science for a changing world

Prepared in cooperation with the Midnite Uranium Mine Natural Resource Trustee Council

Determination of Premining Geochemical Background and Delineation of Extent of Sediment Contamination in Blue Creek Downstream from Midnite Mine, Stevens County, Washington

Scientific Investigations Report 2007–5262

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

Determination of Premining Geochemical Background and Delineation of Extent of Sediment Contamination in Blue Creek Downstream from Midnite Mine, Stevens County, Washington

By Stanley E. Church, Frederick E. Kirschner, LaDonna M. Choate,
Paul J. Lamothe, James R. Budahn, and Zoe Ann Brown

Prepared in cooperation with the
Midnite Uranium Mine Natural Resource Trustee Council

Scientific Investigations Report 2007-5262

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

U.S. Department of the Interior
DIRK KEMPTHORNE, Secretary

U.S. Geological Survey
Mark D. Myers, Director

U.S. Geological Survey, Reston, Virginia: 2008

For product and ordering information:
World Wide Web: http://www.usgs.gov/pubprod
Telephone: 1-888-ASK-USGS

For more information on the USGS--the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment:
World Wide Web: http://www.usgs.gov
Telephone: 1-888-ASK-USGS

Suggested citation: Church, S.E., Kirschner, F.E., Choate, L.M., Lamothe, P.J., Budahn, J.R., and Brown, Z.A., 2008, Determination of premining geochemical background and delineation of extent of sediment contamination in Blue Creek downstream from Midnite Mine, Stevens County, Washington: U.S. Geological Survey Scientific Investigations Report 2007-5262, 177 p.

Cover. Aerial photograph of Midnite Mine site looking southeast. Photograph by Fred E. Kirschner, AESE, Inc., June 21, 2000.

Contents

Abstract 1
Introduction.....1
Purpose and Scope 2
Acknowledgments 7
Regional Setting 7
Mine-Site Geology 7
Previous Work 10
Stream-Sediment Studies 10
Data from Sediment from Lake Roosevelt 10
Water-Quality Data 11
Sampling and Preparation Methods 11
Stream-Sediment Samples, Blue Creek Delta 11
Terrace- and Stream-Sediment Core Samples 11
Description of Terrace Core Sampling Sites 16
Analytical Methods 20
Sediment-Sample Digestion and Analytical Methods 20
Quality Assurance—Quality Control Data 25
Gamma-Ray Spectrometry Methods 25
Quality Assurance—Quality Control Data 27
Statistical Methods 27
Results and Discussion 27
^{137}Cs Data from Cores 06MM01 and 06MM08 27
Geochemical Data from Terrace Cores, Blue Creek 31
Sediment Geochemistry, Core 06MM08 31
Radionuclide Data, Core 06MM08 35
Sediment Geochemistry, Core 06MM06 40
Sediment Geochemistry, Core 06MM05 40
Sediment Geochemistry, Cores from the Blue Creek Delta 40
Sediment Geochemistry, Core 06MM03 40
Sediment Geochemistry, Core 06MM04 45
Sediment Geochemistry, Core 06MM02 45
Sediment Geochemistry, Core 06MM01 45
Radionuclide Data, Core 06MM01 51
Premining Geochemical Background Upstream of the Midnite Mine 57
Comparison of the 1975 USGS Sediment Geochemical Data with Geochemical Data from the 1970s Sample Intervals in 2006 Cores 61
Geochemical Data from the Blue Creek Delta 66
Geochemical Contamination from the Spokane River in Lake Roosevelt 66
Premining Geochemical Background Data, Blue Creek Delta 70
Data from Surface-Sediment Sites, Blue Creek Delta 70
Summary of Geochemical Data 81
Conclusions 88
References Cited 88

Appendix A. Tables Showing Sample Descriptions, Locations, Weights of Sieved Core Segments by Grain Size; Tables Showing Analytical Data from Cores and Sediment Used in Study; Tables Showing Geochemical Background Statistical Data and Calculations, Including Statistical Description in Graphical Form for Each Element; and Photographs of Cores 91
Appendix B. Standard Operating Procedure for Sampling Sediments with Driven Core Sediment Sampler (DCSS) on the Spokane Indian Reservation (SOP_DCSS)....169

Figures

1. Location map of Midnite Mine study area....3
2. Geologic map of study area 4
3. Geologic map of Midnite Mine site....6
4. Map of the Midnite Mine site showing mine pits, waste dumps, roads, pollution control features, and surface drainages 8
5. Graph showing mean daily discharge recorded at gauge # 12433556 on the Midnite Mine tributary 9
6. Map showing localities of the USGS 1975 and the 1979 NURE stream-sediment sites and the USGS 2006 core sites 14
7. Aerial photograph showing localities of the 2006 USGS core and 2005 AESE, Inc., stream-sediment sites in Blue Creek cove....18
8–13. Photographs showing:
8. Core site 06MM01....20
9. Core sites 06MM02–06MM04....21
10. Core site 06MM05....22
11. Core site 06MM06....23
12. Core site 06MM07....23
13. Core site 06MM08....24
14. Graph showing monthly elevations of Lake Roosevelt measured at Grand Coulee Dam, May 1938 through May 2006....33
15. Graph showing ^{137}Cs activity in core 06MM08 34
16. Plot showing water levels at core sites 06MM01–06MM04 measured monthly by year 36
17. Plots showing selected geochemical data, core 06MM08....37
18. Chart of ^{238}U decay series....39
19–28. Plots showing:
19. Activity data from selected intervals, core 06MM08....41
20. Uranium versus carbon concentrations in selected intervals, cores 06MM01 and 06MM08....42
21. Selected geochemical data, core 06MM06 46
22. Selected geochemical data, core 06MM05 47
23. Selected geochemical data, core 06MM03 49
24. Selected geochemical data, core 06MM04 53
25. Selected geochemical data, core 06MM02 55
26. Selected geochemical data, core 06MM01 59
27. Activity data from selected intervals, core 06MM01....60

28. Metal enrichment versus sample site distance from the igneous contact of Loon Lake Granite with rocks of the Togo Formation for selected NURE sediment samples....65
29. Graph showing geochemical dispersion model for dilution downstream from mineralized site....68
30. Map showing NURE aero-radiometric uranium concentration data and localities of NURE sediment samples....69
31. Downstream plots of selected geochemical data from 1975 USGS and 1979 NURE stream-sediment samples, Blue Creek....71
32. Downstream plot of selected 1975 stream-sediment geochemical data and comparison with mining and premining geochemical data from the 2006 core samples, Blue Creek....73
33. Photograph of the top 10-centimeter interval, core 06MM03....75
34. Box plot of geochemical data from the Spokane Arm of Lake Roosevelt and from Blue Creek delta delineated by relative time period....76
35. Map showing localities of downstream sediment sites discussed in text....77
36. Plots showing the relationship of uranium concentration to U/Th and to zinc concentrations delineated by time period....83
37. Graph showing relationship of uranium and radionuclide concentrations in surface sediment, Blue Creek delta, as a function of distance from the mouth of Blue Creek....84
38. Plots of the concentration of zinc versus cadmium/lead, nickel/zinc, and cobalt/zinc in sediment from Blue Creek delta delineated by time period....86

Tables

1. Dates and mean daily discharge of flood events recorded at gauge # 12433556, Midnite Mine tributary, October 1983–May 2006....10
2. Sediment geochemical data collected in study area, August 1975....12
3. Selected geochemical data from NURE samples collected in the Blue Creek basin, July 1979....13
4. Geochemical data from sediment core CSA-8 from the Spokane Arm of Lake Roosevelt, Wash.....15
5. Summary of dissolved constituents in surface water from the Midnite Mine site, 1984....17
6. Sample localities and site descriptions of USGS 2006 cores, Midnite Mine study area....19
7. Comparison of measured values for five International Reference Standards with literature values....26
8. Data and comparison of analyses of blind duplicate samples, cores 06MM01–06MM08 from Blue Creek basin....28
9. Data and comparison of analyses of blind duplicate NURE stream-sediment samples, Blue Creek and Sand Creek basins....29
10. Data and comparison of analyses of blind duplicate samples, Blue Creek delta (May 2005)....30
11. Parameters used to calculate radionuclide concentrations from gamma-ray spectrometry data....30

