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Sediment Cores and Chemistry for the Kootenai River White Sturgeon Habitat Restoration Project, Boundary County, Idaho

Scientific Investigations Report 2011–5006

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

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KEN SALAZAR, Secretary

U.S. Geological Survey
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U.S. Geological Survey, Reston, Virginia: 2012

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Contents

Figures

Tables

Conversion Factors, Datums, and Abbreviations and Acronyms

Conversion Factors

Multiply	By	To obtain
centimeter (cm)	0.06102	inch (in.)
cubic meter per second (m^3/s)	70.07	acre-foot per day (acre-ft/d)
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)
gram (g)	0.03527	ounce (oz)
kilometer (km)	0.6214	mile (mi)
meter (m)	3.281	foot (ft)
meter per second (m/s)	3.281	foot per second (ft/s)
microgram per kilogram (μg/kg)	1.0	parts per billion (ppb)
millimeter (mm)	0.03937	inch (in.)
square meter (m^2)	10.76	square foot (ft^2)

Pressure: 1 Pascal (Pa) = $1 N/m^2$ = 6.895 kPa

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

$$°F = (1.8 \times °C) + 32.$$

Datums

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83), Idaho Transverse Mercator – North American Datum 1983/1998 Idaho West, in meters.

Abbreviations and Acronyms

FRAR	Free Run Aquatic Research
GPS	Global Positioning System
ID	inside diameter
KTOI	Kootenai Tribe of Idaho
LiDAR	Light-Detecting Radar
MD_SWMS	Multidimensional Surface-Water Modeling System
NWIS	National Water Information System
NWQL	National Water Quality Laboratory
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyls
PVC	polyvinyl chloride
RKM	river kilometer
SRM	standard reference material
TOC	total organic carbon
USGS	U.S. Geological Survey

Sediment Cores and Chemistry for the Kootenai River White Sturgeon Habitat Restoration Project, Boundary County, Idaho

By Gary J. Barton, Rhonda J. Weakland, Ryan L. Fosness, Stephen E. Cox, and Marshall L. Williams

Abstract

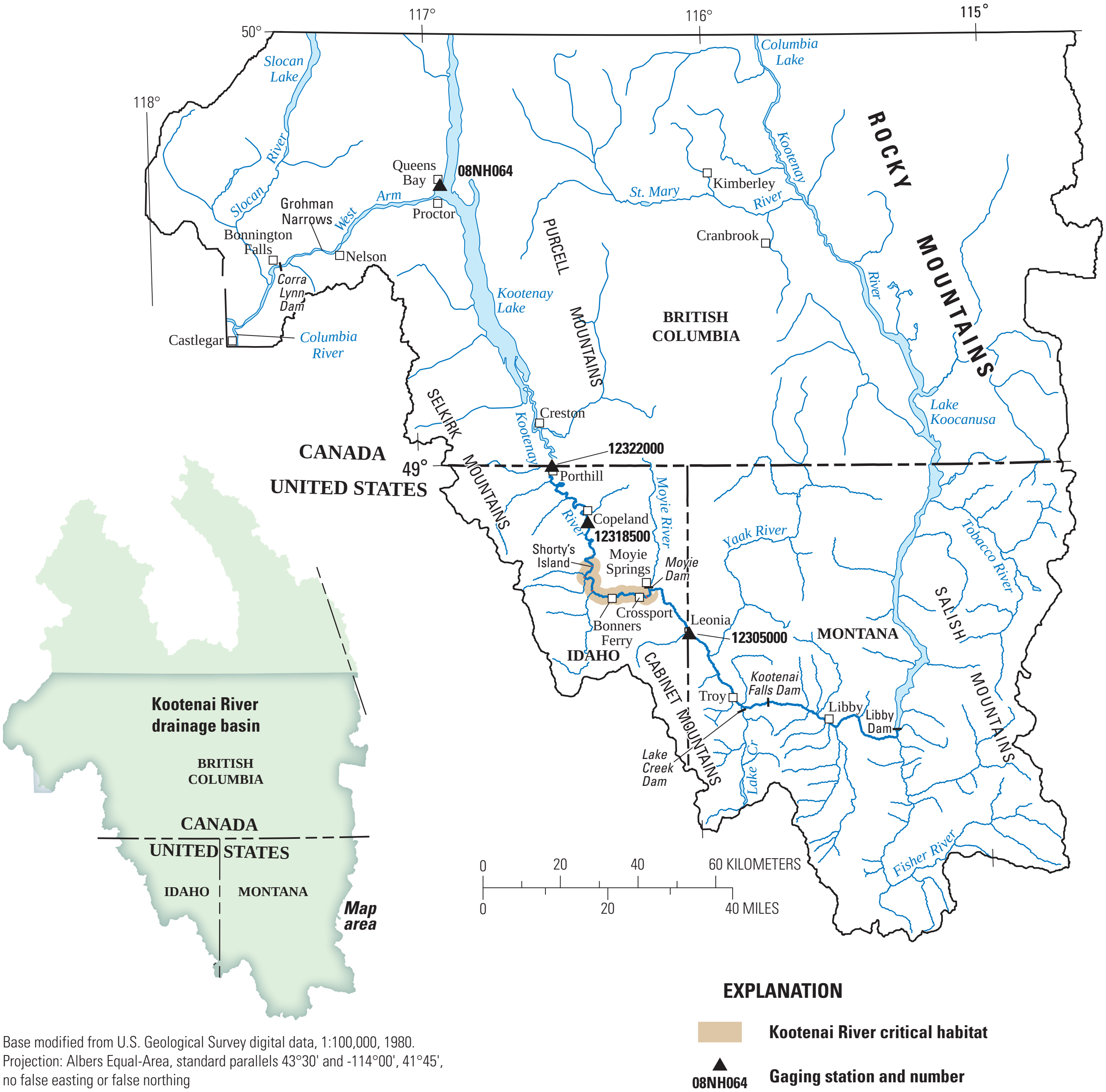
The Kootenai Tribe of Idaho, in cooperation with local, State, Federal, and Canadian agency co-managers and scientists, is assessing the feasibility of a Kootenai River habitat restoration project in Boundary County, Idaho. This project is oriented toward recovery of the endangered Kootenai River white sturgeon (*Acipenser transmontanus*) population, and simultaneously targets habitat-based recovery of other native river biota. Projects currently (2010) under consideration include modifying the channel and flood plain, installing in-stream structures, and creating wetlands to improve the physical and biological functions of the ecosystem. River restoration is a complex undertaking that requires a thorough understanding of the river. To assist in evaluating the feasibility of this endeavor, the U.S. Geological Survey collected and analyzed the physical and chemical nature of sediment cores collected at 24 locations in the river. Core depths ranged from 4.6 to 15.2 meters; 21 cores reached a depth of 15.2 meters. The sediment was screened for the presence of chemical constituents that could have harmful effects if released during restoration activities. The analysis shows that concentrations of harmful chemical constituents do not exceed guideline limits that were published by the U.S. Army Corps of Engineers in 2006.

Introduction

The endangered Kootenai River white sturgeon (*Acipenser transmontanus*) is a naturally landlocked, locally adapted population that has been isolated since the last glacial age, approximately 10,000 years ago. The Kootenai River white sturgeon has long been, and continues to be, a culturally significant species to the Kootenai Tribe.

Since 1931, the Kootenai River white sturgeon spawning habitat in the Upper Columbia Basin was altered after construction of dams including Libby Dam in Montana in 1972 (fig. 1). Construction of dikes and the drainage of wetlands prior to the 1960s, as well as changes in nutrient availability that support the ecosystems also have affected the spawning habitat. One or more of these alterations are thought to be responsible for the recruitment failure of the Kootenai River white sturgeon for more than 3 decades (U.S. Fish and Wildlife Service, 2006). Recruitment occurs when a spawning event produces juvenile fish that survive to create a new year-class of fish in sufficient numbers to maintain the fish population.

The Kootenai Tribe of Idaho (KTOI), in cooperation with local, state, Federal, and Canadian agency co-managers and scientists, is assessing the feasibility of a Kootenai River habitat restoration project in Boundary County, Idaho. This project is oriented toward recovery of the endangered Kootenai River white sturgeon population, and simultaneously targets habitat-based recovery of other native river biota. Some projects under consideration include modifying the channel and flood plain, installing in-stream structures, and creating wetlands adjacent to the river to improve the physical and biological functions of the ecosystem (River Design Group, Inc., 2009). These actions may involve the dredging and moving of sediment, which could cause the migration or release of sequestered chemical constituents that could have a negative effect on the ecosystem. The regulatory community requires a stepwise procedure for determining whether or not contaminants are present in the sediment and if any concentrations exceed sediment-quality guidelines (U.S. Army Corps of Engineers and others, 2006) prior to any disturbance of river sediment during habitat restoration. To that end, in 2007 the KTOI contracted the coring of sediment beneath the Kootenai River from the upstream end of the braided reach at river kilometer (RKM) 257 to 0.2 kilometers upstream of Shorty's Island at RKM 131.9 (fig. 2). The KTOI requested that the U.S. Geological Survey (USGS) help plan the sediment coring, oversee coring operations, log the cores, and sample sediments in each core for chemical analysis. The KTOI also contracted with Free Run Aquatic Research (FRAR), Hayden, Idaho, to help plan sampling of sediment from cores and subsequent chemical analysis.



Base modified from U.S. Geological Survey digital data, 1:100,000, 1980.
Projection: Albers Equal-Area, standard parallels 43°30' and -114°00', 41°45',
no false easting or false northing

Figure 1. Location of study reach in Idaho, and the Kootenai River drainage basin in Idaho, Montana, and in British Columbia, Canada.

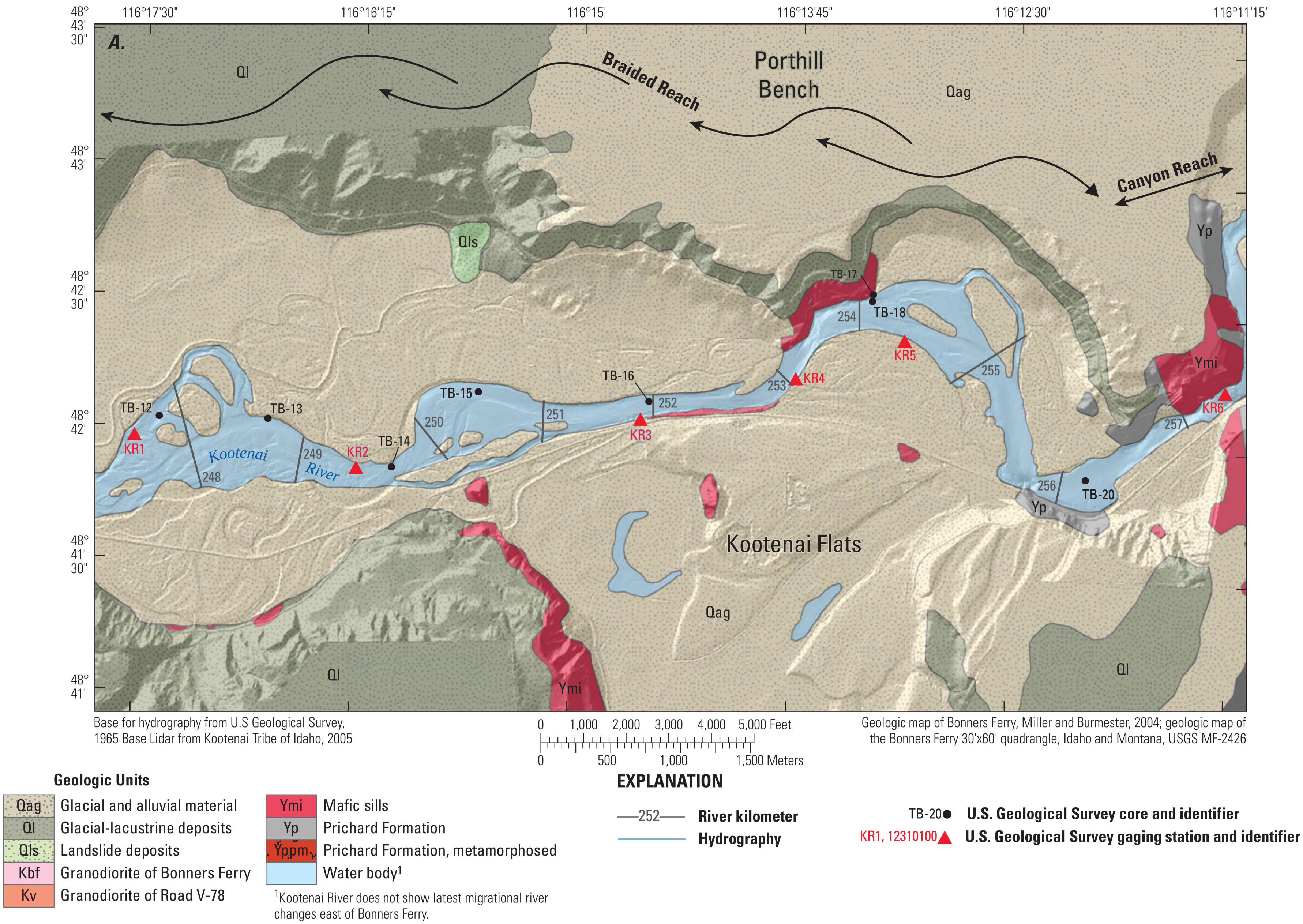
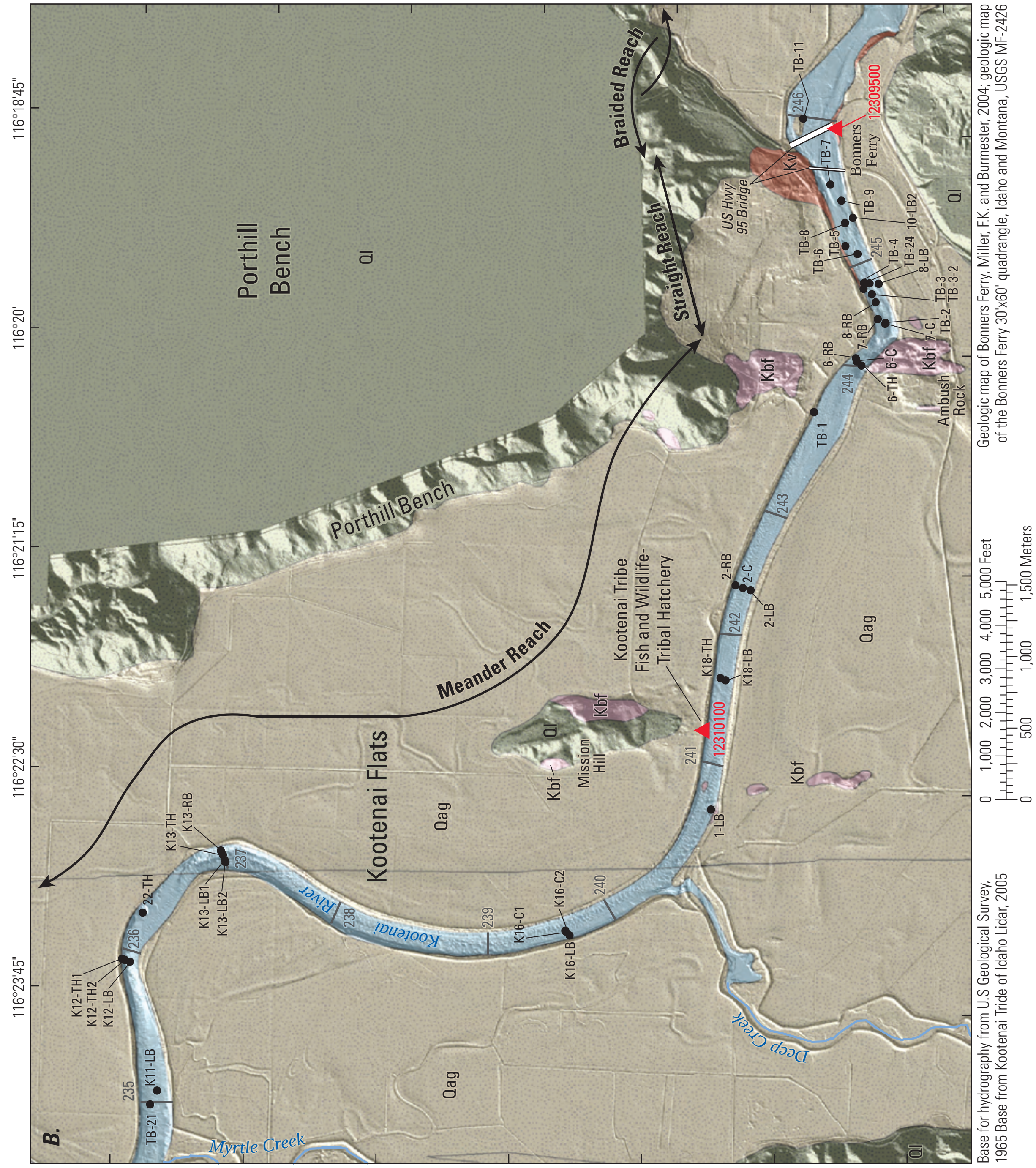


