorinated compounds, known as congeners. There are no known natural sources of PCBs. PCBs are either oily liquids or solids that are colorless to light yellow—they have no known smell or taste (Agency for Toxic Substances and Disease Registry, 2000). PCBs have been used as coolants and lubricants in transformers, capacitors, and other electrical equipment because they do not burn easily and are good insulators. The manufacture of PCBs was stopped in the U.S. in 1977 because of evidence they build up in the environment and can cause harmful health effects (Agency for Toxic Substances and Disease Registry, 2000). Products made before 1977 that may contain PCBs include old fluorescent lighting fixtures and electrical devices containing PCB capacitors, and old microscope and hydraulic oils.

Table 7. Summary of organochlorine pesticides and polychlorinated biphenyl (PCB) concentrations in streambed sediment at selected sites in the lower Chena River watershed near Fairbanks, Alaska, 2002–03.

[**Sediment sample site No.**: See table 1 for full site name. PCB, polychlorinated biphenyl; NWIS, U.S. Geological Survey National Water Data Storage and Retrieval System; µg/kg, micrograms per kilogram, dry weight; <, less than; E, estimated]

Compound category/name organochlorine pesticide and PCB	NWIS code	Method detection level (µg/kg)	Concentration (µg/kg)									
			Sediment sample site No.									
			1	2	3	4	4R	5	6	7	8	9
cis-Nonachlor	49316	1	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0
trans-Nonachlor	49317	1	E0.26	<1.0	<3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0
Oxychlordane	49318	1	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0
Aldrin	49319	1	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0
cis-Chlordane	49320	1	E0.21	<1.0	<3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0
trans-Chlordane	49321	1	E0.25	<1.0	<3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0
Chloroneb	49322	5	<5.0	<5.0	<15	<5.0	<5.0	<5.0	<10	<10	<5.0	<10
DCPA	49324	5	<5.0	<5.0	<15	<5.0	<5.0	<5.0	<10	<10	<5.0	<10
o,p'-DDD	49325	1	6	E0.79	<3.0	E0.60	E0.85	E0.18	E0.22	<2.0	<1.0	<2.0
p,p'-DDD	49326	1	24	31	<3.0	E6.8	E8.8	E2.4	E2.0	E1.8	E0.25	<2.0
o,p'-DDE	49327	1	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0
p,p'-DDE	49328	1	2.9	4.3	E0.51	1.2	1.3	1.2	E1.1	E1.2	E0.30	<2.0
o,p'-DDT	49329	2	E2.4	E0.43	<6.0	<2.0	<2.0	<2.0	<4.0	<4.0	<2.0	<4.0
p,p'-DDT	49330	2	40	90	<6.0	<2.0	<2.0	<2.0	<4.0	<4.0	<2.0	<4.0
Dieldrin	49331	1	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0
Endosulfan I	49332	1	<1.0	<1.2	<3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0
Endrin	49335	2	<2.0	<2.0	<6.0	<2.0	<2.0	<2.0	<4.0	<4.0	<2.0	<4.0
alpha-BHC	49338	1	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0
beta-BHC	49339	1	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0
Heptachlor	49341	1	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0
Heptachlor epoxide	49342	1	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0
Hexachlorobenzene	49343	1	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0
Isodrin	49344	1	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0
Lindane	49345	1	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0
p,p'-Methoxychlor	49346	5	<5.0	<5.0	<15	<5.0	<5.0	<5.0	<10	<10	<5.0	<10
o,p'-Methoxychlor	49347	5	<5.0	<5.0	<15	<5.0	<5.0	<5.0	<10	<10	<5.0	<10
Mirex	49348	1	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0
cis-Permethrin	49349	5	<5.0	<5.0	<15	<5.0	<5.0	<5.0	<10	<10	<5.0	<10
trans-Permethrin	49350	5	<5.0	<5.0	<15	<5.0	<5.0	<5.0	<10	<10	<5.0	<10
Toxaphene	49351	200	<200	<200	<600	<200	<200	<200	<400	<400	<200	<400
PCB	49459	50	E9.3	E9.3	<150	<50	<50	<50	<100	<100	<50	<100
Pentachloroanisole	49460	1	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0
		Count E or >	9	6	1	2	3	2	3	2	2	0

Table 7. Summary of organochlorine pesticides and polychlorinated biphenyl (PCB) concentrations in streambed sediment at selected sites in the lower Chena River watershed near Fairbanks, Alaska, 2002–03.