12. ^{137}Cs activity data from selected black silt samples, cores 06MM01 and 06MM08.........32
13. Selected geochemical data and statistical summary, core 06MM08...............................38
14. Radioisotope data from selected black silt samples, cores 06MM01 and 06MM08.......43
15–20. Selected geochemical data and statistical summary:
15. Core 06MM06 44
16. Core 06MM05 47
17. Core 06MM03 48
18. Core 06MM04 52
19. Core 06MM02 54
20. Core 06MM01 58
21. Selected NURE stream-sediment geochemical data from samples grouped on the basis of underlying geology 62
22. Summary and comparison of statistical data for stream sediment from drainage basins underlain by Loon Lake Granite, Togo Formation, and a combination of Loon Lake Granite and Togo Formation rocks...64
23. Statistical summary of stream-sediment geochemical data from sites not impacted by mining, Blue Creek and Sand Creek basins 67
24. Trace-element concentrations and enrichment factors in sediment, Blue Creek delta 75
25. Premining geochemical background data from cores sampled in 2006 from Blue Creek delta 79
26. Surface-sediment data collected from Blue Creek delta and from sites in the Spokane Arm, Lake Roosevelt, May 2005...80
27. Enrichment of possible contaminants from the Midnite Mine in surface sediment, Blue Creek delta...82
28. Enrichment of uranium and radionuclides in surface sediment, Blue Creek delta.........85
29. Summary of geochemical data from core study 87

Appendix Tables

A1–A8. Sample intervals, descriptions, Munsell color, artifacts found in +10 mesh fraction, total sample weight, and weights of different size fractions recovered after sieving of each interval:
A1. Core 06MM01...92
A2. Core 06MM02...93
A3. Core 06MM03...94
A4. Core 06MM04...95
A5. Core 06MM05...96
A6. Core 06MM06...97
A7. Core 06MM07...97
A8. Core 06MM08...98
A9–A16. Analytical results for elements determined by ICP-MS and total carbon data on selected sample intervals:
A9. Core 06MM01...100
A10. Core 06MM02...101
A11. Core 06MM03...102
A12. Core 06MM04...103

A13. Core 06MM05 104
A14. Core 06MM06 105
A15. Core 06MM07 105
A16. Core 06MM08 106
A17. Sample localities and analytical results for elements determined by ICP-MS on 1979 NURE sediment samples collected in the Blue Creek and Sand Creek basins 107
A18. Geochemical data and statistical summary of analytical results from duplicate sediment samples from the Blue Creek delta 111
A19. Radionuclide data and statistical summary of analytical results from duplicate sediment samples from the Blue Creek delta 112
A20. Geochemical background statistical data and calculations, case I, including statistical description in graphic form for each element 113
A21. Geochemical background statistical data and calculations, case II, including statistical description in graphic form for each element 138

Appendix Figures

A1–A8. Photographs showing sampled intervals of:
A1. Core 06MM01 163
A2. Core 06MM02 164
A3. Core 06MM03 165
A4. Core 06MM04 166
A5. Core 06MM05 167
A6. Core 06MM06 167
A7. Core 06MM07 168
A8. Core 06MM08 168

Conversions, Abbreviations, and Acronyms

To convert	Multiply by	To obtain
short ton (2,000 lb)	0.9072	metric ton (t)
pound (lb)	0.454	kilogram (kg)
foot (ft)	0.3048	meter (m)
cubic foot per second (ft^3/s)	28.32	liter per second (L/s)
centimeter (cm)	0.39	inch (in.)
kilometer (km)	0.6214	mile (mi)

[Note that this report uses both inches/feet/miles and the metric system. For example, elevations of the lake and its varying level and elevations of sites are in feet. Mine production is in pounds and 2,000 pound tons. Core measurements are in centimeters; weighed samples are in grams. Distances, for example, the distance from Blue Creek delta to the Coeur d'Alene mining district, are in kilometers; short distances are in meters. The measurement system utilized is that which is appropriate or standard for the procedure or discussion ongoing.]

ppm	parts per million
ft^3/s, cfs	cubic foot per second
MUMNRTC	Midnite Uranium Mine Natural Resource Trustee Council
NURE	National Uranium Resource Evaluation
INAA	instrumental neutron activation analysis
ICP-MS	inductively coupled plasma–mass spectrometry

Determination of Premining Geochemical Background and Delineation of Extent of Sediment Contamination in Blue Creek Downstream from Midnite Mine, Stevens County, Washington

By Stanley E. Church, Frederick E. Kirschner, LaDonna M. Choate, Paul J. Lamothe, James R. Budahn, and Zoe Ann Brown

Abstract

Geochemical and radionuclide studies of sediment recovered from eight core sites in the Blue Creek flood plain and Blue Creek delta downstream in Lake Roosevelt provided a stratigraphic geochemical record of the contamination from uranium mining at the Midnite Mine. Sediment recovered from cores in a wetland immediately downstream from the mine site as well as from sediment catchments in Blue Creek and from cores in the delta in Blue Creek cove provided sufficient data to determine the premining geochemical background for the Midnite Mine tributary drainage. These data provide a geochemical background that includes material eroded from the Midnite Mine site prior to mine development. Premining geochemical background for the Blue Creek basin has also been determined using stream-sediment samples from parts of the Blue Creek, Oyachen Creek, and Sand Creek drainage basins not immediately impacted by mining. Sediment geochemistry showed that premining uranium concentrations in the Midnite Mine tributary immediately downstream of the mine site were strongly elevated relative to the crustal abundance of uranium (2.3 ppm). Cesium-137 (^{137}Cs) data and public records of production at the Midnite Mine site provided age control to document timelines in the sediment from the core immediately downstream from the mine site. Mining at the Midnite Mine site on the Spokane Indian Reservation between 1956 and 1981 resulted in production of more than 10 million pounds of U_3O_8. Contamination of the sediment by uranium during the mining period is documented from the Midnite Mine along a small tributary to the confluence of Blue Creek, in Blue Creek, and into the Blue Creek delta. During the period of active mining (1956–1981), enrichment of base metals in the sediment of Blue Creek delta was elevated by as much as 4 times the concentration of those same metals prior to mining. Cadmium concentrations were elevated by a factor of 10 and uranium by factors of 16 to 55 times premining geochemical background determined upstream of the mine site. Postmining metal concentrations in sediment are lower than during the mining period, but remain elevated relative to premining geochemical background. Furthermore, the sediment composition of surface sediment in the Blue Creek delta is contaminated. Base-metal contamination by arsenic, cadmium, lead, and zinc in sediment in the delta in Blue Creek cove is dominated by suspended sediment from the Coeur d'Alene mining district. Uranium contamination in surface sediment in the delta of Blue Creek cove extends at least 500 meters downstream from the mouth of Blue Creek as defined by the 1,290-ft elevation boundary between lands administered by the National Park Service and the Spokane Indian Tribe. Comparisons of the premining geochemical background to sediment sampled during the period the mine was in operation, and to the sediment data from the postmining period, are used to delineate the extent of contaminated sediment in Blue Creek cove along the thalweg of Blue Creek into Lake Roosevelt. The extent of contamination out into Lake Roosevelt by mining remains open.

Introduction

The Midnite Mine, an open-pit uranium mine located on the Spokane Indian Reservation in Stevens County, Wash. (fig. 1), was discovered in 1954 (Sheldon, 1959). It is located in the Blue Creek drainage on the Spokane Indian Reservation (fig. 2). According to Sheldon (1959), a geologist working for Newmont Mining Corp., the deposit is hosted by a roof pendant of Togo Formation rocks found along the ridge near the contact of the Loon Lake Granite (figs. 2 and 3). The Dawn Mining Co. was formed in 1955 as a joint venture between Midnite Mines, Inc., and Newmont Mining Corp., who owned 51 percent of the company (Barlow and others, 1958; Sheldon, 1959; Dalton, 1978). They conducted an extensive drilling program at the Midnite Mine site to delineate the ore body and define ore reserves prior to initiation of stripping (D.C. Peters, 1999, Site characterization of the Midnite uranium mine using drill logs, computer modeling of the geology, and historical aerial photographs, unpublished report #ST/BLM-2, 179 p.). Six ore bodies were identified. A contract to sell the processed uranium oxide, known as yellow cake, to the Atomic Energy Commission (AEC) was secured and a permit obtained to build a uranium processing mill at Ford, Wash. Stripping of the overburden at the Midnite Mine began in fall 1956. Mine waste and protore were stockpiled on site, and by June 1957, 164,000 short tons of ore had been shipped to the recently completed ion exchange uranium processing plant at Ford (Sheldon, 1959; Dalton, 1978). Annual production data for the Midnite Mine are not publicly available. The history of mine development has been reconstructed based upon a detailed analysis of historical aerial photographs (D.C. Peters, 1999, Interpretation of historical aerial photographs (IHAP) of the Midnite Mine, unpublished report #ST/BLM-1, 137 p.). The mine operated from 1956 to 1981 with a hiatus in production from 1965 to 1969. Dalton (1978) reported that production had exceeded 10 million pounds of yellow cake by 1978 with reserves of 980,000 short tons of 0.15 percent U_3O_8 ore. An additional 730,000 tons of protore at an average grade of 0.045 percent U_3O_8 had been stockpiled at the mine site. Approximately 300 acres have been disturbed by mining. Today, two open pits remain; both have pit lakes, and active water treatment is ongoing during part of the year. A water treatment plant began operating in 1991. Moore and others (1996) estimated that about 2.3 million tons of protore remain stored on the mine site. Detailed studies of drill core and mine data from Dawn Mining Co. (D.C. Peters, 1999, Site characterization of the Midnite uranium mine using drill logs, computer modeling of the geology, and historical aerial photographs, unpublished report #ST/BLM-2, 179 p.) outline the extent and grade of existing stockpiled protore. The mine site was listed by the U.S. Environmental Protection Agency (U.S EPA) on the National Priorities List (NPL) in 2000 (URL: http://www.epa.gov/superfund/sites/npl/nar1546.htm).