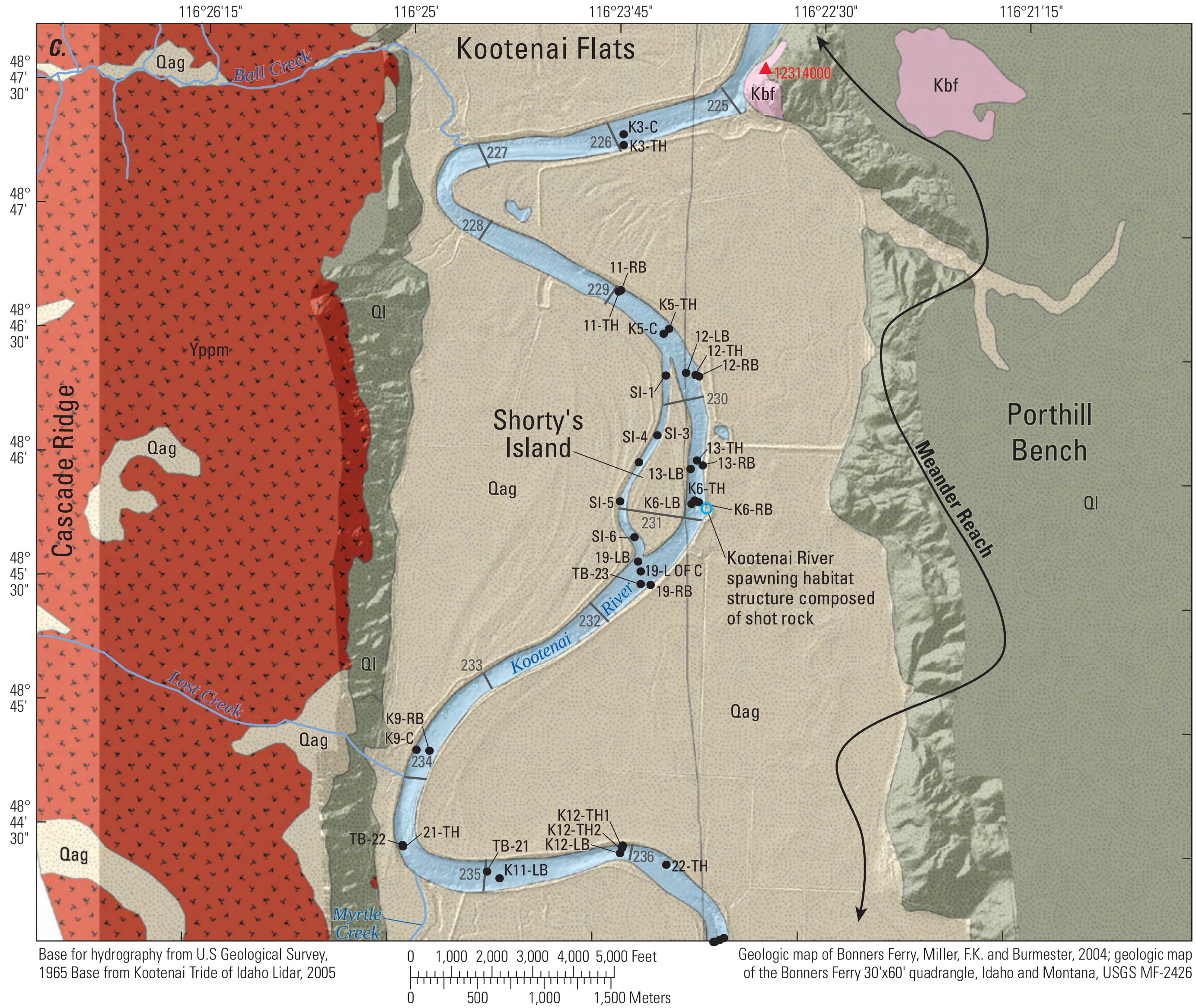
Figure 2. Location of study area, sediment-coring sites, and selected streamflow-gaging stations in the (*A*) braided reach, (*B*), straight reach, and (*C*) meander reach, Kootenai River near Bonners Ferry, Boundary County, Idaho.



Base for hydrography from U.S Geological Survey, 1965 Base from Kootenai Tride of Idaho Lidar, 2005

Geologic map of Bonners Ferry, Miller, F.K. and Burmester, 2004; geologic map of the Bonners Ferry 30'x60' quadrangle, Idaho and Montana, USGS MF-2426

Figure 2. Continued.



Base for hydrography from U.S Geological Survey, 1965 Base from Kootenai Tride of Idaho Lidar, 2005

Geologic map of Bonners Ferry, Miller, F.K. and Burmester, 2004; geologic map of the Bonners Ferry 30'x60' quadrangle, Idaho and Montana, USGS MF-2426

Figure 2. Continued.

Purpose and Scope

This report provides an assessment of the riverine geology between RKMs 257 and 224.5 in the designated white sturgeon critical habitat river reach. This report complies with environmental regulatory requirements for reporting the results of screening done to identify specific chemical constituents within the sediment that have the potential to affect the ecosystem if released during restoration activities. These basic data and interpretations will help to facilitate restoration planning and help assess the feasibility of potential habitat redesign considerations.

Kootenai River White Sturgeon Spawning Habitat

White sturgeon egg collection and telemetry data collected by the Idaho Department of Fish and Game indicates that most spawning on the Kootenai River currently is within the meander reach between RKMs 240 and 228 (figs. 2*B* and 2*C*). Some spawning activity, however, has been monitored near Bonners Ferry, Idaho, in the straight reach between RKMs 245.7 and 245.1 (Paragamian and others, 2002; Barton and others, 2005, fig. 3). A series of research investigations determined that white sturgeon were spawning over unsuitable incubation and rearing habitat (sand) and survival of eggs and larvae was negligible (Paragamian and others, 2002). Sedimentation has been presented as a likely source of mortality for white sturgeon embryos in the Kootenai River (Paragamian and others, 1995, 1996, 1997, 1998, 1999, 2002; Kock and others, 2006). Kock and others (2006) showed that incubating white sturgeon embryos are highly sensitive to sediment cover. Various combinations of sediment depth and sediment cover duration resulted in severely reduced embryo survival. After 9 days, sediment depths of only 5 mm reduced survival to less than 20 percent of uncovered controls. These results indicate that Kootenai River white sturgeon embryos experience high mortality rates in their current spawning habitat, which is characterized by a fine sand substrate (Barton and others, 2006; McDonald and others, 2006). Habitat suitability curves developed for white sturgeon in the Lower Columbia River (Parsley and Beckman, 1994) show that sturgeon spawn over gravel and cobble to provide a stable egg attachment site for developing eggs that will become new fish year classes.

Geology and Morphology of Kootenai River

The present course of the Kootenai River in the study area is controlled by Precambrian and Cretaceous bedrock at several locations and by Quaternary lacustrine clay (fig. 2). The river courses through valley-fill sediment composed of interbedded silts and clays of glaciolacustrine origin and sands, gravels, and cobbles of fluvial and glaciofluvial origin. Most gravels and sands in the study area were deposited during the cyclic retreat of the Purcell Trench Lobe about 14,000 years ago (fig. 3; Atwater, 1986, pl. 1; Buchanan, 1989). Additionally, some gravels and cobbles occur in the alluvial fan deposits associated with tributaries flowing off the flank of the Selkirk Mountains (fig. 1). Lacustrine clays and silts are common in the Kootenai Flats (fig. 2*B* and 2*C*) and along the flanks of the mountains bordering the valley. As the Purcell Trench Lobe retreated to the north, a glacial Kootenay Lake was formed behind the ice dam and fine-grained sediments consisting of silts and clays were deposited in the glacial lake in Idaho and British Columbia. These clays and silts often are underlain by sands, gravels, and cobbles associated with the retreat of the Purcell Trench Lobe. J-U-B Engineers, Inc. (1998) reported that the lacustrine clay tends to thicken in the downstream direction.

The Kootenai River in the upper part of the study area is a braided reach that actively changes course and flows over gravel and cobbles, some sand, and a few areas of bedrock (fig. 4). This 11.1-km reach extends from RKM 257 downstream of the Moyie River to RKM 245.9 at Bonners Ferry. This reach is mostly a multi-threaded channel; about 3 km of the reach is a single-threaded channel (figs. 2*A* and 2*B*). Many gravel bars, sloughs, and islands are in the channel and many of the side sloughs are dry during periods of low flow. Scour pools form at two locations upstream of Crossport where bedrock outcrops along the river and water depths in the pools exceed 15 m; bedrock rubble in these locations is scattered on the riverbed. When streamflow is 850 m^3/s (30,000 ft^3/s), the average depth of water in the braided reach is about 3 m; depths generally are less than other parts of the study area. The average and maximum velocities are about 1.2 and 2.8 m/s, respectively (Barton and others, 2009).

A short straight reach downstream of the braided reach is between RKMs 245.9 and 244.5 and forms a transition zone between the braided reach and the meander reach (fig. 2*B*; Tetra Tech, Inc., 2003). The river substrate in the straight reach consists of gravel, sand, and traces of cobble and bedrock. This bedrock outcrops at several small areas along the right bank. A large outcrop with a deep scour hole (known as Ambush Rock) is along the left bank (fig. 4). The channel in this area is single threaded except during low flow when gravel bars are exposed in the upstream half of the reach.

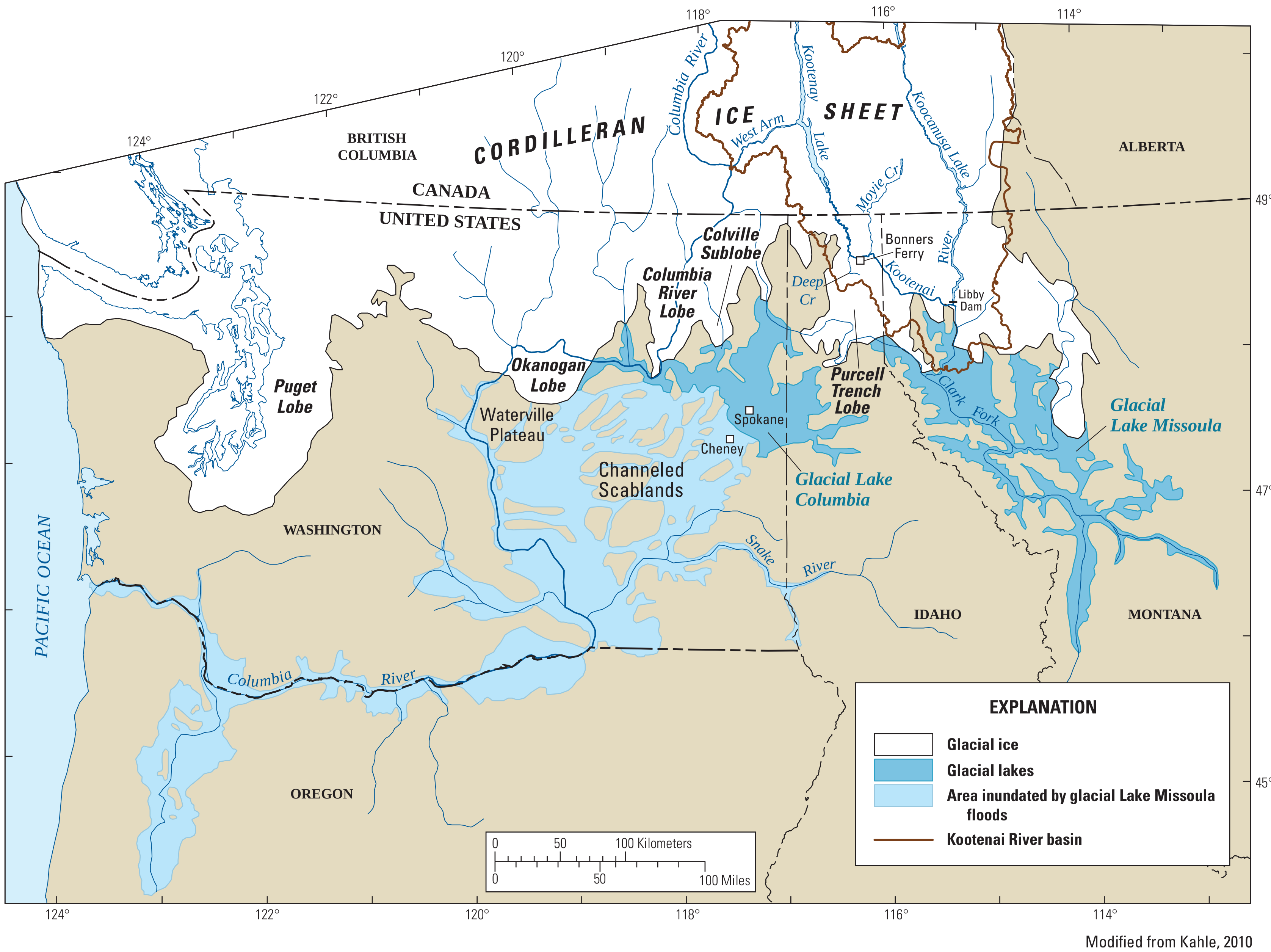


Figure 3. Kootenai River basin and extent of glacial ice and glacial lakes in northern Washington, Idaho, and parts of Montana. (Modified from Allen and Burns, 1986; Atwater, 1986; and Kahle and others, 2010.)