[**Sediment sample site No.**: See table 1 for full site name. PCB, polychlorinated biphenyl; NWIS, U.S. Geological Survey National Water Data Storage and Retrieval System; µg/kg, micrograms per kilogram, dry weight; <, less than; E, estimated]

Compound category/name organochlorine pesticide and PCB	NWIS code	Method detection level (µg/kg)	Concentration (µg/kg)									
			Sediment sample site No.									
			10	11	12	13	13R	14	15	16	17	18
cis-Nonachlor	49316	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
trans-Nonachlor	49317	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
Oxychlordane	49318	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
Aldrin	49319	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
cis-Chlordane	49320	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
trans-Chlordane	49321	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
Chloroneb	49322	5	<15	<10	<25	<25	<25	<25	<50	<25	<25	<5.0
DCPA	49324	5	<15	<10	<25	<25	<25	<25	<50	<25	<25	<5.0
o,p'-DDD	49325	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
p,p'-DDD	49326	1	E0.97	E1.3	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	6
o,p'-DDE	49327	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
p,p'-DDE	49328	1	E0.56	E0.64	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	M
o,p'-DDT	49329	2	<6.0	<4.0	<10	<10	<10	<10	<20	<10	<10	<2.0
p,p'-DDT	49330	2	<6.0	E5.4	<10	<10	<10	<10	<20	<10	<10	<2.0
Dieldrin	49331	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
Endosulfan I	49332	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
Endrin	49335	2	<6.0	<4.0	<10	<10	<10	<10	<20	<10	<10	<2.0
alpha-BHC	49338	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
beta-BHC	49339	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
Heptachlor	49341	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
Heptachlor epoxide	49342	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
Hexachlorobenzene	49343	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
Isodrin	49344	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
Lindane	49345	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
p,p'-Methoxychlor	49346	5	<15	<10	<25	<25	<25	<25	<50	<25	<25	<5.0
o,p'-Methoxychlor	49347	5	<15	<10	<25	<25	<25	<25	<50	<25	<25	<5.0
Mirex	49348	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
cis-Permethrin	49349	5	<15	<10	<25	<25	<25	<25	<50	<25	<25	<5.0
trans-Permethrin	49350	5	<15	<10	<25	<25	<25	<25	<50	<25	<25	<5.0
Toxaphene	49351	200	<600	<400	<1000	<1000	<1000	<1000	<2000	<1000	<1000	<200
PCB	49459	50	<150	<100	<250	<250	<250	<250	<500	<250	<250	<50
Pentachloroanisole	49460	1	<3.0	<2.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0
		Count E or >	2	3	0	0	0	0	0	0	0	2

Table 8. Summary of aquatic-life criteria for organochlorine pesticides and polychlorinated biphenyl (PCB) concentrations in streambed sediment at selected sites in the lower Chena River watershed near Fairbanks, Alaska, 2002–03.

[Modified from Gilliom and others (1998). **Noyes Slough concentration:** Noyes Slough values provided for comparison (see Kennedy and others, 2004). µg/kg, micrograms per kilogram, dry weight. **Type of criterion:** ER-M, effects range-median; PEL, probable effect level; USEPA, U.S. Environmental Protection Agency; SQC, sediment-quality criterion. PCB, polychlorinated biphenyl; <, less than]