The mine is located in the Blue Creek drainage basin on the Spokane Indian Reservation (fig. 1). Blue Creek is a youthful, down-cutting stream, actively eroding a new channel along much of its length. Downstream of the Midnite Mine site, Blue Creek has been affected by releases of radioactive materials, metals, and sulfate (SO_4) in both water and sediment from the Midnite Mine site (Midnite Uranium Mine Natural Resource Trustee Council, 2004, Midnite Uranium Mine Natural Resource Damage Assessment, Assessment Plan Report I—Injury Determination, unpublished report, 78 p.). Blue Creek has long been used by the members of the Spokane Indian Tribe. The Blue Creek drainage provides terrestrial, riparian, wetland, and aquatic habitat that supports a fishery and provides important cultural resources for tribal members. The area of the mine site is also traversed by animals that are routinely hunted by the Tribe for subsistence.

Purpose and Scope

The current study was conducted to provide an evaluation of the extent of downstream impact of the Midnite Mine site on Blue Creek and Lake Roosevelt. The objectives of this study, initiated in April 2006, were:

- To determine the premining geochemical background, or the pre-release concentrations, of uranium and other metals in sediment associated with the Midnite Mine deposit
- To identify releases of metals in the historical record preserved in core sediment to determine the extent of those releases from mining and mine-waste management practices at the mine site through time
- To compare those metal releases with historical data to constrain the time frame of the releases from the Midnite Mine site
- To use data from both a 1975 U.S. Geological Survey (USGS) stream-sediment survey (Otton, 1976) and the 1979 National Uranium Resource Evaluation (NURE) stream-sediment studies in the area (Babcock and others, 1981) to test the validity of the historical record determined using the sediment core data
- To determine the transport efficiency of metals, including uranium, downstream in Blue Creek into the Blue Creek delta as a result of mining at the Midnite Mine, and
- To determine the changes in geochemical background in Blue Creek with respect to both time and distance downstream from the Midnite Mine site.

The term geochemical background, as used in this paper, shall be defined as the concentration of any metal present in sediment prior to mining activity at the Midnite Mine site. In the absence of detailed premining data from the study area, the premining geochemical background is best approximated by geochemical data from sediment collected from small basins that were undisturbed by mining and from sediment from cores as demonstrated in this study. The concentration of metals in sediment has increased through time during the mining period and will be referred to as the sediment geochemistry at any point in a stream at that time. For example, the postmining sediment geochemical data determined at any point immediately following the cessation of mining would be referred to in this study as the 1981-geochemical sediment data from Blue Creek at that site. This 1981-geochemical sediment data will change as a function of distance downstream from the mine site because the effect of mining would be diluted by sediment eroded from undisturbed tributary basins downstream of the mine site. Further, the 1981-geochemical sediment data will be different from the 2006-geochemical sediment data because the decreased activity at the mine site would result in less contamination of the tributaries draining the mine site and

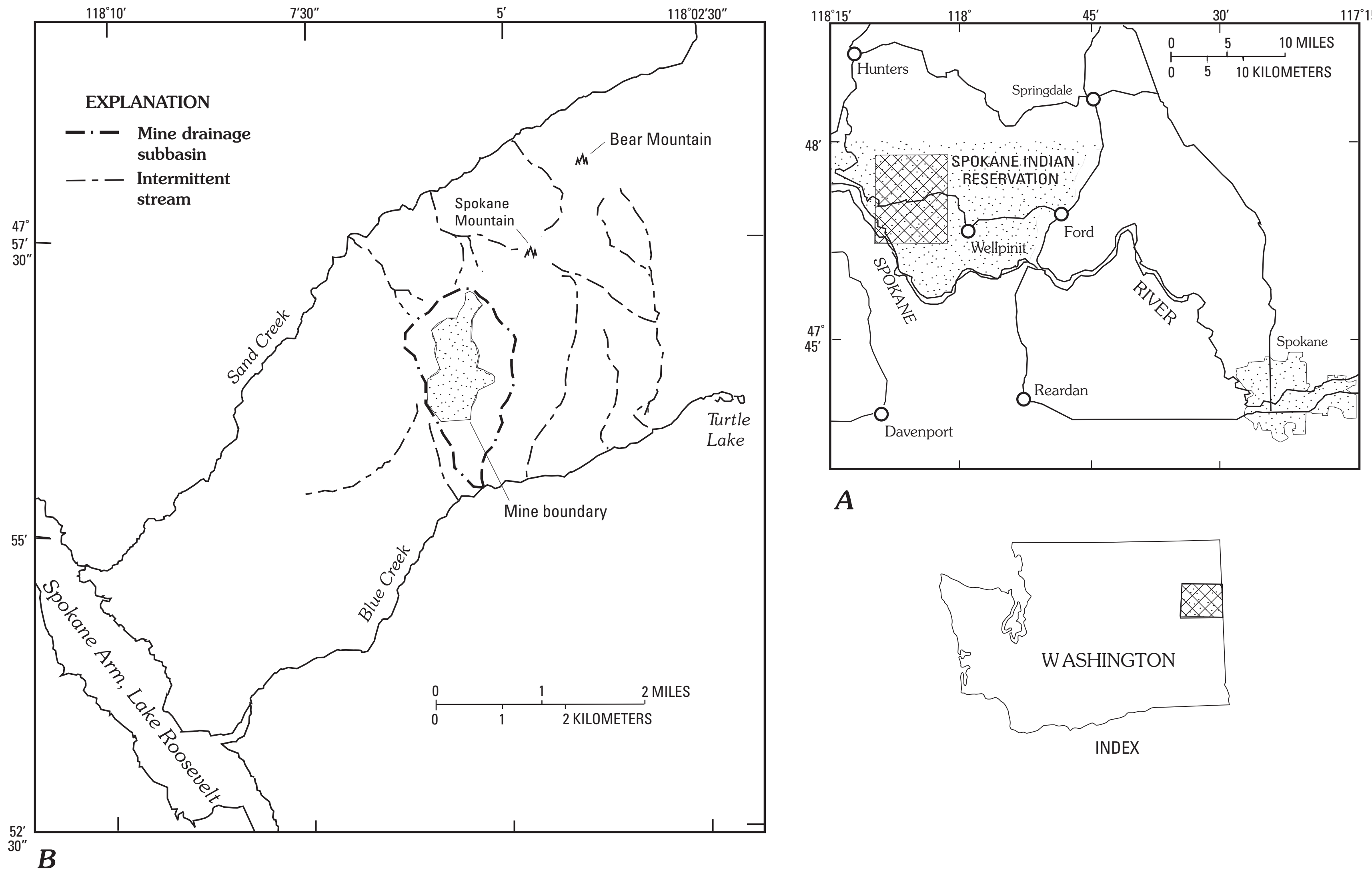
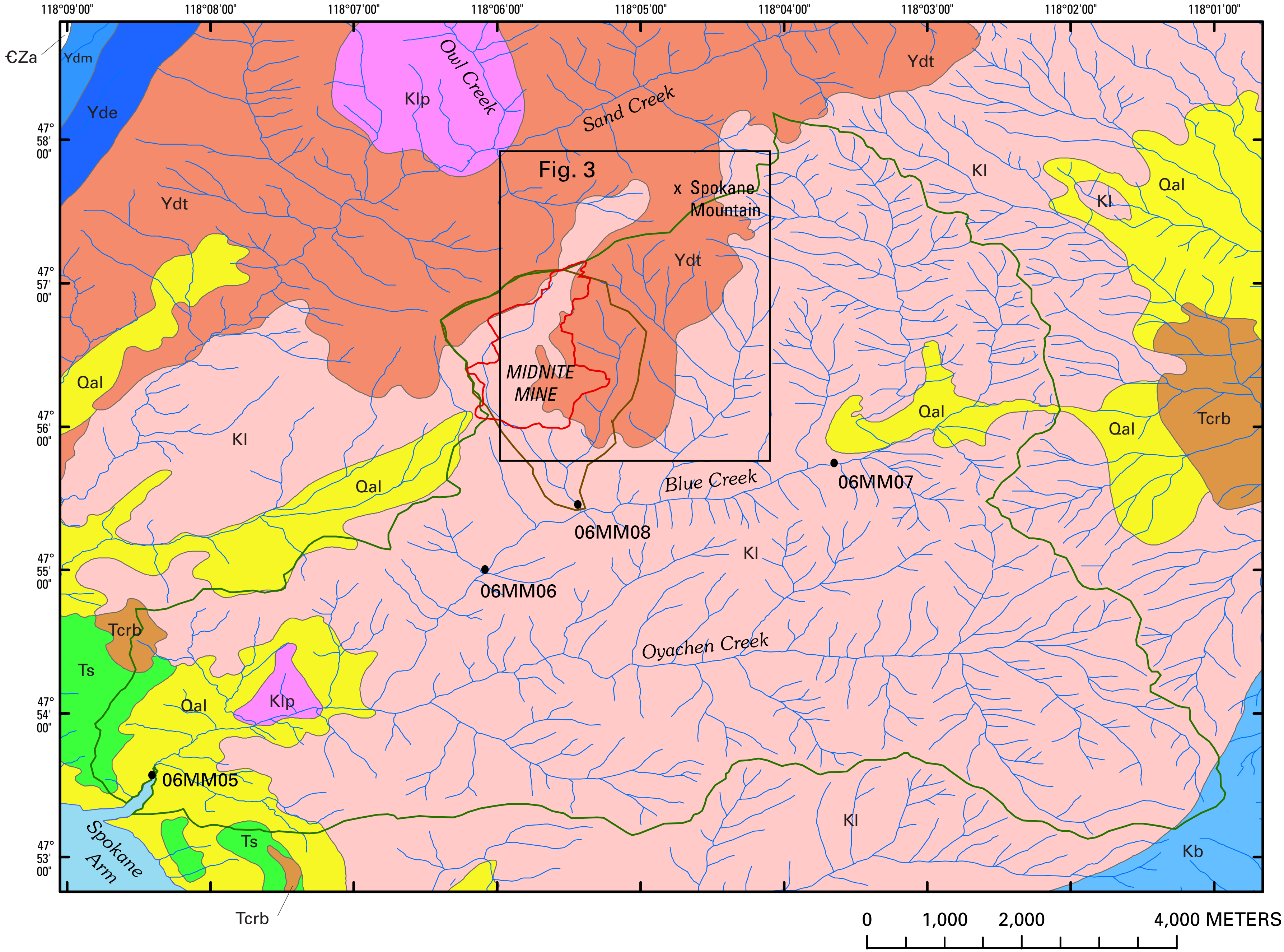