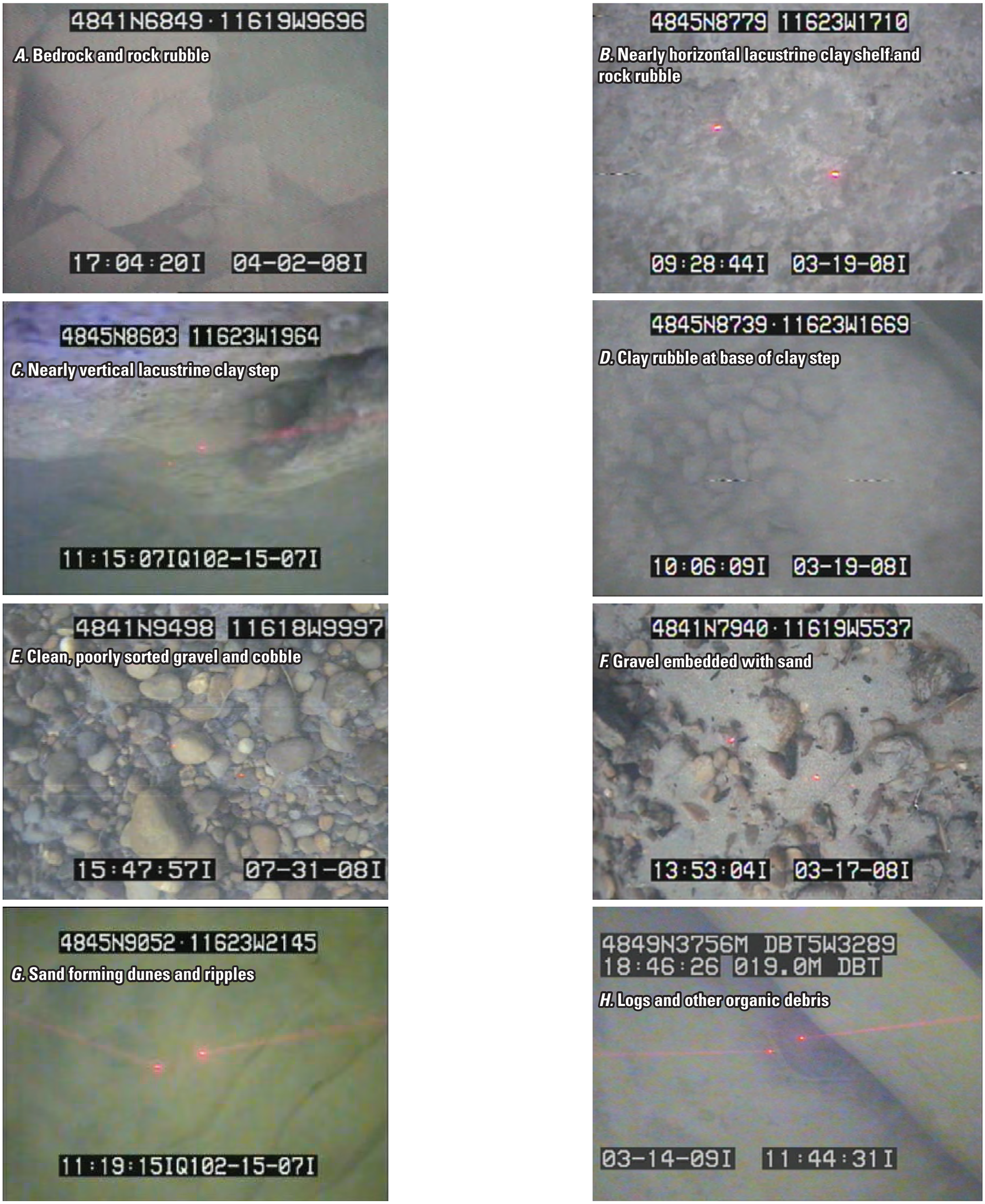


Figure 4. Underwater video photographs showing types of substrate that form the bed of the Kootenai River near Bonners Ferry, Idaho, 2007–09. Information on photographs includes coordinates as North American Datum of 1983, date, time, and (*H*) shows depth to riverbed in meters (DBT). Laser scale is 10.5 centimeters. (Underwater video photographs taken by Marshall Williams, U.S. Geological Survey, dates indicated in photographs.)

When streamflow is 850 m^3/s, the average and maximum depth and velocity in the straight reach is about 4 and 23 m and 0.9 and 1.3 m/s, respectively (Barton and others, 2009).

The meander reach, downstream of the straight reach, extends from RKM 244.5 to Kootenay Lake and for this study extends downstream to RKM 224.5 (fig. 2*C*). The study reach is mostly a sand riverbed that is entrenched in the lacustrine clay valley. The sand forms a mobile streambed consisting mostly of dune bedforms with amplitudes that sometimes are greater than 1 m (Barton and others, 2006). Lacustrine clay and silt generally form steep steps and flat lying shelves mostly in the meander bends (fig. 4). Clay rubble with the appearance of gravel and cobble is at the base of the clay steps. At a few locations, bedrock outcrops in the channel and along the riverbank with rock rubble on the riverbed at the base of outcrops. Small patches of gravel and cobble lag deposits form the riverbed downstream of the mouth of some tributaries and near Shorty's Island. Additionally, some small isolated gravel lenses are buried by sand in the meander reach (Barton, 2004). Riprap consisting of shot rock, boulders, and cobble has been placed on the dikes in select locations for armoring. Some riprap has rolled down the riverbank and into the channel. When streamflow is 850 m^3/s, the average and maximum depth and velocity in the meander reach are about 7 and 23 m and 0.6 and 1.1 m/s, respectively (Barton and others, 2009).

Hydrology of Kootenai River

The historical natural flow of the Kootenai River followed the annual hydrologic cycle. Average annual precipitation at Bonners Ferry for 1907–2008 is 56 cm with a mean monthly minimum of 2.3 cm in July and mean monthly maximum of 7.8 cm in December; the autumn and winter months are the wettest and summer months are the driest. The greatest discharge during each year was generally caused by melting of snow at high altitudes. As each spring approached, snowmelt caused the streamflow to increase until the maximum flow was reached, usually in June. Thereafter, the flow generally would decrease with minor fluctuations until the following spring. The tributaries follow the same general flow pattern but with much less predictability (Dion and Whitehead, 1973).

Based on historical data (1966–71) collected at the Copeland gaging station (12318500; fig. 1), during the pre-Libby Dam era, the median annual peak spring-summer streamflow was about 2,240 m^3/s. The annual peak spring-summer streamflow during the beginning of the Libby Dam era, 1970s through 1980s, was several times less than during the pre-Libby Dam era with much higher winter flows (Barton, 2004). The altered hydrology created by Libby Dam is suspected as part of the problem in sturgeon recruitment, and is the focus of many studies over the past several decades.

Since the mid-1990s, the U.S. Fish and Wildlife Service requested that Kootenai River streamflows be increased during white sturgeon spawning in May and June in an attempt to help re-establish hydrologic regimes that would more closely approach historical spawning conditions to benefit recruitment. To achieve this, Kootenai River streamflows are augmented with additional release of water from Libby Dam; however, the median streamflow during spawning season is about one-half that of the pre-Libby Dam era (Barton and others, 2009). A summary of streamflow gaging stations on the Kootenai River near Bonners Ferry, Idaho, is provided in table 1. The USGS has operated several stage gages in the braided reach since 2006.

Table 1. Summary of streamflow-gaging stations on the Kootenai River near Bonners Ferry, Idaho.

[**Abbreviations:** RKM, river kilometer; S, stage; T, temperature; Q, discharge; V, stream velocity; USGS, U.S. Geological Survey]

Station No.	Station name	Agency	RKM	Data parameters	Period of record
KR1	KootR_abv_Watint	USGS	247.7	S, T	2006–present (fragmentary)
KR2	KootR_blw_Weber	USGS	249.3	S, T	2006–present (fragmentary)
KR3	KootR_at_Crossport	USGS	251.9	S, T	2006–present (fragmentary)
KR4	KootR_nr_Crossport	USGS	253.1	S, T	2006–2007 (fragmentary)
KR5	KootR_abv_Crossport	USGS	254.4	S, T	2006–present (fragmentary)
KR6	KootR_blw_Moyie	USGS	256.8	S, T	2006–present (fragmentary)
12309500	Kootenai River at Tribal Hatchery, near Bonners Ferry, Idaho	USGS	245.9	S	October 2002–present
12310100	Kootenai River at Bonners Ferry, Idaho	USGS	241.2	S, Q, V, T	May–October 1904, October 1927–present
12314000	Kootenai River at Klockmann Ranch, near Bonners Ferry, Idaho	USGS	225.4	S	May 1928–Present (fragmentary prior to April 1930, partial record year 2006)

One of the most important components for successful wetland development is the evaluation of water availability and control. These basic data are needed for designing sustainable wetland habit; therefore, water levels from wells, Kootenai River stage for low streamflow, and mean annual peak and record high streamflow during the Libby Dam era are included with the geohydrologic sections. Kootenay Lake in British Columbia, Canada, creates backwater conditions in the Kootenai River that can extend several kilometers upstream of Bonners Ferry into the braided reach (fig. 2*A*). The extent of backwater is a function of river flows upstream of the backwater reach and Kootenay Lake levels. During periods of low streamflow, backwater conditions diminish and free-flowing water may extend a few kilometers downstream of RKM 245.9 in the straight reach. A detailed analysis of the location of transition between the free-flowing river and backwater under a range of streamflow conditions is presented in Berenbrock (2005).

The USGS studied stage of the Kootenai River and water levels from wells in the Kootenai Flats between the Moyie River and Porthill, Idaho, from 1928 to 1958 and results of the studies are presented in several informal progress reports prepared during that period (Newell, 1933; U.S. Geological Survey, 1966). Prior to the 1931 construction of Corra Linn Dam in British Columbia, Canada, the USGS began a study concerning the effects of Kootenay Lake and Kootenai River regulation on the groundwater system of the Kootenai Flats. During this study, 300 shallow wells were installed to monitor the effect of the impending change in river stage on the groundwater system. Prior to the commencement of operations at Libby Dam in March 1972, the USGS installed and measured water levels in wells in the Kootenai Flats area during 1971 (Dion and Whitehead, 1973).

Recharge to the valley-fill aquifer system in the Kootenai Flats is mainly by downward percolation of precipitation and snowmelt, groundwater flow from adjacent upland areas, upward leakage of groundwater from bedrock beneath the valley-fill sediments, and seepage from the Kootenai River and its tributaries. Groundwater beneath the Kootenai Flats is locally shallow. The valley-fill aquifer system contains considerable amounts of fine-grained sediments and coarse grained sediment such as gravel. Due to the Pleistocene-Holocene glaciations, however, the sediment composition in the study area can vary laterally over short distances. Groundwater moves slowly through the glaciofluvial and glaciolacustrine aquifer system to the closest points of discharge, namely, agricultural drainage ditches, stream and river channels, and areas of evapotranspiration. Drainage districts were formed throughout the Kootenai Flats in the early 20th century. These drainage districts have focused on intercepting groundwater and lowering the water table using permanent or temporary drainage ditches in fields to support agricultural activities. This water is conveyed in open ditches to a pumping plant and then is pumped to the river (U.S. Army Corps of Engineers, 2005).

During long periods of low river stage in the Kootenai River, the water table slopes downward from the foothills all the way to the river channel where water seeps from the aquifer into the river. During long periods of high river stage, the water table slopes downward and away from the river channel and from the surrounding foothills. Near the river channel, the aquifer is partly recharged by seepage from the river during periods of high river stage. Dion and Whitehead (1973) reported that an examination of water levels from wells installed in 1930 indicates that the effects of aquifer recharge from the Kootenai River are dampened with distance and cannot be detected more than about 900 m from the river. Under pre-Libby Dam conditions, the highest water levels in wells away from the river occurred in spring, immediately following the period of greatest recharge, and lowest water levels occurred in autumn following the period of least recharge. Dion and Whitehead (1973) also reported that the timing and magnitude of these relations during the Libby Dam era were dependent on the regulation of streamflow in the river. Operation of Libby Dam changed long-established patterns of river stage and groundwater-level fluctuation. Regulated river levels and higher than natural levels during winter low streamflow seasons diminish the opportunity for subdrainage from the surrounding agricultural lands to the deep channel of the Kootenai River. Water levels in wells away from the river are influenced primarily by local groundwater recharge and discharge, which includes melting of the snowpack on the Kootenai Flats, discharge of tributary streams carrying low-altitude snowmelt, agricultural drainage ditches, water-supply wells, and evapotranspiration.

Methods

Methods used in this study include sediment coring, lithologic logging of sediment cores, sampling and chemical analysis of sediment cores, riverbed sediment facies mapping, and multibeam echosounder mapping.

Sediment Cores

Sediment cores were collected at 24 locations during June and July 2007 (fig. 2; table 2). Core depths ranged from 4.6 to 15.2 m with 21 cores reaching a depth of 15.2 m. A maximum coring depth of 15.2 m below the riverbed was established for the coring program because channel modifications under consideration are not likely to extend to depths much greater than 15.2 m (Dave Rosgen, Wildland Hydrology, written commun., 2007). Sediment cores were bored using a 6 × 12 m drilling barge operated by Crux Subsurface, Inc., of Spokane, Washington.

Table 2. Sediment cores and sediment chemistry samples collected by the U.S. Geological Survey and Idaho Department of Transportation in the Kootenai River near Bonners Ferry, Idaho.