Compound	Chena Slough concentration range (µg/kg)	Chena River concentration range (µg/kg)	Noyes Slough concentration range (µg/kg)	Aquatic-life criteria			Sediment sample concentration greater than criterion (µg/g)
				Criterion (µg/kg, dry weight)	Type of criterion	Criterion reference	
Total chlordane:				6	ER-M	Long and Morgan (1991)	
cis-Chlordane	<1.0–<3.0	<1.0–<10	<2.0				
trans-Chlordane	<1.0–<3.0	<1.0–<10	<2.0				
cis-Nonachlor	<1.0–<3.0	<1.0–<10	<2.0				
trans-Nonachlor	<1.0–<3.0	<1.0–<10	<2.0				
Oxychlordane	<1.0–<3.0	<1.0–<10	<2.0				
Total DDT[1]:				46.1	ER-M	Long and others (1995)	Sample #1, Total DDT>70; Sample #2, Total DDT>120
o,p'-DDD	<1.0–6.0	<1.0–<10	<1.0–2.6				
p,p'-DDD	<1.0–31	<5.0–<10	<1.0–E12	Sum of *p,p'* and *o,p'*-DDE isomers = 8.51	Canada PEL	Canadian Council of Ministers of the Environment (2002)	
o,p'-DDE	<1.0–<3.0	<1.0–<10	<2.0				
p,p'-DDE	<1.0–<4.3	<5.0–<10	<1.0	Sum of *p,p'* and *o,p'*-DDE isomers = 6.75	Canada PEL	Canadian Council of Ministers of the Environment (2002)	
o,p'-DDT	<1.0–<6.0	<2.0–<20	<2.0–<4.0				
p,p'-DDT	<2.0–90	<2.0–<20	<1.0–<4.0	Sum of *p,p'* and *o,p'*-DDT isomers = 4.77	Canada PEL	Canadian Council of Ministers of the Environment (2002)	
Dieldrin	<1.0–<3.0	<1.0–<10	<2.0	110	USEPA SQC[2]	USEPA (1991)	
Endrin	<2.0–<6.0	<2.0–<20	<4.0	42	USEPA SQC[2]	USEPA (1989)	
y-HCH (Lindane)	<1.0–<3.0	<1.0–<10	<2.0	1.38	Canada PEL	Canadian Council of Ministers of the Environment (2002)	
Total PCBs	<10–<150	<50–<500	<100	189	Florida PEL	MacDonald (1994)	

[1] Sum of *o,p'* and *p,p'* isomers for DDD, DDE, and DDT.

[2] Value assumes a 1-percent sediment organic carbon.

Summary

Streambed sediments collected from Chena Slough and Chena River near Fairbanks, Alaska, were analyzed for concentrations of selected nutrients, trace elements, and organochlorine compounds. The analytical results were compared to streambed-sediment guidelines for the protection of aquatic life and to sediment data collected in 2001–02 from Noyes Slough, a side channel of the lower Chena River. These comparative data increase the understanding of occurrence and concentration of selected contaminants in the lower Chena River watershed and provide baseline data to help guide management decisions for improving impaired waterways.

Results of the analyses indicated considerable differences in chemical and organic character of the sediments within and among the interconnected waterways. Concentrations of total phosphorus and sulfate were substantially greater in Chena Slough sediment samples than in Chena River samples and the median concentration of chloride was approximately two times greater in Chena Slough samples than in Chena River samples. Orthophosphate, nitrate, and ammonia concentrations varied between the two streams. Nutrient data for Noyes Slough sediments were not available for comparisons.

Sediment samples from Chena Slough and Chena River were analyzed for 24 trace elements. All samples contained reportable concentrations of multiple trace elements. Arsenic, nickel, and zinc were detected in the samples from a limited number of sites in concentrations that exceeded probable effect levels (PELs) for the protection of aquatic life, and three samples from Chena Slough exceeded the CB-PEC guideline for arsenic of 33 mg/kg. Except for greater concentrations of arsenic in Chena Slough, median concentrations of nine priority pollutant trace elements in Chena Slough and Chena River sediment samples are similar to or less than those reported for Noyes Slough.

Relatively low concentrations of semivolatile organic compounds (SVOCs) were widespread in sediment samples collected from Chena Slough and Chena River. At least one or more of 78 selected SVOC s were detected, at an estimated or reportable concentration, in all samples except for one sample from the Chena River, upstream of urban development. The number of SVOCs detected varied from 5 to 21 for most of Chena Slough sediment samples. In contrast, the number of SVOCs detected in the Chena River sediment samples was three or less, most likely because chemical-matrix interference resulted in elevated reporting limits for organochlorine compounds in these samples. Low concentrations of additional semivolatile organic compounds may have been present in the Chena River sediment samples but were not detected because of the matrix interference.

The organochlorine pesticide and PCB compounds most frequently reported were DDT or its metabolites in 11 samples, PCBs in two samples, and chlordane or its breakdown products in one sample. Comparison of reported pesticide and PCB concentrations with sediment quality guidelines indicate total DDT concentrations of about 70 and 120 μg/kg in two Chena Slough sediment samples exceeded the total DDT criterion of 46.1 μg/kg. The chlordane and PCBs were detected at low concentrations in the same Chena Slough sediment samples that exceeded the total DDT criterion. With the exception of elevated concentrations of total DDT in the two Chena Slough samples, concentrations and detection frequency of organochlorine pesticides in Chena Slough were similar to or less than those reported for the samples collected from Noyes Slough in an earlier study.

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