Figure 1. Location map of the Midnite Mine study area, eastern Washington. *A*, location in eastern Washington. *B*, Spokane Indian Reservation showing mine area.


118°09'00"
118°08'00"
118°07'00"
118°06'00"
118°05'00"
118°04'00"
118°03'00"
118°02'00"
118°01'00"
47° 58' 00"
47° 57' 00"
47° 56' 00"
47° 55' 00"
47° 54' 00"
47° 53' 00"
ЄZa
Ydm
Yde
Ydt
Klp
Owl Creek
Sand Creek
Fig. 3
x Spokane Mountain
Kl
Qal
MIDNITE MINE
Blue Creek
06MM07
06MM08
06MM06
Tcrb
Ts
Oyachen Creek
06MM05
Spokane Arm
Kb
0
1,000
2,000
4,000 METERS

EXPLANATION

Qal	Quaternary alluvium
Tcrb	Tertiary Columbia River Basalt
Ts	Eocene Sanpoil Volcanics
Kb	Cretaceous granodiorite of Benjamin Lake
Kl	Cretaceous Loon Lake Granite
Klp	Granite porphyry
	Cambrian and Neoproterozoic
ЄZa	Addy Quartzite
	Mesoproterozoic Deer Trail Group
Ydm	McHale Slate
Yde	Edna Dolomite
Ydt	Togo Formation

Figure 2 (pages 4 and 5). Geologic map of Midnite Mine study area (from Waggoner, 1990; Becraft and Weis, 1963). Green line, outline of Blue Creek basin; brown line, outline of Midnite Mine tributary drainage; red line, outline of area disturbed by mining at Midnite Mine site. Localities of cores 06MM05–06MM08 in the Blue Creek basin are also shown, as is the area of the detailed geologic map of the mine site (fig. 3).

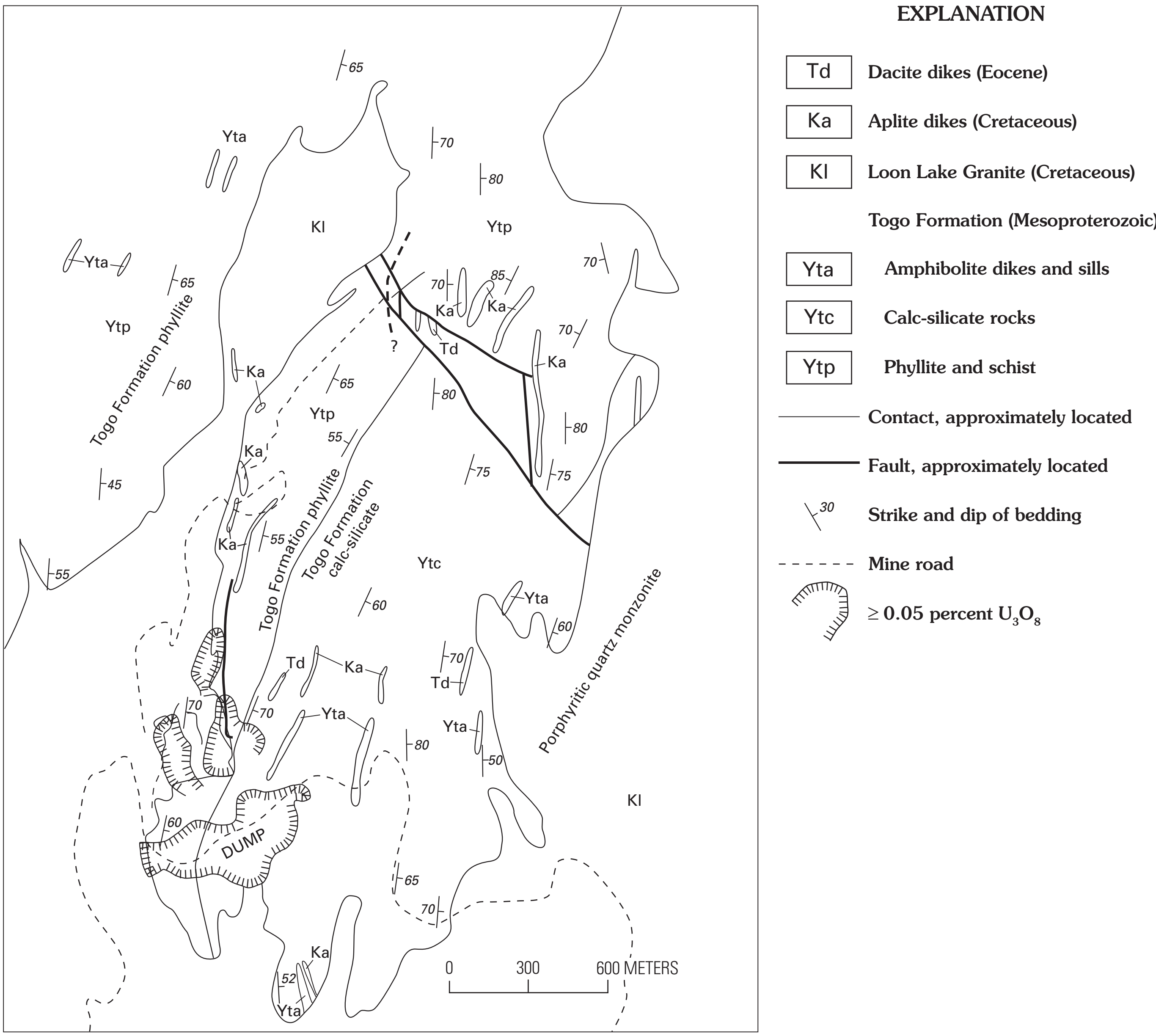


Figure 3. Geologic map of Midnite Mine site (Ludwig and others, 1981). Faults dashed and (or) queried where inferred.

therefore lower concentrations of metals contributed by the mine site to the sediment in Blue Creek in 2006. The different times-series sediment geochemistry data sets show that the sediment geochemistry of Blue Creek is not stationary with time, that is, the sediment geochemistry is constantly changing downstream following the cessation of mining.