[**NWIS well identification No.:** From U.S. Geological Survey National Water Inventory Site (NWIS) database. **Abbreviations:** USGS, U.S. Geological Survey; IDT, Idaho Department of Transportation; TB, test boring; RB, core collected near right bank; C, core collected near center of channel; TH, core collected near thalweg; R of C, core collected right of center of channel; L of C, core collected left of center of channel; LTH, core collected left of thalweg; RTH, core collected right of thalweg; SI, core collected in minor channel at Shorty's Island; cm, centimeter; m, meter; –, not applicable or no data]

NWIS well identification No.	Station No.	River reach	Agency	Coring date	Latitude	Longitude	Land surface elevation (m)	Coring method	Core diameter (cm)	Total core depth (m)	Sediment chemistry samples
484156116202001	TB-1	Meander	USGS	06-20-2007	48.699	116.339	529	Sonic drill	15	14.3	x
484141116194901	TB-2	Straight	USGS	06-20-2007	48.695	116.330	526	Sonic drill	15	15.2	x
484143116194201	TB-3	Straight	USGS	06-22-2007	48.695	116.328	528	Sonic drill	15	15.2	x
484143116194202	TB-3-2	Straight	USGS	07-12-2007	48.695	116.328	549	Sonic drill	15	7.6	x
–	TB-4	Straight	USGS	06-21-2007	48.696	116.327	528	Sonic drill	15	15.1	–
484150116192601	TB-5	Straight	USGS	06-22-2007	48.697	116.324	529	Sonic drill	15	15.2	x
484148116192601	TB-6	Straight	USGS	06-22-2007	48.697	116.324	531	Sonic drill	15	15.2	–
484154116190301	TB-7	Straight	USGS	06-27-2007	48.698	116.317	532	Sonic drill	15	15.2	x
484151116191601	TB-8	Straight	USGS	06-26-2007	48.697	116.321	532	Sonic drill	15	15.2	x
484153116190501	TB-9	Straight	USGS	06-26-2007	48.698	116.318	533	Sonic drill	15	15.2	x
484201116184001	TB-11	Braided	USGS	06-27-2007	48.700	116.311	532	Sonic drill	15	15.2	x
484202116172301	TB-12	Braided	USGS	07-11-2007	48.701	116.290	534	Sonic drill	15	15.2	x
484202116164501	TB-13	Braided	USGS	07-11-2007	48.701	116.279	532	Sonic drill	15	15.2	x
–	TB-14	Braided	USGS	07-11-2007	48.698	116.267	535	Sonic drill	15	4.6	–
484210116153301	TB-15	Braided	USGS	07-10-2007	48.703	116.259	535	Sonic drill	15	15.2	x
484209116143501	TB-16	Braided	USGS	07-10-2007	48.702	116.243	535	Sonic drill	15	15.2	x
484234116131901	TB-17	Braided	USGS	07-08-2007	48.710	116.222	536	Sonic drill	15	15.2	x
–	TB-18	Braided	USGS	07-07-2007	48.709	116.222	537	Sonic drill	15	15.2	–
–	TB-19	Braided	USGS	07-07-2007	48.698	116.206	535	Sonic drill	15	15.2	–
484154116120401	TB-20	Braided	USGS	07-07-2007	48.698	116.201	539	Sonic drill	15	15.2	x
484421116242401	TB-21	Meander	USGS	06-24-2007	48.739	116.407	529	Sonic drill	15	15.2	x
484427116245501	TB-22	Meander	USGS	06-24-2007	48.741	116.415	520	Sonic drill	15	15.2	x
484532116233101	TB-23	Meander	USGS	06-28-2007	48.759	116.392	529	Sonic drill	15	15.2	x
484145116193601	TB-24	Straight	USGS	06-21-2007	48.696	116.327	527	Sonic drill	15	12.5	x
–	10-C	Straight	USGS	09-10-2004	48.698	116.319	533	Vibracore	9	.6	–
–	10-LB2	Straight	USGS	09-14-2004	48.697	116.320	531	Vibracore	9	1.4	–
–	10-RB	Straight	USGS	09-10-2004	48.699	116.319	531	Vibracore	9	2.1	–
–	11-RB	Meander	USGS	09-12-2004	48.779	116.395	527	Vibracore	9	3.3	–
–	11-TH	Meander	USGS	09-12-2004	48.779	116.395	523	Vibracore	9	3.3	–
–	12-LB	Meander	USGS	09-12-2004	48.773	116.388	528	Vibracore	9	1.8	–
–	12-RB	Meander	USGS	09-12-2004	48.773	116.387	524	Vibracore	9	3.3	–
–	12-TH	Meander	USGS	09-12-2004	48.773	116.387	518	Vibracore	9	3.3	–
–	13-LB	Meander	USGS	09-15-2004	48.767	116.387	529	Vibracore	9	3.3	–
–	13-RB	Meander	USGS	09-15-2004	48.767	116.386	528	Vibracore	9	3.3	–
–	13-TH/C	Meander	USGS	09-12-2004	48.767	116.387	524	Vibracore	9	3.1	–
–	14-RB	Meander	USGS	09-15-2004	48.741	116.396	528	Vibracore	9	3.3	–

Table 2. Sediment cores and sediment chemistry samples collected by the U.S. Geological Survey and Idaho Department of Transportation in the Kootenai River near Bonners Ferry, Idaho.—Continued

[**NWIS well identification No.:** From U.S. Geological Survey National Water Inventory Site (NWIS) database. **Abbreviations:** USGS, U.S. Geological Survey; IDT, Idaho Department of Transportation; TB, test boring; RB, core collected near right bank; C, core collected near center of channel; TH, core collected near thalweg; R of C, core collected right of center of channel; L of C, core collected left of center of channel; LTH, core collected left of thalweg; RTH, core collected right of thalweg; SI, core collected in minor channel at Shorty's Island; cm, centimeter; m, meter; –, not applicable or no data]

NWIS well identification No.	Station No.	River reach	Agency	Coring date	Latitude	Longitude	Land surface elevation (m)	Coring method	Core diameter (cm)	Total core depth (m)	Sediment chemistry samples
–	14-TH	Meander	USGS	09-12-2004	48.741	116.396	520	Vibracore	9	2.3	–
–	16-TH	Meander	USGS	09-14-2004	48.706	116.381	523	Vibracore	9	2.4	–
–	17-TH	Meander	USGS	09-14-2004	48.707	116.384	524	Vibracore	9	2.1	–
–	18-TH	Meander	USGS	09-14-2004	48.705	116.387	540	Vibracore	9	1.6	–
–	19-L of C	Meander	USGS	09-14-2004	48.760	116.392	531	Vibracore	9	3.3	–
–	19-LB	Meander	USGS	09-14-2004	48.760	116.392	532	Vibracore	9	3.3	–
–	19-R of C	Meander	USGS	09-14-2004	48.759	116.391	529	Vibracore	9	3.3	–
–	19-RB	Meander	USGS	09-14-2004	48.759	116.391	531	Vibracore	9	3.3	–
–	1-LB	Meander	USGS	09-14-2004	48.705	116.377	521	Vibracore	9	.4	–
–	20-RB	Meander	USGS	09-14-2004	48.770	116.386	532	Vibracore	9	3.3	–
–	21-TH	Meander	USGS	09-15-2004	48.741	116.415	520	Vibracore	9	1.2	–
–	22-TH	Meander	USGS	09-15-2004	48.740	116.388	518	Vibracore	9	.9	–
–	23-TH	Meander	USGS	09-15-2004	48.737	116.384	522	Vibracore	9	2.3	–
–	2-C	Meander	USGS	09-10-2004	48.703	116.356	528	Vibracore	9	3.3	–
–	2-LB	Meander	USGS	09-10-2004	48.703	116.356	529	Vibracore	9	3.3	–
–	2-RB	Meander	USGS	09-10-2004	48.704	116.356	528	Vibracore	9	.9	–
–	4-L OF C	Meander	USGS	09-10-2004	48.699	116.342	532	Vibracore	9	2.6	–
–	4-LB	Meander	USGS	09-11-2004	48.698	116.342	532	Vibracore	9	2.2	–
–	4-R OF C	Meander	USGS	09-11-2004	48.699	116.342	529	Vibracore	9	3.3	–
–	4-RB	Meander	USGS	09-11-2004	48.699	116.341	526	Vibracore	9	3.3	–
–	5-C	Meander	USGS	09-11-2004	48.697	116.337	529	Vibracore	9	3.3	–
–	5-LB	Meander	USGS	09-11-2004	48.697	116.337	530	Vibracore	9	1.4	–
–	5-RB	Meander	USGS	09-11-2004	48.698	116.336	531	Vibracore	9	3.3	–
–	6-C	Straight	USGS	09-11-2004	48.696	116.334	526	Vibracore	9	3.4	–
–	6-RB	Straight	USGS	09-11-2004	48.696	116.334	529	Vibracore	9	3.3	–
–	6-TH	Straight	USGS	09-11-2004	48.696	116.334	518	Vibracore	9	.1	–
–	7-C	Straight	USGS	09-11-2004	48.695	116.330	526	Vibracore	9	.9	–
–	7-RB	Straight	USGS	09-11-2004	48.695	116.330	529	Vibracore	9	.9	–
–	8-LB	Straight	USGS	09-14-2004	48.695	116.327	529	Vibracore	9	3.3	–
–	8-RB	Straight	USGS	09-14-2004	48.696	116.327	530	Vibracore	9	1.4	–
–	8-RB2	Straight	USGS	09-14-2004	48.696	116.328	533	Vibracore	9	3.3	–
–	8-TH	Straight	USGS	09-13-2004	48.696	116.327	526	Vibracore	9	.8	–
–	9-C	Straight	USGS	09-10-2004	48.697	116.323	530	Vibracore	9	.9	–
–	9-LB	Straight	USGS	09-10-2004	48.697	116.322	531	Vibracore	9	.8	–
–	9-RB	Straight	USGS	09-14-2004	48.698	116.323	531	Vibracore	9	.3	–
–	9-RB2	Straight	USGS	09-14-2004	48.698	116.323	531	Vibracore	9	.3	–
–	K10-RC	Meander	USGS	09-20-2000	48.740	116.414	530	Vibracore	9	2.1	–

Table 2. Sediment cores and sediment chemistry samples collected by the U.S. Geological Survey and Idaho Department of Transportation in the Kootenai River near Bonners Ferry, Idaho.—Continued

[**NWIS well identification No.:** From U.S. Geological Survey National Water Inventory Site (NWIS) database. **Abbreviations:** USGS, U.S. Geological Survey; IDT, Idaho Department of Transportation; TB, test boring; RB, core collected near right bank; C, core collected near center of channel; TH, core collected near thalweg; R of C, core collected right of center of channel; L of C, core collected left of center of channel; LTH, core collected left of thalweg; RTH, core collected right of thalweg; SI, core collected in minor channel at Shorty's Island; cm, centimeter; m, meter; –, not applicable or no data]

NWIS well identification No.	Station No.	River reach	Agency	Coring date	Latitude	Longitude	Land surface elevation (m)	Coring method	Core diameter (cm)	Total core depth (m)	Sediment chemistry samples
–	K10-RTH	Meander	USGS	09-20-2000	48.740	116.415	522	Vibracore	9	3.5	–
–	K10-TH1	Meander	USGS	09-19-2000	48.740	116.415	525	Vibracore	9	.9	–
–	K10-TH2	Meander	USGS	09-19-2000	48.740	116.415	523	Vibracore	9	0.8	–
–	K11-C	Meander	USGS	09-20-2000	48.739	116.405	528	Vibracore	9	3.5	–
–	K11-LB	Meander	USGS	09-20-2000	48.739	116.405	529	Vibracore	9	3.5	–
–	K12-LB	Meander	USGS	09-22-2000	48.741	116.393	524	Vibracore	9	2.2	–
–	K12-TH1	Meander	USGS	09-20-2000	48.741	116.393	538	Vibracore	9	3.5	–
–	K12-TH2	Meander	USGS	09-22-2000	48.741	116.393	522	Vibracore	9	2.9	–
–	K13-LB1	Meander	USGS	09-20-2000	48.735	116.383	529	Vibracore	9	3.5	–
–	K13-LB2	Meander	USGS	09-20-2000	48.735	116.383	530	Vibracore	9	3.5	–
–	K13-RB	Meander	USGS	09-19-2000	48.735	116.382	528	Vibracore	9	.4	–
–	K13-TH	Meander	USGS	09-20-2000	48.735	116.383	523	Vibracore	9	3.5	–
–	K14-TH	Meander	USGS	09-22-2000	48.729	116.388	527	Vibracore	9	.6	–
–	K15.5-TH	Meander	USGS	09-22-2000	48.719	116.391	525	Vibracore	9	3.5	–
–	K16-C1	Meander	USGS	09-19-2000	48.714	116.389	528	Vibracore	9	.6	–
–	K16-C2	Meander	USGS	09-22-2000	48.714	116.389	528	Vibracore	9	3.1	–
–	K16-LB	Meander	USGS	09-22-2000	48.713	116.389	529	Vibracore	9	3.4	–
–	K18-LB	Meander	USGS	09-22-2000	48.704	116.365	528	Vibracore	9	3.5	–
–	K18-TH	Meander	USGS	09-22-2000	48.704	116.365	527	Vibracore	9	2.3	–
–	K20-TH	Meander	USGS	09-22-2000	48.697	116.337	530	Vibracore	9	1.4	–
–	K3-C	Meander	USGS	09-21-2000	48.789	116.395	529	Vibracore	9	3.5	–
–	K3-TH	Meander	USGS	09-21-2000	48.788	116.395	527	Vibracore	9	3.5	–
–	K5-C	Meander	USGS	09-21-2000	48.776	116.390	526	Vibracore	9	3.2	–
–	K5-TH	Meander	USGS	09-21-2000	48.776	116.390	525	Vibracore	9	2.2	–
–	K6.5-C	Meander	USGS	09-21-2000	48.757	116.396	529	Vibracore	9	1.4	–
–	K6-LB	Meander	USGS	09-21-2000	48.764	116.387	525	Vibracore	9	3.5	–
–	K6-RB	Meander	USGS	09-21-2000	48.765	116.386	527	Vibracore	9	3.5	–
–	K6-TH	Meander	USGS	09-21-2000	48.765	116.387	520	Vibracore	9	3.5	–
–	K9.5-C	Meander	USGS	09-20-2000	48.743	116.415	524	Vibracore	9	2.1	–
–	K9.5-RB	Meander	USGS	09-20-2000	48.743	116.415	526	Vibracore	9	3.5	–
–	K9.5-TH	Meander	USGS	09-20-2000	48.744	116.416	522	Vibracore	9	.5	–
–	K9-C	Meander	USGS	09-19-2000	48.747	116.414	528	Vibracore	9	2.5	–
–	K9-LB	Meander	USGS	09-19-2000	48.747	116.414	526	Vibracore	9	.3	–
–	K9-RB	Meander	USGS	09-20-2000	48.747	116.413	529	Vibracore	9	.6	–
–	SI-1	Meander	USGS	09-14-2004	48.773	116.390	534	Vibracore	9	2.9	–
–	SI-2	Meander	USGS	09-14-2004	48.771	116.390	533	Vibracore	9	3.4	–