A stream-sediment survey of sediment on the active surface of the delta in Blue Creek, conducted by the Midnite Uranium Mine Natural Resource Trustee Council (MUMNRTC) and AESE, Inc., in May 2005, showed elevated metal concentrations in the sediment in Blue Creek delta. Eight new sediment cores were taken in April 2006 in the Blue Creek drainage, five of them in the Blue Creek delta at the mouth of the stream where periodic deposition and subsequent erosion of sediment has occurred following the filling of the reservoir beginning in July 1942. These cores were used to reconstruct the history of change in sediment geochemistry of Blue Creek with time.

Acknowledgments

We thank the Midnite Uranium Mine Natural Resource Trustee Council (MUMNRTC) for funding this study, and for reviewing and approving the publication of these results. We thank the Spokane Indian Tribe for full access to the mine site and to the Blue Creek stream drainage downstream from the mine site for the purposes of sample collection (April 24–26, 2006). We thank Lam Chan for GPS work subsequent to our visit. The sampling team was accompanied by a member of the Spokane Tribe of Indians, Department of Natural Resources, to ensure that Native American artifacts were handled properly in the event that any such artifacts were encountered during sampling. We thank the following U.S. Geological Survey personnel for their assistance in this project: David G. Walters prepared the terrace core samples for geochemical analysis, Alan E. Koenig did the dendrochronology for core 06MM06T, Ruth E. Wolf prepared some of the quality-control data tables, Anne E. McCafferty provided the aero-radiometric uranium map, John Horton did the GIS work necessary to produce some of the figures, and Brenda Dutton did some of the graphics work on figures and photographs. The senior author thanks Robert A. Zielinski for discussions and insight into the nature of the radioisotope disequilibrium data from core 06MM08. We also thank Dennis R. Helsel for his review of the statistics used in the manuscript and James K. Otton and Raymond H. Johnson for their technical reviews of this manuscript.

Regional Setting

The study area is in a relatively dry climate east of the Cascade Mountains in the rain shadow. Average annual precipitation recorded at Wellpinit (fig. 1) was 47.3 cm (18.6 in.) during the period 1961 through 1980 (Williams and others, 1996). The mine site lies in the headwaters of three unnamed tributaries in the Blue Creek drainage, which flows southwest into the Spokane Arm of Lake Roosevelt 9.1 km (5.65 mi) downstream (fig. 1). The three small intermittent streams have been referred to as the East, Central, and West mine-site tributaries (fig. 4); in some published reports they are referred to as the Mine tributary. In this report, these streams will be referred to collectively as the Midnite Mine tributary.

A USGS stream gauge (location, fig. 6) on the Midnite Mine tributary has operated since 1984 (gauge # 12433556). Mean daily discharge from the Midnite Mine tributary does not exceed 1 ft^3/s (cubic foot per second or cfs; fig. 5) over most of the period of record. Peak discharge occurs when early spring rains fall on the snow pack, generally in the month of March (table 1). No data were recorded at this gauge for the period from October 1998 to January 2000. Unfortunately, the period of record at the gauge does not overlap with the interval of time that the mine operated, but the data provide important information on the frequency of large early-spring rain storms and the shape of the hydrograph for the last 20 plus years.

The Blue Creek basin is almost entirely underlain by the Loon Lake Granite (fig. 2; Weaver, 1920). Subsequently, Becraft and Weis (1957, 1963) subdivided the Loon Lake Granite into several informal igneous rock units. Of these, the Loon Lake monzonite is the most prominent in the study area, although other rock units have been mapped in the study area (fig. 2; Waggoner, 1990). Except near the mine site, sediment and surface water geochemistry of Blue Creek basin is dominated by the Loon Lake Granite. The mine site drains 6.4 percent of the Blue Creek drainage area; 49 percent of the mine site is underlain by rocks of the Togo Formation (figs. 2, 3). The total area of the Blue Creek basin underlain by rocks of the Togo Formation is only 7.2 percent.

Historical aerial photographs of the study area (Dean and others, 1996) and USGS topographic maps show that the topography at the mine site was gently dipping in the southern part of the mine site, but steeply dipping on the north. Elevations in the Midnite Mine tributary drainage range from 3,400 ft at the north highwall of Pit # 4 (fig. 4) to about 2,400 ft down slope from the mine-waste piles on the south side of the disturbed area (Moore and others, 1996). Interpretation of historical aerial photographs of the mine site prior to mining (D.C. Peters, 1999, Interpretation of historical aerial photographs (IHAP) of the Midnite Mine, unpublished report #ST/BLM-1, 137 p.) indicated no disturbance in the basin by logging or other mechanized activity prior to preparation of the drill pads in 1956.

Mine-Site Geology

The Midnite Mine is located in the Turtle Lake 1:24,000-scale quadrangle, Washington, which was being mapped at the time of discovery of the ore body (Becraft and Weis, 1957, 1963; Barlow and others, 1958). The ore body is located in a roof pendant consisting of calc-silicate rock and graphitic and pyritic phyllite of the Precambrian Togo Formation (Nash and Lehrman, 1975; Nash, 1977). The roof pendant rocks are a steeply dipping, overturned sequence of Precambrian rocks that strike north to northeast, forming the Midnite trend. The Spokane Mountain uranium deposit to the northeast in the Sand Creek drainage (Robbins, 1978) also lies along this trend. The roof pendant is surrounded by the Cretaceous Loon Lake Granite, a medium- to coarse-grained leucocratic granitic batholith. At the mine site, the Loon Lake Granite consists of a porphyritic quartz monzonite containing both aplitic and pegmatitic phases. Ludwig and others (1981) dated zircon separates from the Loon Lake Granite from the mine site at 75 Ma. Younger dikes of the Eocene Sanpoil Volcanics (fig. 2, fig. 3, Ts, Td) intrude the granite and the roof pendant at the mine site. Rocks of the Eocene Sanpoil Volcanics (Pearson and Obradovich, 1977) and their related feeder dikes are the youngest rocks in the vicinity of the mine site (Ludwig and others, 1981).

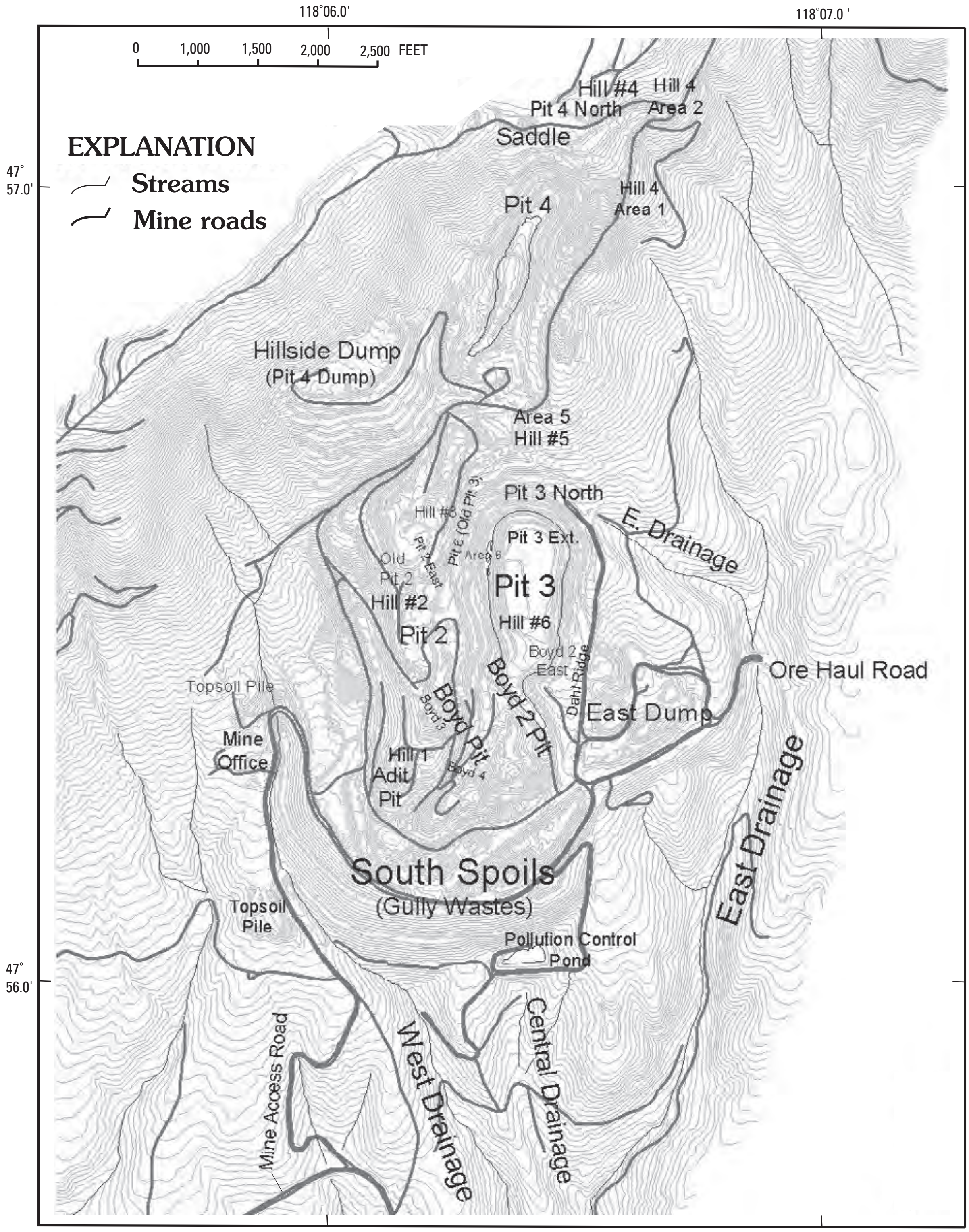


Figure 4. Map showing mine pits, waste dumps, roads, pollution control features, and surface drainages, Midnite Mine site (modified from D.C. Peters, 1999, Interpretation of historical aerial photographs (IHAP) of the Midnite Mine: Unpublished Report #ST/BLM-1, 137 p., published with permission). The west, central, and east drainages shown constitute the upper reaches of the Midnite Mine tributary of this report.

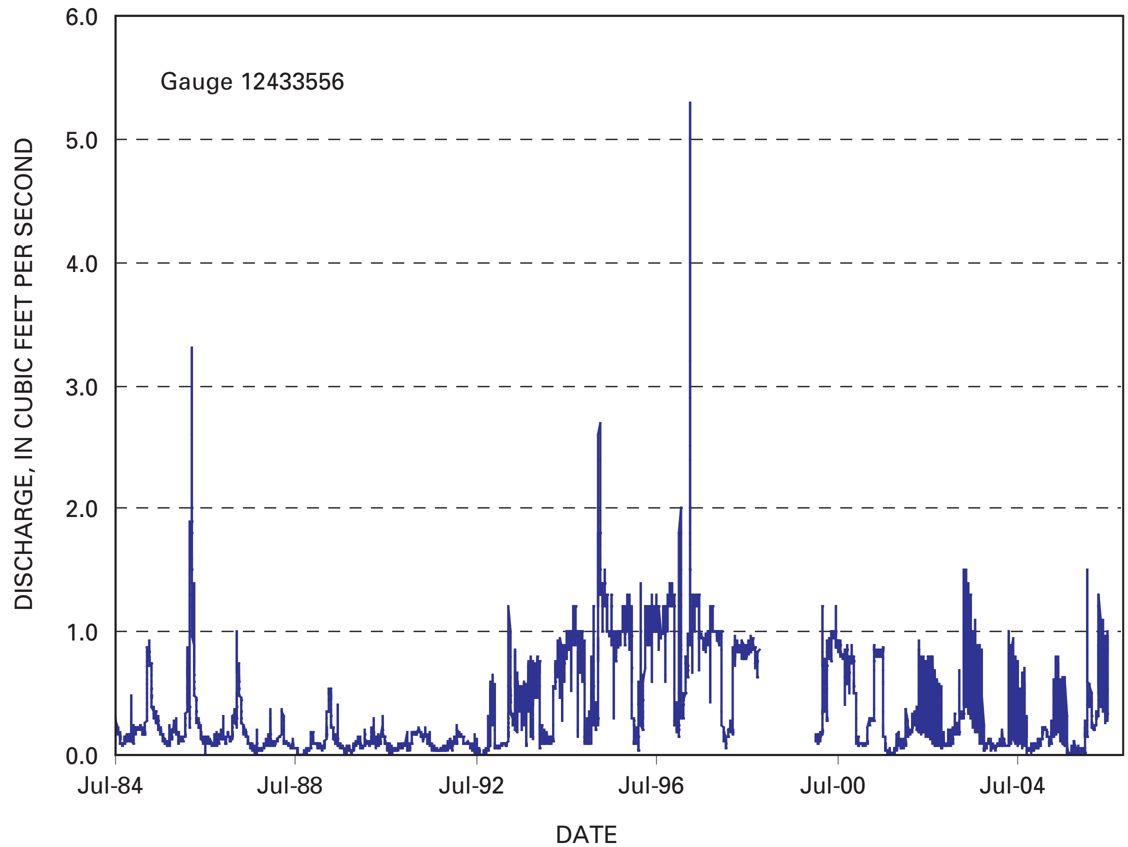


Figure 5. Mean daily discharge recorded at gauge # 12433556 on the Midnite Mine tributary. Maximum discharges (table 1) generally occur in the month of March. No data were recorded during the period from October 1998 through December 1999. Stream flow exceeded 1 cfs 5.2 percent, 2 cfs 0.26 percent, and 3 cfs 0.06 percent of the time during the monitored period. Data are available at URL http://waterdata.usgs.gov/nwis/inventory/?site_no=12433556&amp.

Geologic studies at the Midnite Mine showed that uranium ore occurred along the igneous contact and in faults and fractures within the roof pendant (fig. 3, Ytc, Ytp). Sheldon (1959) stated that the ore minerals above the water table at the site were secondary uranium phosphates and silicates:

meta-autunite	$Ca(UO_2)_2(PO_4)_2 \bullet 0–6\ H_2O$
uranophane	$(UO_2)_6(SO_4)(OH)_{10} \bullet 12\ H_2O$
and sooty uraninite	UO_2

whereas the primary uranium ore below the water table was pitchblende (amorphous UO_2). Metallic gangue minerals include as much as 2 percent pyrite (FeS_2); sphalerite (ZnS), chalcopyrite ($CuFeS_2$), and trace amounts of molybdenite (MoS_2; seen only in drill core) also occur in the ore. Barrington and Kerr (1961) identified the following primary ore minerals:

autunite	$Ca(UO_2)_2(PO_4)_2 \bullet 10–12\ H_2O$
meta-autunite	$Ca(UO_2)_2(PO_4)_2 \bullet 0–6\ H_2O$
coffinite	$U(SiO_4)_{1-x}(OH)_{4x}$
and uraninite	UO_2

Pitchblende (amorphous U_3O_8) was observed in drill core at depth. Secondary uranium minerals identified were:

meta-autunite	$Ca(UO_2)_2(PO_4)_2 \bullet 0–6\ H_2O$
uranophane	$(UO_2)_6(SO_4)(OH)_{10} \bullet 12\ H_2O$
zippeite	$K_4(UO_2)_6(SO_4)_3(OH)_{10} \bullet H_2O$
phosphuranylite	$Ca(UO_2)_4(PO_4)_2 \bullet 4\ H_2O$
autunite	$Ca(UO_2)_2(PO_4)_2 \bullet 10–12\ H_2O$
hebergite (liebigite?)	$Ca_2(UO_2)(CO_3)_3 \bullet 11\ H_2O$
torbernite	$Cu(UO_2)_2(PO_4)_2 \bullet 12\ H_2O$

and gummite, a mixture of various secondary uranium minerals.

Table 1. Dates and mean daily discharge of flood events recorded at gauge 12433556, Midnite Mine tributary, October 1983–May 2006.

[ft^3/s, cubic feet per second]

Date	Mean daily stream-flow (ft^3/s)
March 7, 1986	3.3
March 23, 1993	1.2
March 21, 1995	2.7
January 2, 1997	2.0
March 20, 1997	5.3
April 17, 2003	1.5
April 24, 2003	1.5
January 14, 2006	1.5
April 20, 2006	1.3

They reported that uraninite and marcasite in the ore body formed contemporaneously during ore deposition. Barrington and Kerr (1961, p. 253) stated: "***walls of microfractures or small cavities in the phyllite that contain these [uranium] minerals commonly have a thin veneer of marcasite," suggesting ore deposition in a low-temperature, slightly acidic environment. Ludwig and others (1981) reported that sphalerite was formed in the Midnite uranium deposit late in the mineralization process and was intergrown with pitchblende and coffinite in the ore, whereas earlier chalcopyrite grains were corroded. Early workers ascribed the formation of the deposit to the intrusion of the Loon Lake batholith (for example, Sheldon, 1959). Subsequent work at the Midnite Mine by Ludwig and others (1981) showed that the uranium mineralization formed during the emplacement of the Sanpoil Volcanics. A K-Ar age on hornblende from a dacite dike in one of the open pits gave an age of 51.8±3.1 Ma, and fission-track ages from zircon and apatite from the dike are in good agreement at 47.2±1.9 and 47.5±1.9 Ma, respectively. These ages are in good agreement with the K-Ar ages of the Sanpoil Volcanics determined by Pearson and Obradovich (1977). Uranium-lead ages from eight high-grade ore samples (that is, greater than 1 percent U) from the Midnite deposit defined a precise $^{207}Pb/^{204}Pb$–$^{235}U/^{204}Pb$ isochron age of 51.0±0.5 Ma (Ludwig and others, 1981). Thus the Midnite uranium deposit formed in the Eocene as a result of hydrothermal activity associated with the localized intrusion of the Sanpoil Volcanics.