Table 2. Sediment cores and sediment chemistry samples collected by the U.S. Geological Survey and Idaho Department of Transportation in the Kootenai River near Bonners Ferry, Idaho.—Continued

[**NWIS well identification No.:** From U.S. Geological Survey National Water Inventory Site (NWIS) database. **Abbreviations:** USGS, U.S. Geological Survey; IDT, Idaho Department of Transportation; TB, test boring; RB, core collected near right bank; C, core collected near center of channel; TH, core collected near thalweg; R of C, core collected right of center of channel; L of C, core collected left of center of channel; LTH, core collected left of thalweg; RTH, core collected right of thalweg; SI, core collected in minor channel at Shorty's Island; cm, centimeter; m, meter; –, not applicable or no data]

NWIS well identification No.	Station No.	River reach	Agency	Coring date	Latitude	Longitude	Land surface elevation (m)	Coring method	Core diameter (cm)	Total core depth (m)	Sediment chemistry samples
–	SI-3	Meander	USGS	09-14-2004	48.769	116.391	533	Vibracore	9	2.9	–
–	SI-4	Meander	USGS	09-14-2004	48.767	116.393	532	Vibracore	9	1.2	–
–	SI-5	Meander	USGS	09-14-2004	48.764	116.394	533	Vibracore	9	1.6	–
–	SI-6	Meander	USGS	09-14-2004	48.762	116.393	532	Vibracore	9	1.6	–
–	IDT DH-2[1]	Straight	IDT	04-01-1980	48.699	116.312	530	Rotary	–	13.3	
–	IDT DH-3[1]	Straight	IDT	04-01-1980	48.700	116.313	533	Rotary	–	15.1	
–	IDT DH-4[1]	Straight	IDT	04-01-1980	48.701	116.314	539	Rotary	–	11.3	
–	IDT DH-6[1]	Straight	IDT	04-01-1980	48.698	116.312	536	Rotary	–	30.0	
–	IDT DH-7[1]	Straight	IDT	04-01-1980	48.699	116.313	533	Rotary	–	29.9	
–	IDT DH-8[1]	Straight	IDT	04-01-1980	48.701	116.314	534	Rotary	–	26.2	

Site locations for the sediment cores were established by aligning sites with a conceptual river design provided by KTOI and selecting sites near bedrock that could impede realignment of the channel. The upstream and downstream extent of core site selection was based on the conceptual design for the braided and meander reaches. Substrate in this extent consisted of cobbles, gravel, sand, silt, clay, and bedrock. The spacing of the cores was not evenly distributed, but focused on key areas where examination of the geology would provide the most information. Previous core samples were collected by the USGS during 2000 and 2004 (Barton, 2004; Berenbrock and Bennett, 2005), and provided information about the geology within the meander reach and some information about the straight reach. An important goal of the 2007 coring effort was to learn more about the geology of the straight and braided reaches. Of the 24 coring sites bored in 2007, 10 sites were distributed throughout the braided reach, 10 sites were between Ambush Rock (RKM 244.5) and the U.S. Highway 95 Bridge (RKM 245.9), and 4 sites were in the meander reach between Ambush Rock and Shorty's Island. A mapping-grade global positioning system (GPS) and pusher boats were used to move the drilling barge into position for coring. Four 1-ton anchors or jack-up legs, depending on river depth, maintained the position of the barge during coring.

A track-mounted sonic drill operated by Boart Longyear of Tualatin, Oregon, was mounted on the drilling barge, and collected continuous cores of sediments beneath the riverbed (fig. 5). A 17.8-cm inside diameter (ID) override casing extended from the barge drill deck through the water column and into the sediments beneath the riverbed. A 15.2-cm ID stainless steel core barrel ranging from 1.5- to 6-m long was advanced through the bottom of the override casing to core the sediment. The override casing prevented the core hole from collapsing, and prevented river water from contacting and possibly contaminating the sediments in the core barrel. Before coring commenced at each core site, the core barrel was steam cleaned with deionized water to remove contaminants on the core barrel and to avoid cross-contamination between coring sites. Drilling fluids were not used during the sediment coring to avoid introducing contaminants into sediments in the core barrel. Sediments in the core barrel were extruded by gravity and vibration into a 2 mm thick, 15.2-cm ID and 1.5 m long polyethylene core bag (fig. 6). The core bags were placed into 1.5-m long core boxes, labeled, and prepared for chemical sampling and lithologic logging.

Lithologic Logs of Sediment Cores

After sediment samples were collected from a core, USGS scientists took digital photographs and developed a lithologic log. Some sediment was placed under a macroscope to aid the description of samples and to measure the grain diameter of small gravel, sand, and silt (fig. 7). The colors of samples were determined while wet. Color and size of sediment were determined using the Geotechnical Gauge manufactured by W.F. McCollough. A gravelometer was used to measure the B-axis of gravel and cobble. Lithologic logs were transcribed to the Arcmap module CrossView to generate digital logs. All logs and photographs of the sediment cores are presented in appendix A.

Figure 5. Sediment-coring system on a barge on the Kootenai River, Bonners Ferry, Idaho. (Photograph taken by Gary Barton, U.S. Geological Survey, July 7, 2007.)

Sampling and Chemical Analysis of Sediment Cores

Free Run Aquatic Research (FRAR) provided procedures for sediment sampling design, protocol, and chemical analysis to KTOI (Gretchen Kruse, Free Run Aquatic Research, written commun., 2007) that were based on Inland Testing Manual (U.S. Environmental Protection Agency, 1998). These procedures subsequently were modified prior to sampling by the USGS to match U.S. Army Corps of Engineers protocols as described in the Northwest Regional Sediment Evaluation Framework manual (U.S. Army Corps of Engineers and others, 2006). The sediment samples from cores were collected and analyzed for select chemicals that are listed in the sediment-quality guidelines: organochlorine pesticides, polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls, (PCBs), metals, total organic carbons (TOC), and asbestos (U.S. Army Corps of Engineers and others, 2006, table 7-1).

Sediment sampling equipment was cleaned at the beginning of each day and before installation at each coring site using the following procedures: (1) wash with deionized water, (2) wash with laboratory-grade detergent, (3) rinse with acetone, and (4) rinse with deionized water. To quickly process and sample the cores and get the sediment samples on ice, the sampling of cores took place on the drilling platform upwind of exhaust fumes and drilling operations. With the core resting in the core box, a clean knife was used to slice open the polyethylene core bag. The interior section of the core was exposed using a clean Teflon spatula to remove the outer layer of sediment in contact with the core barrel because sediment in contact with the inner wall of a core barrel can become contaminated (MacDonald and Ingersoll, 2002). Sampling was limited to silt and sand in the center of the core. Some fine gravel was sampled along with the silt and sand due to the heterogeneity of the sediment. Organochlorine pesticide, PAH, PCB, metal, TOC, and asbestos samples were collected from each sampled depth interval at each core site and analyzed as described in U.S. Army Corps of Engineers and others (2006). Sample depths for chemical analysis are shown on the lithologic logs in appendix A.

Samples for analysis of organochlorine, pesticides, PAHs, PCBs, and TOC analysis were collected as described by the U.S. Army Corps of Engineers and others (2006). A clean stainless steel spatula was used to collect samples of silt and sand from of each sediment core. Samples were placed into a clean, baked glass sample bottle, stored on ice, and processed at the KTOI sample preparation laboratory. Samples for analysis of metals, asbestos, and particle size were collected from the sediment using a clean plastic scoop, placed into clean plastic sample bottles, put on ice, and processed at the KTOI sample preparation laboratory.

Figure 6. Extrusion of sediments from core barrel into a 1.5-m long polyethylene core bag with a 15.2-cm inside diameter, Kootenai River near Bonners Ferry, Idaho. The sediment core was recovered after the drill pipe and bit was brought up to the drill deck. (Photograph taken by Gary Barton, U.S. Geological Survey, June 2007.)

At the KTOI sample preparation laboratory, the sediment sub-samples from each core were composited into a single homogenized sample for each core site. For each core, an equal volume of sediment from each sampled depth interval was placed in a clean glass-mixing bowl. These sediments were vigorously mixed using a clean, stainless steel mixing spoon. Approximately, 200 g of homogenized samples were collected for metals analysis, 200 g for organochlorine pesticide, PCB, and TOC analysis, and 175 g for asbestos analysis. The composite samples then were placed in plastic and glass sample bottles and stored at about -10 °C in a secure building at the KTOI Tribal Hatchery.

After completion of the coring fieldwork, the samples were processed and shipped by FRAR to commercial testing facilities outside the USGS chain of custody for analysis of metals, organochlorine and pesticide compounds, and asbestos. The chemical analyses and results are provided in appendix B.

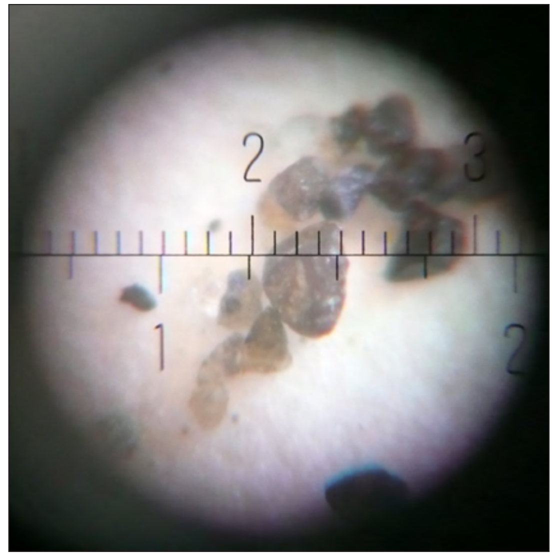


Figure 7. Macroscopic view of sediment sampled from a core collected from the Kootenai River near Bonners Ferry, Idaho. (Photograph taken by Ryan Fosness, U.S. Geological Survey, June 2007.)

Samples for the analysis of PAHs, PCB, and TOC were shipped by overnight courier in sealed coolers using USGS chain-of-custody procedures to the USGS Washington Water Science Center in Tacoma, Washington, for further preparation. The samples were stored in a freezer in a secure laboratory. After processing, these samples were shipped by overnight courier in sealed coolers using USGS chain-of-custody procedures to the USGS National Water Quality Laboratory (NWQL) in Lakewood, Colorado.

Chemical Analysis and Sediment Sieving

Sediment samples were analyzed for PAHs at the NWQL using procedures described by Olson and others (2004) and for PCBs using procedures described by Noriega and others (2004). Sediment samples were analyzed for TOC at the USGS Geologic Division Geochemistry Laboratory, Lakewood, Colorado, following procedures described by Arbogast (1996). The USGS analytical methodology and reporting level for each chemical constituent met or exceeded requirements listed on the sediment-quality guidelines (U.S. Army Corps of Engineers and others, 2006) and analytical results are provided in table 3. An approximately 25 g subsample of sediment from each composite sample was dry sieved by the USGS Washington Water Science Center laboratory to measure the percent finer than sand (table 3). The mesh opening of the sieve was 62.5 µm. Sediment was sieved using procedures described by Guy (1969).

Table 3. Select polynuclear aromatic hydrocarbons, total polychlorinated biphenyls, and total organic carbon concentrations and sediment-particle sizes in sediment samples collected from cores at the Kootenai River near Bonners Ferry, Idaho, June–July 2007, and sediment-quality guidelines.

[Concentrations in micrograms per kilograms except as noted. Values in **bold** are non-censored or estimated values between laboratory detection limit and laboratory reporting limit. **Sediment quality guideline**: Depths below riverbed that sediment subsamples were collected from a core is provided on lithologic logs in appendix A and summarized in table 2. Subsamples were composited into a single sample for a core for chemical analysis. **Grain size:** Dry sieved at the U.S. Geological Survey, Washington Water Science Center laboratory, Tacoma, Washington. Sediment quality guideline: From U.S. Army Corps of Engineers (2006). Concentrations are in micrograms per kilograms, dry weight, except as noted. **Nitrobenzene-d**: Laboratory surrogate, bed sediment with particle-size diameter less than 2 millimeters, wet sieved using native water. **Abbreviations:** PCB, polychlorinated biphenyl; TB, test boring; SRM, standard reference material; E, estimated; m, meter; cm, centimeter; mm, millimeter; NA, not applicable; <, less than; –, no data]

Station No.	Date	Grain size <0.063 mm (percent)	Inorganic carbon (percent)	Organic carbon (percent)	Total carbon (percent)	p-Cresol	Naphthalene	2-Ethylnaph-thalene	2,6-Dimethyl-naphthalene
Sediment quality guideline		–	–	–	–	–	**500**	–	–
Database parameter No.						**P49451**	**P49402**	**P49948**	**P49406**
TB-1	06-20-07	8.6	–	–	–	–	–	–	–
TB-2	06-20-07	3.5	–	–	–	–	–	–	–
TB-3	06-22-07	5.4	1.16	0.26	1.42	<100	<100	<100	E4
TB-3-2[1]	07-12-07	4.8	1.3	<.05	1.34	**E9**	**E8**	<100	**E15**
TB-4	06-21-07	3.4	–	–	–	–	–	–	–
TB-5	06-22-07	3.6	.44	<.05	.47	<100	<100	<100	<100
TB-7	06-27-07	7.5	.68	.09	.77	<100	<100	<100	<100
TB-7[1]	06-27-07	–	–	–	–	<100	<100	<100	**E16**
TB-8	06-26-07	4.5	.54	.15	.69	<100	<100	<100	<100
TB-8[1]	06-26-07	–	.74	.16	.90	<100	<100	<100	<100
TB-9	06-26-07	10.8	1.81	.61	2.42	**200**	**68**	<100	**110**
TB-9[1]	06-26-07	–	–	–	–	<100	<100	<100	<100
TB-11	06-27-07	3.0	.67	.08	.75	**E20**	**E2**	<100	**E10**
TB-12	07-11-07	84.9	1.81	.56	2.37	<100	<100	<100	**E13**
TB-12[1]	07-11-07	5.2	1.79	.61	2.40	–	–	–	–
TB-13	07-11-07	–	1.7	.05	1.75	<100	<100	<100	<100
TB-15	07-10-07	6.3	.66	.05	.71	<100	<100	<100	<100
TB-16	07-10-07	7.0	.24	.07	.31	<100	<100	<100	<100
TB-17	07-08-07	10.3	.87	.15	1.02	<100	<100	<100	<100
TB-20	07-07-07	5.6	.48	.05	.53	<100	<100	<100	<100
TB-21	06-24-07	5.5	1.91	.17	2.08	<100	<100	<100	**E4**
TB-22	06-24-07	5.5	1.86	.19	2.05	<100	<100	<100	<100
TB-22[1]	06-24-07	6.4	–	–	–	–	–	–	–
TB-23	06-28-07	7.5	1.49	.37	1.86	**E12**	**E19**	<100	**E19**
TB-23[1]	06-28-07	–	1.54	.41	1.95	**E6**	<100	<100	**E8**
TB-24	06-21-07	16.8	–	–	–	–	–	–	–
HS-1[2] Expected value			–	–	–	–	–	–	–
H-1[2] Laboratory reported value		–	–	–	–	**E8.4**	**E7.6**	<100	<100
HS-6[2] Expected value			–	–	–	–	4,100	–	–
H-6[2] Laboratory reported value		–	–	–	–	178	2,420	307	801
HS-6[2] Percent recovery			–	–	–	–	59	–	–