Previous Work

Stream-Sediment Studies

In August 1975, Otton (1976) collected a series of stream-sediment samples covering the area of the Midnite Mine. Samples were collected from the Midnite Mine drainage east of the mine site and from Blue Creek downstream to Lake Roosevelt (fig. 6). The samples were sieved to minus-82-mesh (minus-175 µm (micrometers)) through silk cloth in the field. Samples were analyzed for Cu, Pb, Zn, Ni, Co, Fe, Mn, Mo, Cd, Cr, Ag, and V by Barringer Laboratories using a 2 N HCl extraction. Arsenic was determined using a potassium pyrosulfate fusion; uranium was determined using a hot 4 M HNO_3 extraction; and iron and manganese were determined from total digestion in HF and $HClO_4$. All metal concentrations were determined by atomic absorption analysis (AAS). Total organic carbon (C) was extracted with hot H_2SO_4, oxidized in the presence of iron and copper, and analyzed using a Leco Carbon Analyzer (Otton, 1976). Subsequent to this report, some samples were also analyzed for uranium and thorium using delayed neutron activation analysis (Millard and Keaten, 1982). These data provide a 1975 stream-sediment geochemical data set sampled during the mining phase at the Midnite Mine site (table 2).

In 1979, sediment was sampled in the area by the National Uranium Resource Evaluation (NURE) program (Babcock and others, 1981). Stream-sediment samples were sieved to minus-100-mesh. Analytical data (Smith, 1997) from the Ritzville 1:250,000-scale quadrangle provide a 1979 stream-sediment geochemical data set for tributary streams in the Blue Creek and Sand Creek drainage basins (fig. 6). Samples from this study were analyzed by the Savannah River Laboratory using instrumental neutron activation analysis (INAA) for the following elements: Al, Dy, Eu, Fe, Hf, La, Lu, Mn, Na, Sc, Sm, Th, Ti, V, Yb, and U. Only the uranium and thorium data from the NURE stream-sediment analyses have proven useful in this study (table 3). We emphasize here that the U/Th values determined in sediment samples from the NURE sediment study, excluding the samples collected from the Midnite Mine tributary, are very uniform. Excluding the two samples with values of U/Th greater than 1.0 (table 3), values for the median (0.322), geometric mean (0.336), and mean (0.365±0.155, n = 29) are comparable to the crustal abundance value of 0.284 (Fortescue, 1992). Given that most of the elements of interest for this study were not analyzed, samples collected during the NURE program from the Blue Creek and Sand Creek basins (Babcock and others, 1981) were retrieved from the U.S. Geological Survey archive (Smith and others, 2003) and reanalyzed during this study.

Data from Sediment from Lake Roosevelt

Lake Roosevelt was formed by damming of the Columbia River by the Grand Coulee Dam (constructed between 1934 and 1941). The reservoir has two arms formed by the flooding of the Columbia River valley (Columbia Arm) and the Spokane River valley (Spokane Arm). The reservoir is the site of accumulation of sediment containing trace elements from several large mining, milling, and smelting operations in the region. Contaminants enter the Columbia Arm of the reservoir from Canada where the large smelter at Trail, B.C., processed a variety of ores. Base metals were introduced largely from processing of ore from sediment-hosted base-metal deposits (Lydon, 2000), but also from other metallic and nonmetallic mineral deposits including, but not limited to, rare earths for industrial applications and phosphate for fertilizer. On the other hand, metals enter the Spokane Arm of the reservoir from the Coeur d'Alene mining district, a large base-metal district approximately 260 km upstream from the Blue Creek delta that was exploited primarily for its lead, zinc, and silver content (Fryklund, 1964; Long, 2001). Contamination of sediment in the Coeur d'Alene River, Lake Coeur d'Alene, and the Spokane River from mining activities in the Coeur d'Alene district is well documented (Horowitz and others, 1993, 1995; Grosbois and others, 2002). Cox and others (2004) studied the trace-element distribution in bed sediment and dated core intervals using ^{137}Cs from Lake Roosevelt from six localities collected in September 2002. Elevated concentrations of the trace elements As, Cd, Cu, Hg, Pb, and Zn were identified in the reservoir sediment. Core CSA-8 (Cox and others, 2004), collected from the Spokane Arm of Lake Roosevelt (fig. 1) about 7 km downstream from the confluence with Blue Creek, has a ^{137}Cs peak at 63–66 cm depth in the core, which is assigned a calendar date of 1963±2 years. No uranium anomalies were found in bed sediment in this core (table 4).

Water-Quality Data

Water-quality studies at the mine site summarized here were conducted in 1984 by Sumioka (1991) prior to the establishment of the water treatment facility on the site in 1988 (http://yosemite.epa.gov/r10/CLEANUP.NSF/738cdf3a6d72acce88256feb0074f9f4/25f296f579940d8b88256744000327a5/$FILE/ROD-Midnite06.pdf) and in 1995 by Ames and others (1996). No premining water-quality data are available. Both reports show that surface water quality is impaired by historical mining activity. Sumioka (1991) stated that the predominant ions in the surface water of Blue Creek upstream of the Midnite Mine tributary confluence were calcium and bicarbonate, whereas the predominant ions in Blue Creek downstream from the Midnite Mine site were calcium and sulfate. Upstream, dissolved concentrations of trace metals and radionuclides were low. Downstream from the Midnite Mine tributary confluence, concentrations of Al, Cd, Cu, Mn, Ni, Sr, Zn, U, and radionuclides in Blue Creek were elevated, some by as much as 500 times over that in the upstream sites. Values of pH in Blue Creek at the gauge site (fig. 6) ranged from 5.4 to 7.7, whereas surface water from Blue Creek upstream of the Midnite Mine tributary confluence was alkaline (pH 7.2 to 7.9). Water from Pit # 3 (fig. 4 and table 5) was acidic (pH 4.5 to 4.7) and from Pit # 4 was near neutral (pH 6.8 to 7.1). Water in the pollution control pond was acidic and very enriched in many mine-site constituents (table 5). Many of the trace metals had greater total recoverable concentrations (Sumioka, 1991) than dissolved concentrations, indicating that they were present as suspended particles. Water-quality data reported by Sumioka (1991) also showed the water in the pit lakes contained much greater concentrations of major and trace elements than water from surface drainages upstream from the Midnite Mine tributary confluence (table 5). Minimum concentrations reported in the data table occurred during periods when spring snowmelt diluted the ground water.

Ground-water studies at the mine site were conducted by Williams and others (1996). The conceptual ground-water model for the site is one in which moderately conductive alluvial and colluvial material overlies less conductive fractured bedrock. Several wells were drilled, and the chemistry, hydrologic head, and the change in water level monitored for a period of several years (generally from 1990 through 1995). Water quality during this period in wells in waste rock down gradient from the mine site showed increases in the concentration of sulfate from about 7,000 mg/L to 15,000 mg/L (milligrams per liter), zinc from 10 to 40 ppb, and uranium from 10 to more than 200 ppb (parts per billion or nanograms per gram). These data indicate that the geochemistry of the ground water was changing with time. The pH in wells in the mineralized zone also changed substantially, from about 6.0 to as low as 4.0 over this period. In contrast, wells in the unmineralized granitic rock at the mine site had near-neutral pH, contained much lower concentrations of zinc and uranium, and showed much smaller changes in water quality during the period of observation. Ground-water flow paths calculated from these data indicate multiple discharge points in the headwaters of the Midnite Mine tributary (Williams and others, 1996, figs. 17–19) during and subsequent to the period of operation of the mine (1974–1994).