Table 3. Select polynuclear aromatic hydrocarbons, total polychlorinated biphenyls, and total organic carbon concentrations and sediment-particle sizes in sediment samples collected from cores at the Kootenai River near Bonners Ferry, Idaho, June–July 2007, and sediment-quality guidelines.—Continued

[Concentrations in micrograms per kilograms except as noted. Values in **bold** are non-censored or estimated values between laboratory detection limit and laboratory reporting limit. **Sediment quality guideline**: Depths below riverbed that sediment subsamples were collected from a core is provided on lithologic logs in appendix A and summarized in table 2. Subsamples were composited into a single sample for a core for chemical analysis. **Grain size:** Dry sieved at the U.S. Geological Survey, Washington Water Science Center laboratory, Tacoma, Washington. Sediment quality guideline: From U.S. Army Corps of Engineers (2006). Concentrations are in micrograms per kilograms, dry weight, except as noted. **Nitrobenzene-d**: Laboratory surrogate, bed sediment with particle-size diameter less than 2 millimeters, wet sieved using native water. **Abbreviations:** TB, test boring; SRM, standard reference material; E, estimated; m, meter; cm, centimeter; mm, millimeter; NA, not applicable; <, less than; –, no data]

Station No.	Date	1,6-Dimethyl-naphthalene	Acenaph-thylene	1,2-Dimethyl-naphthalene	Acenaph-thene	2,3,6-Trimethyl-naphthalene	1-Methyl-9H-fluorene	2-Methylan-thracene	1-Methylphen-anthrene
Sediment quality guideline		–	**470**	–	**1,100**	–	–	–	–
Database parameter No.		**P49404**	**P49428**	**P49403**	**P49429**	**P49405**	**P49398**	**P49435**	**P49410**
TB-1	06-20-07	–	–	–	–	–	–	–	–
TB-2	06-20-07	–	–	–	–	–	–	–	–
TB-3	06-22-07	<100	<100	<100	<100	<100	<100	<100	**E7**
TB-3-2[1]	07-12-07	**E16**	<100	<100	<100	<100	<100	<100	**E15**
TB-4	06-21-07	–	–	–	–	–	–	–	–
TB-5	06-22-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-7	06-27-07	<100	<100	<100	<100	<100	<100	<100	**E20**
TB-7[1]	06-27-07	<100	<100	<100	<100	**E14**	<100	<100	<100
TB-8	06-26-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-8[1]	06-26-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-9	06-26-07	**92**	<100	<100	**E27**	**E51**	**E45**	**E50**	**90**
TB-9[1]	06-26-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-11	06-27-07	**E10**	<100	<100	<100	<100	<100	<100	**E10**
TB-12	07-11-07	**E10**	<100	<100	<100	<100	<100	<100	**E15**
TB-12[1]	07-11-07	–	–	–	–	–	–	–	–
TB-13	07-11-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-15	07-10-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-16	07-10-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-17	07-08-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-20	07-07-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-21	06-24-07	**E5**	<100	<100	<100	<100	<100	<100	**E7**
TB-22	06-24-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-22[1]	06-24-07	–	–	–	–	–	–	–	–
TB-23	06-28-07	**E19**	<100	<100	<100	**E13**	<100	<100	**E18**
TB-23[1]	06-28-07	**E8**	<100	<100	<100	<100	<100	<100	**E9**
TB-24	06-21-07	–	–	–	–	–	–	–	–
HS-1[2] Expected value		–	–	–	–	–	–	–	–
H-1[2] Laboratory reported value		<100	<100	<100	**E11.50**	<100	<100	<100	**E23.20**
HS-6[2] Expected value		–	190	–	230	–	–	–	–
H-6[2] Laboratory reported value		718	285	236	100	378	154	228	479
HS-6[2] Percent recovery		–	150	–	43	–	–	–	–

Table 3. Select polynuclear aromatic hydrocarbons, total polychlorinated biphenyls, and total organic carbon concentrations and sediment-particle sizes in sediment samples collected from cores at the Kootenai River near Bonners Ferry, Idaho, June–July 2007, and sediment-quality guidelines.—Continued

[Concentrations in micrograms per kilograms except as noted. Values in **bold** are non-censored or estimated values between laboratory detection limit and laboratory reporting limit. **Sediment quality guideline**: Depths below riverbed that sediment subsamples were collected from a core is provided on lithologic logs in appendix A and summarized in table 2. Subsamples were composited into a single sample for a core for chemical analysis. **Grain size:** Dry sieved at the U.S. Geological Survey, Washington Water Science Center laboratory, Tacoma, Washington. Sediment quality guideline: From U.S. Army Corps of Engineers (2006). Concentrations are in micrograms per kilograms, dry weight, except as noted. **Nitrobenzene-d**: Laboratory surrogate, bed sediment with particle-size diameter less than 2 millimeters, wet sieved using native water. **Abbreviations:** TB, test boring; SRM, standard reference material; E, estimated; m, meter; cm, centimeter; mm, millimeter; NA, not applicable; <, less than; –, no data]

Station No.	Date	1-Methyl-pyrene	Phenan-threne	Anthracene	Dibenzo[a,h]-anthracene	Fluoran-thene	Pyrene	Benzo[a]-anthracene	Chrysene
Sediment quality guideline		–	6,100	1,200	800	11,000	8,800	4,300	5,900
Database parameter No.		P49388	P49409	P49434	P49461	P49466	P49387	P49436	P49450
TB-1	06-20-07	–	–	–	–	–	–	–	–
TB-2	06-20-07	–	–	–	–	–	–	–	–
TB-3	06-22-07	<100	**E5**	<100	<100	<100	<100	<100	<100
TB-3-2[1]	07-12-07	<100	**E18**	<100	<100	<100	<100	<100	<100
TB-4	06-21-07	–	–	–	–	–	–	–	–
TB-5	06-22-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-7	06-27-07	<100	**E18**	<100	<100	<100	<100	<100	<100
TB-7[1]	06-27-07	<100	**E18**	<100	<100	<100	<100	<100	<100
TB-8	06-26-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-8[1]	06-26-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-9	06-26-07	**E49**	**180**	**E54**	<100	**220**	**190**	**130**	**E140**
TB-9[1]	06-26-07	<100	**E17**	<100	<100	<100	<100	<100	<100
TB-11	06-27-07	<100	**E14**	<100	<100	<100	<100	<100	<100
TB-12	07-11-07	<100	**E25**	<100	<100	<100	**E8**	<100	<100
TB-12[1]	07-11-07	–	–	–	–	–	–	–	–
TB-13	07-11-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-15	07-10-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-16	07-10-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-17	07-08-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-20	07-07-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-21	06-24-07	<100	**E5**	<100	<100	<100	<100	<100	<100
TB-22	06-24-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-22[1]	06-24-07	–	–	–	–	–	–	–	–
TB-23	06-28-07	<100	**E25**	<100	<100	<100	<100	<100	<100
TB-23[1]	06-28-07	<100	**E12**	<100	<100	<100	<100	<100	<100
TB-24	06-21-07	–	–	–	–	–	–	–	–
HS-1[2] Expected value		–	–	–	–	–	–	–	–
H-1[2] Laboratory reported value		<100	**E200**	**E21.30**	<100	**E661**	**E341**	**E94.20**	**E202**
HS-6[2] Expected value		–	3,000	1,100	490	3,540	3,300	1,800	2,000
H-6[2] Laboratory reported value		245	2,350	680	<273	2,430	1,760	1,050	1,450
HS-6[2] Percent recovery		–	78	62	<56	69	53	58	72

Table 3. Select polynuclear aromatic hydrocarbons, total polychlorinated biphenyls, and total organic carbon concentrations and sediment-particle sizes in sediment samples collected from cores at the Kootenai River near Bonners Ferry, Idaho, June–July 2007, and sediment-quality guidelines.—Continued

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Station No.	Date	Benzo[b]-fluoranthene	Benzo[k]-fluoranthene	Benzo[a]-pyrene	Indeno [1,2,3-cd] pyrene	Benzo[ghi] perylene	4H-Cyclopenta[def]-phenanthrene	9H-Fluorene	Isophorone
Sediment quality guideline		**600**	**600**	**3,300**	**4,100**	**4,000**	**–**	**1,000**	**–**
Database parameter No.		**P49458**	**P49397**	**P49389**	**P49390**	**P49408**	**P49411**	**P49399**	**P49400**
TB-1	06-20-07	–	–	–	–	–	–	–	–
TB-2	06-20-07	–	–	–	–	–	–	–	–
TB-3	06-22-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-3-2[1]	07-12-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-4	06-21-07	–	–	–	–	–	–	–	–
TB-5	06-22-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-7	06-27-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-7[1]	06-27-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-8	06-26-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-8[1]	06-26-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-9	06-26-07	**160**	**E63**	**100**	<63	**E65**	**E38**	**E27**	<100
TB-9[1]	06-26-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-11	06-27-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-12	07-11-07	<100	<100	<100	<100	**E9**	<100	<100	<100
TB-12[1]	07-11-07	–	–	–	–	–	–	–	–
TB-13	07-11-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-15	07-10-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-16	07-10-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-17	07-08-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-20	07-07-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-21	06-24-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-22	06-24-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-22[1]	06-24-07	–	–	–	–	–	<100	–	–
TB-23	06-28-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-23[1]	06-28-07	<100	<100	<100	<100	<100	<100	<100	<100
TB-24	06-21-07	–	–	–	–	–	–	–	–
HS-1[2] Expected value		–	–	–	–	–	–	–	–
H-1[2] Laboratory reported value		**E219**	**E88.10**	**E65.20**	**E67.9**	**E70.10**	E22.5	<100	**E7.8**
HS-6[2] Expected value		2,800	1,430	2,200	1,950	1,780	–	470	–
H-6[2] Laboratory reported value		2,310	853	972	<856	910	225	191	E26.4
HS-6[2] Percent recovery		82	60	44	<44	51	–	41	–

Table 3. Select polynuclear aromatic hydrocarbons, total polychlorinated biphenyls, and total organic carbon concentrations and sediment-particle sizes in sediment samples collected from cores at the Kootenai River near Bonners Ferry, Idaho, June–July 2007, and sediment-quality guidelines.—Continued

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Station No.	Date	Phenanthridine	Nitrobenzene-d	Total PCBs	PCB congeners surrogate (percent recovery)	p-Terphenyl-d14 (percent recovery)	2-Fluoro-biphenyl (percent recovery)
Sediment quality guideline		–	NA	60	NA	NA	NA
Database parameter number		P49393		P39519	P90794		
TB-1	06-20-07	–	–	–	–	–	–
TB-2	06-20-07	–	–	–	–	–	–
TB-3	06-22-07	<100	–	<5	–	–	–
TB-3-2[1]	07-12-07	<100	71	<5	67	91	**75**
TB-4	06-21-07	–	–	–	–	–	–
TB-5	06-22-07	<100	49	<5	**E101**	69	57
TB-7	06-27-07	<100	60	<5	62.8	73	65
TB-7[1]	06-27-07	<100	56	<5	68.4	73	63
TB-8	06-26-07	<100	55	<5	92	71	60
TB-8[1]	06-26-07	<100	58	<5	74.3	72	63
TB-9	06-26-07	<100	52	<5	73.7	68	61
TB-9[1]	06-26-07	<100	58	<5	80.6	70	64
TB-11	06-27-07	<100	50	<5	69.7	70	63
TB-12	07-11-07	<100	53	<5	70.2	72	56
TB-12[1]	07-11-07	–	–	–	–	–	–
TB-13	07-11-07	<100	48	<5	89.2	69	55
TB-15	07-10-07	<100	44	<5	76.8	71	52
TB-16	07-10-07	<100	35	<5	91.3	69	47
TB-17	07-08-07	<100	50	<5	87.6	68	58
TB-20	07-07-07	<100	42	<5	83	64	47
TB-21	06-24-07	<100	46	<5	**E124**	70	55
TB-22	06-24-07	<100	38	<5	87.2	68	55
TB-22[1]	06-24-07	–	–	–	–	–	–
TB-23	06-28-07	<100	76	–	71	92	85
TB-23[1]	06-28-07	<100	56	<5	61.8	63	57
TB-24	06-21-07	–	–	–	–	–	–
HS-1[2] Expected value		–	–	22	–	–	–
H-1[2] Laboratory reported value		<100	**E14.72**	8	**E15.54**	**E17.16**	**E12.68**
HS-6[2] Expected value		–	–	–	–	–	–
H-6[2] Laboratory reported value		<76.5	51.73	224	63.79	89.18	65.31
HS-6[2] Percent recovery		–	–	–	–	–	–

[1]Duplicate quality-assurance sample.

[2]Standard reference material quality-assurance sample from National Research Council of Canada (http://www.nrc-cnrc.gc.ca/eng/programs/imb/crmp.html).

Data Archives

USGS chemical data presented in this report are stored in the USGS National Water Information System (NWIS). NWIS is a comprehensive and distributed application that supports the acquisition, processing, and long-term storage of water data including sediment chemical data. The chemical data are publicly available on the NWISWeb at http://waterdata.usgs.gov/nwis/qw.

Quality Assurance

Quality assurance and control were incorporated into field and laboratory procedures to assure that data generated were of known and acceptable quality. Quality-assurance procedures included collection of samples using non-contaminating protocols, laboratory analysis of the samples following rigorously proven laboratory procedures, and insertion of quality-control samples in the sample set to assess the effectiveness of these procedures.

Bias and variability in the sample data were assessed using blank samples to detect bias originating in either the field or the laboratory. Duplicate samples were used to assess variability in field sampling or laboratory analysis. Accuracy in the analytical process was assessed by using certified standard reference materials inserted as blind samples from the field and the addition of surrogate compounds added to the samples being analyzed.

Quality-control samples were generated in the field and in the laboratory. Laboratory quality-control samples included analysis of reagent blank samples to assess bias in the analytical process. The NWQL protocol is to analyze one duplicate, one analytical blank, and one spiked sample with each set of 12 environmental samples (Noriega and others 2004). The NWQL analyzed several surrogate compounds with each regular and replicate sediment sample. Surrogate compounds are readily identifiable non-target compounds, which are added to the sample in known quantities so that recovery of sample extraction process can be assessed. Known quantities of surrogate compounds were added to the sediment samples being analyzed for organic compounds. Recovery of the surrogate compounds is a good indicator of how well the organic extraction process detected organic compounds in the sediment samples. Laboratory duplicate samples provided data on variability in the ensuing data arising from variability in the laboratory process.

Accuracy in the analysis of organic chemical data was assessed by use of standard reference materials. Standard reference materials, HS-1 and HS-6, which list known concentrations of selected PAHs and PCBs, were obtained from the National Research Council Canada. These standard reference materials were submitted to the NWQL as blind samples with the other samples (table 3) and document bias and recovery of the analytical process.

Duplicate field samples were collected at five cores sites. The duplicate samples were collected following the composite sample mixing process and assess the degree of homogeneity in the composite sample. The duplicate samples were collected by adding alternating spoon-sized scoops of composited sediment first to one sample bottle and then to another.

Twenty equipment rinsate blank samples were collected after decontamination of the core barrel and prior to sampling. Decontamination of the core barrel consisted of pressure spraying deionized water into the barrel and collecting the run-off in a plastic jar as it flowed out the end of barrel. Equipment blanks also were collected from the clean sample jar prior to compositing the samples. Six of these equipment blanks were analyzed for metals.

Trip blanks were collected to document any contamination attributable to field handling, procedures, and shipping. The blank was created by exposing analyte-free water to the atmosphere during sample processing and then analyzing for metals. These blanks were used by Kruse (2008) to document any contamination attributable to field handling procedures and shipping.

Sediment Chemistry of Cores From the Kootenai River

Habitat-ecosystem restoration projects for the Kootenai River may require moving and dredging the riverbed, and these actions may cause sediment to spread along the river with any contaminant(s) possibly bound to the sediment. Kruse (2000) reported multiple sources of historical contaminant input to the Kootenai River. Many sources of contaminants have been reduced or eliminated during the past 30 years. Recent monitoring efforts, however, have detected the presence of organochlorine pesticides, PCBs, and metals in the Kootenai River ecosystem in the Idaho and British Columbia reaches (Knudson, 1994; Kruse and Scarnecchia, 2002; Kruse, 2003; and Kruse, 2005). The USGS analyzed the sediment chemistry for 16 of 24 cores from the Kootenai River. The sediment in four cores was too coarse for chemical analysis. This study determined that concentrations of 29 PAHs and total PCBs in composite sediment samples from 16 cores were substantially less than concentrations considered to be contaminated as recognized in the Pacific Northwest regional sediment evaluation framework (U.S. Army Corps of Engineers and others, 2006). Reported concentrations for all selected PAHs and total PCBs analyzed for in the sediments samples were less than 220 µg/kg. Concentrations of sediment chemistry and guidelines for sediment-quality are shown in table 3.

Quality-control data indicate that the collected data met the quality objectives of the study, although chemical concentrations reported by the NWQL were affected by a negative bias. Two blind standard reference material samples were submitted with the sample set to NWQL to assess bias in the analytical procedures. The standard reference material (SRM) used in samples HS-1 (total PCBs) and HS-6 (PAHs) were obtained from National Research Council of Canada (2010). All analytes certified as present in the SRM samples were detected by the NWQL analytical procedures; however, the recoveries tended to be lower than the most probable expected values (table 3). The median of comparisons between laboratory-reported values and most probable expected values present in the SRM was 59 percent, with a range of 41 to 150 percent.

Spike matrix recoveries for analytes added to each sample analyzed ranged from 63 and 77 percent and were within laboratory control limits. Positive bias in the analytical data was not apparent in the data as no target analytes were observed in the laboratory blank samples analyzed by NWQL or in the field rinsate blank samples analyzed with samples (appendix B). These results indicate that although laboratory results have a negative bias, they are not likely to result in a false negative indication of absence of contaminant in the sediment samples.

Based on low recoveries of the SRM and spike samples, the minimum reporting level shown in table 3 as a less than value was increased by a factor of 2 over the minimum reporting level provided with the laboratory analysis. A less than 50 µg/kg reported by the laboratory is re-censure as less than 100 µg/kg in table 3. The laboratory provided an estimated concentration value when the instrument indicted that the specific analyte was present but at a concentration less than the range of the lowest calibration standard. The estimated values are presented in table 3 as provided by the laboratory and have not been adjusted.

The reported concentrations of total PCBs in sediment samples from all 16 cores were less than 5 µg/kg; concentrations of PCBs were not carbon normalized. The sediment-quality guideline for concentrations of total PCBs in dredged sediments is 60 µg/kg.

The concentration of PAHs measured in the composite sediments for Kootenai River was substantially less than the sediment-quality guideline for dredged sediments. Reported concentrations for the 29 PAH compounds analyzed typically were less than the laboratory reporting level, as shown in table 3. Fewer than five PAH compounds were detected and concentrations typically were less than 220 µg/kg for 64 percent of the composite samples. Sample TB-9, however, indicated the presence of 23 PAHs compounds, although only phenanthrene was detected in the duplicated sample from that composite. The comparatively large PAH concentrations in the sample from TB-9 may have resulted from charred organic fragments similar to the large charred woody debris that was observed on the 2 mm screen used in sample preparation for organic carbon analysis. Less variability between duplicates was observed in the other four duplicate sample pairs, TB-3, TB-7, TB-8, and TB-12, indicating that constituent concentrations are consistently low, but that the variability in constituent concentration can be relatively large, as often is the case when measuring low concentrations of environmental constituents.

Concentrations of TOC ranged from 0.31 to 2.42 percent (table 3). Grain sizes finer than sand for the 18 sieved samples ranged from 3.0 percent in TB-11 to 84.9 percent in TB-12, with a median of 5.6 percent fines. A layer of clay and silt was sampled from TB-12. Because the concentration of PAHs and PCBs were low, the toxic equivalencies, probable effects quotients, and theoretical bioaccumulation potential are not reported.

Summary

River restoration is a complex undertaking that requires a thorough understanding of the river and flood plain landscape. Evaluating the feasibility of proposed white sturgeon habitat-ecosystem restoration projects, such as modifying the channel and flood plain and installing in-stream structures requires many types of information that includes analyzing chemicals in sediment beneath the riverbed and a detailed understanding of sediment types beneath the river and in the nearby flood plain, river stage, and groundwater levels.

The U.S. Geological Survey collected and analyzed critical data for the Kootenai River habitat restoration project. Sediment cores were collected at 23 locations during July 2007 in the Kootenai River white sturgeon habitat. Sediment coring site selection was based on a preliminary conceptual river design and the potential effect of bedrock on rechannelizing the river. A sonic drill rig was mounted on a drilling barge and collected continuous cores of sediments beneath the riverbed. Core depths ranged from 4.6 to 15.2 meters and 21 cores reached a depth of 15.2 meters. A maximum coring depth of 15.2 meters below the riverbed was established for the coring program because the channel modifications under consideration are not likely to extend to depths much greater than 15.2 meters. Lithologic logs were constructed and photographs were taken of the cores. Sediment samples were collected from these cores and analyzed by the U.S. Geological Survey for polyaromatic hydrocarbons, polychlorinated biphenyls, total organic carbon, and sieved for particle size.

Habitat-ecosystem restoration projects for the Kootenai River may require moving and dredging the riverbed. These actions may cause sediment to spread along the river with any contaminant(s) possibly bound to the sediment. This study determined that concentrations of PAHs and total PCBs in the sediment sampled in all cores were less than the sediment quality guidelines for river sediment dredging. Total organic carbon concentrations ranged from 0.31 to 2.42 percent. For the 19 sieved samples collected, the median percent finer than sand was 5.6 percent with a minimum of 3.0 percent and maximum of 84.9 percent fines. Because the concentration of PAHs and PCB are low, the toxic equivalencies, probable effects quotients, and theoretical bioaccumulation potential are not reported.

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The authors thank the people of the Kootenai River Valley in Idaho who provided access to the Kootenai River for coring. Sue Ireland of the Kootenai Tribe of Idaho provided storage facilities for USGS boats and equipment and a sample preparation lab. Gretchen Kruse of Free Run Aquatics provided sampling equipment. The authors also thank Jack Siple of the Kootenai Tribe of Idaho who provided logistical support for fieldwork. Andre Makarov, USGS Washington Water Science Center, collected data on the Kootenai River for this project. Regan Huffman, USGS Washington Science Center, helped enter the analytical data into the USGS database and generated chemical data tables. Sandra Ball, USGS, Post Falls, Idaho, helped with many logistical issues.

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Appendix A. Lithologic Strip Logs With Sediment Sampling Depth Interval for Chemical Analysis and Photographs of Sediment Cores

Lithologic strip log and photographs of sediment cores from the Kootenai River, Bonners Ferry, Idaho, are presented in appendix A. Each log includes links to photographs; click on a link to view photographs individually. These logs and photographs are available at http:/pubs.usgs.gov/sir/2011/5006/.

Appendix B. Sediment Core Chemical Analysis Data

Free Run Aquatic Research, Hayden, Idaho, processed sediment samples collected by the U.S. Geological Survey (USGS) from cores of the Kootenai River. The samples were analyzed for asbestos, which is associated with the mineral tremolite, metals, organochlorine and pesticide compounds, and polynuclear aromatic hydrocarbons (PCBs). These samples were sent to commercial testing facilities outside the USGS chain of custody. Tremolite analysis was done by EMSL Analytical, Inc., in San Leandro, California. Metals and total organic carbon analyses were done by ALS Laboratory Group, Vancouver, British Columbia, Canada. Organochlorine and PCB analyses were done by Axys Analytical Services, LTD, Sidney, British Columbia, Canada. The chemical analysis from Kruse (2008) is provided in the appendix B and was prepared and presented by Free Run Aquatic Research. These data have not been reviewed or approved by the USGS.

Kootenai River Sediment Drilling: Contaminant Assessment Report (Report Prepared in Partial Fullfillment of Project Number 200200200: Restore Natural Recruitment of Kootenai River White Sturgeon)

Report Prepared For:
Kootenai Tribe of Idaho
Bonners Ferry

Report Prepared By:
Gretchen Kruse
Free Run Aquatic Research
214 E. Hayden Ave.
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February 2008

Laboratory Analysis

Tremolite: Tremolite analysis was conducted by EMSL Analytical, Inc. in San Leandro California. Twenty soil samples were milled and prepped following CARB 435 guidelines (EPA2). Target analytical sensitivity was set to 0.1%. Each sample was analyzed by both Polarized Light Microscopy (PLM) and

Transmission Electron Microscopy (TEM). For each sample processed by PLM, samples were initially scanned by stereoscopic exam for properties and possible fibrous material. Following initial scan, samples were analyzed using a combination of 100X and 400X magnification, employing a 1,000 Point Count procedure following the EPA 600/R-93-116 method (EPA2). Transmission Electron Microscopy involved analysis using EPA 600/R-93-116, Section 2.5.5.2 method for asbestos percent by mass. Asbestos fibers are defined as having a 3:1 aspect ratio and were categorized based on length: (a) <5.0 microns and (b) $\geq$5.0 microns.

Metals: Analysis for metals was conducted by ALS Laboratory Group, Vancouver B.C., Canada. Sediment samples were analyzed for:

- Hardness
- CSR pH by 1:2 water leach
- Percent moisture
- Total mercury by CVAFS (cold vapour Fluorescent Atomic Spectrometry)
- ICPMS (Inductively Coupled Plasma - Mass Spectrometry) for thallium (Tl) by CSR SALM (Contaminated Sites Regulation Strong Acid Leachable Metals)
- Metals by ICP-OES (inductively coupled plasma-optical emission spectrometry)

Total Organic Carbon: ALS Laboratory Group analysed Total Organic Carbon (TOC) in sediment samples by high temperature combustion (APHA Method 5310; EPA2).

Organochlorine pesticides and PCBs: Organochlorine pesticides and PCB (aroclor and congener specific) analysis was conducted by Axys Analytical Services LTD., Sidney, B.C., Canada. Organochlorine pesticides and PCBs were analyzed by HRGC/LRMS (High-Resolution Gas Chromatography with detection by Low-Resolution Mass Spectrometry) and GC/ECD (Gas Chromatography with Electron Capture Detection).

Table 1. Results of Polarized Light Microscopy (PLM) analysis conducted on core sediment samples collected from the Kootenai River, 2007.

Sample Number	Sample Appearance	% Fibrous	% Non-Fibrous	% Asbestos (type)
TB-1	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-2	Gray, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-3	Gray, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-3-2	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-5	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-6	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-7	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-8	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-9	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-11	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-12	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-13	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-15	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-16	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-17	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-20	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-21	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-22	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-23	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-231A/1=1	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-231B/1=1	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-23-L	Gray, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected
TB-24	Brown, Non-Fibrous, Homogenous	0	100% Non-Fibrous (other)	None Detected

Table 2. Results of Transmission Electron Microscopy (TEM) analysis conducted on core sediment samples collected from the middle Kootenai River, 2007. Orange highlighted boxes indicate a sample that contained regulated asbestos fibers. Yellow highlighted boxes indicate a sample that contained unregulated asbestos fibers.

Sample Number	USGS Sample ID	Asbestos Type	Number of Asbestos Structures Detected	Analytical Sensitivity (%)	Asbestos Weight (%)
TB-1	484156116202001	None Detected	None Detected	0.01	<0.01
TB-2	484141116194901	None Detected	None Detected	0.01	<0.01
TB-3	484143116194201	None Detected	None Detected	0.01	<0.01
TB-3-2	484143116194202	Chrysotile	1	0.01	<0.01
TB-5	484150116192601	None Detected	None Detected	0.01	<0.01
TB-6	484148116192601	None Detected	None Detected	0.01	<0.01
TB-7	484154116190301	None Detected	None Detected	0.01	<0.01
TB-8	484151116191601	None Detected	None Detected	0.01	<0.01
TB-9	484153116190501	None Detected	None Detected	0.01	<0.01
TB-11	484201116184001	None Detected	None Detected	0.01	<0.01
TB-12	484202116172301	None Detected	None Detected	0.01	<0.01
TB-13	484202116164501	None Detected	None Detected	0.01	<0.01
TB-15	484210116153301	None Detected	None Detected	0.01	<0.01
TB-16	484209116143501	None Detected	None Detected	0.01	<0.01
TB-17	484234116131901	None Detected	None Detected	0.01	<0.01
TB-20	484154116120401	Ferro-Actinolite	N/A	0.01	<0.01
TB-21	484421116242401	None Detected	None Detected	0.01	<0.01
TB-22	484427116245501	Ferro-Actinolite	N/A	0.01	<0.01
TB-23	484532116233101(02)	None Detected	None Detected	0.01	<0.01
TB-231A/1=1		None Detected	None Detected	0.01	<0.01
TB-231B/1=1		Actinolite	1	0.01	<0.01
TB-23-L	484532116233101(02)	None Detected	None Detected	0.01	<0.01
TB-24	484145116193601	None Detected	None Detected	0.01	<0.01

Table 3. Metals concentrations (ppm; mg/kg; dry weight) in sediment core samples collected from the Kootenai River, 2007 compared with established background, TEC, MEC and PEC criteria [a b c d e]. "<" indicates a value less than the method detection limit (the number that follows this flag is the method detection limit. The number that follows is the sample detection limit). Yellow highlighted boxes indicate lower level background exceedance and Green highlighted boxes indicate upper level background exceedance for compounds with a range of allowable concentrations. Orange highlighted boxes indicate both background and TEC exceedances. PEL – Probable Effects Level; *H. azteca* PEL is based on bioassay results.

Sample ID	Percent Moisture	pH	Total Organic Carbon	Sb	As	Ba	Be	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	Tl	Sn	V	Zn
TB-1	19.8	8.47	0.2	<10	<5.0	36.2	<0.50	<0.50	7.3	4.5	7.9	<30	0.0080	<4.0	7.7	<2.0	<2.0	<1.0	<5.0	13.1	45.2
TB-2	17.7	8.53	<0.1	<10	<5.0	36.7	<0.50	<0.50	8.6	4.9	8.0	<30	0.0068	<4.0	8.1	<2.0	<2.0	<1.0	<5.0	15.5	35.3
TB-3	23.1	8.45	0.2	<10	<5.0	49.4	<0.50	<0.50	9.1	5.2	10.6	<30	0.0088	<4.0	9.1	<3.0	<2.0	<1.0	<5.0	16.8	37.9
TB-3-2	29.4	8.29	0.2	<10	<5.0	41.6	<0.50	<0.50	7.6	4.9	9.0	<30	0.0072	<4.0	7.9	<2.0	<2.0	<1.0	<5.0	14.8	60.2
TB-5	11.8	8.79	<0.1	<10	<5.0	29.8	<0.50	<0.50	8.4	5.2	9.9	<30	0.0172	<4.0	8.2	<2.0	<2.0	<1.0	<5.0	17.2	32.0
TB-6	21.2	8.59	0.2	<10	<5.0	34.8	<0.50	<0.50	8.3	4.5	7.5	<30	0.0074	<4.0	7.3	<2.0	<2.0	<1.0	<5.0	15.8	46.0
TB-7	27.3	8.46	0.2	<10	<5.0	43.7	<0.50	<0.50	8.6	4.6	9.9	<30	0.0106	<4.0	8.4	<2.0	<2.0	<1.0	<5.0	15.3	34.1
TB-8	17.7	8.68	<0.1	<10	<5.0	40.9	<0.50	<0.50	7.8	4.1	8.6	<30	0.0073	<4.0	6.9	<2.0	<2.0	<1.0	<5.0	15.9	26.6
TB-9	33.3	8.17	1.3	<10	<5.0	78.2	<0.50	<0.50	44.6	7.6	10.4	36	0.0181	<4.0	15.8	<2.0	<2.0	<1.0	<5.0	14.8	81.2
TB-11	29.0	8.41	0.4	<10	<5.0	61.0	<0.50	<0.50	16.1	5.7	9.4	<30	0.0066	<4.0	8.9	<2.0	<2.0	<1.0	<5.0	18.4	71.6
TB-12	18.6	8.36	0.7	<10	<5.0	177	0.64	<0.50	17.0	9.2	22.2	<30	0.0345	<4.0	19.1	<2.0	<2.0	<1.0	<5.0	26.2	69.8
TB-13	27.4	8.56	<0.1	<10	7.5	36.2	<0.50	<0.50	9.1	7.1	17.8	<30	0.0089	<4.0	9.9	<2.0	<2.0	<1.0	<5.0	15.3	35.9
TB-15	23.0	8.75	0.1	<10	<5.0	72.4	<0.50	<0.50	16.0	7.8	26.6	<30	0.0061	<4.0	12.3	<2.0	<2.0	<1.0	<5.0	26.3	42.3
TB-16	23.0	8.39	<0.1	<10	<5.0	57.8	<0.50	<0.50	7.8	4.6	12.9	<30	<0.0050	<4.0	7.7	<2.0	<2.0	<1.0	<5.0	16.1	32.1
TB-17	20.5	8.56	0.2	<10	<5.0	29.3	<0.50	<0.50	9.0	5.2	11.0	<30	0.0063	<4.0	7.7	<2.0	<2.0	<1.0	<5.0	16.0	29.2
TB-20	23.8	8.67	<0.1	<10	<5.0	37.1	<0.50	<0.50	10.6	4.8	13.5	<30	0.0058	<4.0	7.9	<2.0	<2.0	<1.0	<5.0	16.4	39.7
TB-21	24.4	8.65	<0.1	<10	<5.0	34.3	<0.50	<0.50	7.2	4.1	6.5	<30	0.0141	<4.0	7.6	<2.0	<2.0	<1.0	<5.0	12.6	30.7
TB-22	20.8	8.77	<0.1	<10	<5.0	36.2	<0.50	<0.50	7.3	4.1	7.1	<30	0.0096	<4.0	7.3	<2.0	<2.0	<1.0	<5.0	12.5	30.4
TB-23	30.8	8.80	0.8	<10	<5.0	23.0	<0.50	<0.50	8.1	3.4	7.8	<30	0.0146	<4.0	7.0	<2.0	<2.0	<1.0	<5.0	9.3	24.3
TB-24	29.5	8.67	0.4	<10	<5.0	37.9	<0.50	<0.50	7.5	4.3	8.1	<30	0.0078	<4.0	7.8	<2.0	<2.0	<1.0	<5.0	12.9	30.4
Background[a]				1.6	1.1	0.7		0.1-0.3	7-13	10	10-25	4-17	0.004-0.051		9.9	0.29	<0.5		5	50	7-38
TEC[b] (Geometric Mean of "Threshold Criteria")				2.0	9.8			0.99	43.4		31.6	35.8	0.18		22.7		1.6				121
MEC[b] (Geometric mean of Threshold and Probable Criteria)				13.5	21.4			3.0	76.5		91.0	83.0	0.64		36.0		1.9				290
PEC[b] (Geometric mean of "Probable Criteria")				25.0	33.0			4.98	111		149.0	128	1.06		48.6		2.2				459
LEL ("Threshold Effects")				2.0[d]	6.0[e]			0.6[e]	26[e]		16[e]	31[e]	0.15[d]		16[e]		1.0[d]				120[deg]
TEL[b] ("Threshold Effects")					5.9			0.596	37.3		35.7	35	0.174		18						123.1
ER-L ("Threshold Effects")					8.2[c]; 33[b]			1.2[c]	81[c]; 80[b]		34[c]; 70[b]	46.7[c]; 35[b]	0.15[c b]		20.9[c]; 30[b]		1.0[c]				150[c]; 120[b]
PEL[b] ("Probable Effects")					17			3.53	90.0		197	91.3	0.486		36.0						315
SEL ("Probable Effects")				25.0[d]	33[e]			10.0[d]	110[e]		110[e]	110[e]	1.3[d]		50[d]		2.2[d]				270[d]
ER-M[c] ("Probable Effects")					70.0			9.6	370		370	218	0.71		51.6		3.7				410
H. azteca PEL[b] ("Probable Effects")					11			0.58	36		28	37			20						98

[a] Source: NOAA 2004; [b] Source: MacDonald et al. 2000: [c] Source: Long et al. 1995; [d] Source: Long and Morgan 1990; [e] Source: Persaud et al. 1993
Probable Effect = Frequently Occur - 50 Percentile; Threshold Effect = Rarely occur – 15[th] Percentile

Table 4. Organochlorine concentrations detected in sediment core samples, Kootenai River, Idaho - **NORMALIZED TO 1% TOTAL ORGANIC CARBON (detected concentration divided by TOC% as a whole number)**. Non-detects are indicated by "<mdl"; see Appendix 1 for detection limits. Orange highlighted boxes indicate compounds classified as "POPs" (persistent organic pollutants). Green highlighted cells indicate comparative criteria based on 1% carbon content – blank spaces within green highlighted data indicate lack of established criteria. Yellow highlighted text indicated values that exceed one or more criteria (based on 1% TOC) in green highlighted section. Pink highlighted text indicates samples with <0.2%TOC – Due to low or below mdl TOC, raw data for these samples were **NOT** carbon normalized to 1% TOC.

Sample Number	Organochlorine Pesticide Compound (ng/g; ppb dry weight)												
	Total Organic Carbon (TOC %)	Methoxychlor	Hexachlorobenzene	Alpha-Hexachlorocyclohexane	Heptachlor	Oxychlordane	Mirex	o,p-DDE	p,p-DDE	p,p-DDD	o,p-DDT	p,p-DDT	**Total DDT + Metabolites**
TB-1	0.2	1.05 (E)	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	2.500 (E)	**2.500**
TB-1 Duplicate	0.2	1.265 (E)	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	0.220 (E)	**0.220**
TB-2	<0.1	0.100 (E)	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	**0.000**

Table 4 continued. Organochlorine concentrations detected in sediment core samples, Kootenai River, Idaho

Sample Number	Organochlorine Pesticide Compound (ng/g; ppb dry weight): Total Organic Carbon (TOC %)	Methoxychlor	Hexachlorobenzene	Alpha-Hexachlorocyclohexane (α-HCH)	Heptachlor	Oxychlordane	Mirex	o,p-DDE	p,p-DDE	p,p-DDD	o,p-DDT	p,p-DDT	Total DDT + Metabolites
TB-3	0.2	0.615 (E)	0.175 (E)	<mdl	<mdl	<mdl	0.430 (Q)	<mdl	<mdl	<mdl	<mdl	<mdl	0.000
TB-3-2	0.2	0.605 (E)	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	12.0 (E)*	12.000
TB-5	<0.1	0.022 (E)	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	0.000
TB-6	0.2	0.245 (E)	0.235 (E)	<mdl	<mdl	<mdl	<mdl	<mdl	0.150 (E)	0.210 (Q)	<mdl	0.225 (E)	0.585
TB-7	0.2	0.570 (E)	0.195 (E)	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	0.000
TB-8	<0.1	0.030 (E)	0.050 (E)	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	0.000
TB-9	1.3	0.323 (E)	0.045 (E)	<mdl	0.461 (E)	3.92 (E)	3.75 (E)	0.652 (Q)	<mdl	<mdl	<mdl	<mdl	0.652
TB-11	0.4	0.388 (E)	0.103 (E)	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	0.000
TB-13	<0.1	0.025 (E)	0.033 (E)	<mdl	<mdl	<mdl	<mdl	<mdl	0.023 (E)	<mdl	<mdl	<mdl	0.460
TB-15	0.1	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	0.021 (E)	<mdl	<mdl	<mdl	0.201
TB-16	<0.1	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	0.021 (E)	<mdl	<mdl	<mdl	0.420
TB-17	0.2	0.200 (E)	0.270 (E)	0.290 (E)	<mdl	<mdl	<mdl	<mdl	0.130 (E)	<mdl	<mdl	<mdl	0.130
TB-20	<0.1	0.043 (E)	0.044 (E)	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	0.000
TB-21	<0.1	0.090 (E)	0.062 (E)	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	0.000
TB-22	<0.1	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	0.021 (E)	<mdl	<mdl	<mdl	0.420
TB-23	0.8	0.286 (E)	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	0.000
TB-23 Duplicate	0.4	0.194 (E)	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	0.000
TB-24	0.4	0.400 (E)	0.058 (E)	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	0.388 (E)	5.98 (E)*	6.368
Comprehensive screening Criteria (Includes Threshold and Probable Effects)													
TEC				6.0[b]			7.0[c]	3.16[a]		4.88[a]	4.16[a]		5.28[a]
MEC				53.0[b]			10.5[cd]	17.0[j]		16.5[j]	33.6[j]		289[j]
PEC				100.0[b]			14[c]	31.3[a]		28.0[a]	62.9[a]		572[a]
Threshold Effects Criteria – occurrence of <25% adverse effects when exceeded													
LEL			20[f]	6[f]			7[g]	5[a]		8[a]	8[a]		7[a]
TEL				0.32[j]	10[f]			1.42[ai]		1.22[h]; 3.54[ai]	3.89[ci]		6.98[h]; 7[a]
ER-L								2[a]		1.58[h]; 2[a]	1.0[da]; 1.58[h]		3[a]
Probable Effects Criteria – occurrence of >50% adverse effects when exceeded													
PEL					2.74[i]			6.75[ai]		7.81[h]; 8.51[gi]	4.77[g]		4450[ai]
SEL			240[f]	100[f]			1300[f]	190[a]		60[a]	710[a]		120[a]
ER-M								15.0[da]		27.0[h]; 20[a]	7.0[da]; 46.1[h]		350.0[da]

[a] Source: Consensus-based sediment quality guildeline (CBSQ); MacDonald et. al 2000
[b] Regulatory Agency: Ontario Ministry of the Environment Sediment Quality Criteria, 1993
[c] Regulatory Agency: Environment Canada National Sediment Quality Criteria, 1995
[d] Regulatory Agency: NOAA Benchmark Guidelines, Long and Morgan, 1990
[e] Source: BCMOE; MacDonald and MacFarlane 1999
[f] Source: BCMOE Working Guidelines for Sediments, 2005
[g] Source: Canadian Environmental Quality Guidelines, 1999; Environment Canada 2003
[h] Source: Florida Department of Environmental Protection 1994; Long et. al 1995 as cited in the National Sediment Quality Survey Appendix D.
[i] Source: NOAA SQUIRTS; NOAA 2004
[j] Source: Wisconsin DNR 2003

TEC=Threshold Effects Concentration; LEL=Lowest Effects Level; TEL=Threshold Effects Level; ER-L=Lowest Effects Range; MEC=Median Effects Concentration; PEC=Probable Effects Concentration, PEL=Probable Effects Level, SEL=Severe Effects Level; ER-M=Effects Range Median; * = potential cross-contamination during transport.

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