Sampling and Preparation Methods

Stream-Sediment Samples, Blue Creek Delta

Surficial-sediment samples (fig. 7) were collected using plastic scoops from the upper 5 cm of surface sediment. Sediment samples from Blue Creek delta in 2005 were dried and then sieved to <63 µm (micrometers). The samples were analyzed for trace elements as specified in the Midnite Uranium Mine Natural Resource Trustee Council (MUMNRTC, 2002, Laboratory Services Contract for the Midnite Uranium Mine Natural Resource Trustee Council, 60 p.). Sample collection procedures differed from those used by EPA (1999, 2001, 2005) in that EPA used bulk sediment samples (that is, unsieved sedimentary material) in their studies.

Terrace- and Stream-Sediment Core Samples

Core samples of alluvium were taken at four terrace sites in Blue Creek delta (cores 06MM01–06MM04; fig. 7) and four sediment-accumulation sites in Blue Creek (cores 06MM05–06MM08; fig. 6). Core tubes (5 cm-diameter polyvinyl chloride, PVC) were capped and rinsed three times using

Table 2. Sediment geochemical data collected in study area, August 1975.

[Geochemical results from Otton (1976, table 1); concentrations in parts per million (ppm) or weight percent (wt. percent); R is duplicate sample; Ag was largely undetected and V showed no variation so it is not reported here; DD, decimal degrees; latitude north, longitude west; --, no data; * data by delayed neutron activation, H.T. Millard, analyst, USGS, 1976]

Sample No.	Sample type Comment	Latitude DD	Longitude DD	As ppm	Cd ppm	Co ppm	Cr ppm	Cu ppm	Mo ppm	Ni ppm	Pb ppm	Zn ppm	U ppm	U* ppm	Th* ppm	Mn ppm	Fe wt. percent	Total Carbon wt. percent
Midnite Mine tributary:																		
99101	Sand and silt	47.94696	118.08680	12	0.6	11	14	22	4	22	10	48	8.0	17.8	19.1	740	3.0	0.47
99102	Sand and silt	47.94442	118.08641	12	0.6	9	11	20	<2	13	11	59	12.0	18.4	12.2	640	2.9	0.22
99103A	Spring deposit	47.94298	118.08482	10	0.5	12	11	18	2	17	7	57	112	--	--	520	2.5	1.03
99103B	Sand and silt	47.94298	118.08482	8.0	0.6	15	12	18	4	23	8	72	34.0	107	41.7	740	2.3	0.96
99104	Sand and silt	47.93813	118.08512	6.0	0.6	10	14	15	<2	18	9	62	58.0	101	35.2	600	4.0	0.66
99105	Sand and silt	47.93056	118.08838	6.0	0.5	10	10	11	2	13	8	47	4.80	11.7	27.9	720	3.1	0.75
99105R	Sand and silt	47.93056	118.08838	6.0	0.6	9	10	12	<2	16	7	44	5.60	--	--	800	3.2	1.31
99106B	Sand and silt, upstream of tributary.	47.92781	118.09085	6.0	0.6	8	9	9	<2	14	9	45	10.8	18.6	40.0	720	2.8	0.95
99106A	Sand and silt, downstream of tributary.	47.92781	118.09085	50	3.9	60	15	120	2	130	20	470	760	--	--	2,300	4.4	0.23
99106C	Sand and silt from tributary	47.92781	118.09085	50	2.0	46	18	79	4	45	23	190	520	--	--	2,400	4.6	0.89
99106CR	Sand and silt from tributary	47.92781	118.09085	56	1.5	44	17	76	4	43	19	180	360	--	--	2,200	4.8	0.41
99107	Sand and silt	47.92472	118.08992	28	3.3	87	13	90	2	94	13	310	920	--	--	5,600	5.0	0.57
Blue Creek:																		
98101A	Sand and silt	47.92908	118.06072	3.0	0.3	6	7	10	2	8	9	45	19.4	--	--	360	2.4	1.17
98101AR	Sand and silt			4.0	0.3	6	4	10	<2	6	9	40	16.8	--	--	420	2.4	1.87
98102A	Sand and silt	47.92592	118.07009	2.0	0.2	2	4	5	<2	3	5	23	12.8	--	--	420	2.0	0.84
98102C	Organic-rich silt			4.0	0.3	3	3	7	2	4	6	26	8.0	--	--	400	2.6	1.19
98103	Coarse sand	47.92480	118.07979	3.0	0.1	3	5	5	4	3	8	21	20.0	--	--	840	5.1	1.66
98104	Sand and silt, downstream from Midnite Mine tributary.	47.92338	118.08941	<1	4.2	42	7	105	2	120	10	475	720	--	--	1,870	4.0	0.71
98105	Sand and silt	47.91620	118.10067	6.0	3.4	74	6	88	2	78	7	390	920	--	--	2,900	2.1	0.13
98106	Sand and silt	47.91033	118.10586	8.0	1.9	43	6	66	2	43	7	220	192	--	--	1,120	2.4	0.65
98107A	Sand and silt, upstream from confluence.	47.90111	118.11334	8.0	2.0	41	5	57	2	49	8	240	172	--	--	1,650	2.8	0.41
98107B	Organic-rich silt, downstream from confluence.	47.90111	118.11334	8.0	4.1	76	7	79	<2	91	8	410	880	--	--	5,700	4.4	0.13
98108	Sand and silt, Oyachen Creek.	47.90033	118.11215	4.0	0.4	6	15	7	2	8	8	36	7.4	--	--	840	14.8	1.04
98109	Sand and silt	47.90060	118.11437	6.0	3.1	55	6	58	<2	81	8	375	172	--	--	2,800	2.7	0.80
98109R	Sand and silt			3.0	3.0	55	7	55	<2	82	8	365	200	--	--	2,600	2.7	1.49
98110	Sand and silt	47.90075	118.11774	6.0	1.0	18	6	15	2	25	6	91	50.0	--	--	1,070	3.2	1.32
98111	Sand and silt, average of 2 samples.	47.89444	118.13831	7.0	3.0	47	8	44	2	67	8	365	158	--	--	1,515	3.6	0.42

Table 3. Selected geochemical data from NURE samples collected in the Blue Creek basin, July 1979.

[Geochemical data reported in parts per million (ppm) or in weight percent (wt. percent); Babcock and others (1981); DD, decimal degrees, latitude north, longitude west; --, no data]

Sample No.	Latitude (DD)	Longitude (DD)	Sample type	Th ppm	U ppm	U/Th	Mn ppm	Fe wt. percent
Blue Creek tributaries upstream of Midnite Mine tributary confluence:								
RZAH027S1	47.94310	118.04980	Sediment	46.0	15.8	0.34	473	1.8
DSOR128S1	47.92510	118.07980	Sediment	32.0	18.3	0.57	950	3.6
DSOR403S1	47.93740	118.03570	Sediment	48.0	29.6	0.62	1,340	4.0
DSOR404S1	47.93450	118.03470	Sediment	17.0	3.6	0.21	790	3.2
DSOR419S1	47.94410	118.04130	Sediment	16.0	4.6	0.29	720	3.3
DSOR420S1	47.95190	118.04050	Sediment	34.0	9.0	0.26	990	3.6
DSOR421S1	47.93610	118.05300	Sediment	22.0	9.7	0.44	760	3.4
DSOR422S1	47.93380	118.06270	Sediment	13.0	5.9	0.45	630	3.1
DSOR423S1	47.94560	118.06860	Sediment	25.0	12.1	0.48	920	3.4
DSOR424S1	47.95150	118.06920	Sediment	34.0	18.2	0.54	1,230	3.5
DSOR425S1	47.94870	118.06260	Sediment	12.0	3.6	0.30	630	3.2
DSOR426S1	47.94180	118.05730	Sediment	35.0	8.8	0.25	1,070	4.0
DSOR441S1	47.93240	118.07480	Sediment	29.0	22.7	0.78	1,250	3.0
DSOR442S1	47.93150	118.08070	Sediment	17.0	11.2	0.66	1,010	3.0
Blue Creek tributaries downstream of Midnite Mine tributary confluence:								
RZAH028S1	47.92490	118.08900	Sediment	52.0	41.7	0.80	--	3.2
RZAH037S1	47.90070	118.11940	Sediment	59.0	25.0	0.42	590	2.9
DSOR131S1	47.91600	118.10880	Sediment	13.0	21.2	1.63	800	3.6
DSOR133S1	47.91700	118.10040	Sediment	27.0	7.8	0.29	600	2.7
DSOR134S1	47.91070	118.10630	Sediment	36.0	11.6	0.32	720	3.5
DSOR135S1	47.90100	118.12340	Sediment	20.0	5.2	0.26	760	3.1
DSOR136S1	47.90040	118.11530	Sediment	165	59.6	0.36	1,690	8.1
DSOR340S1	47.89250	118.14360	Sediment	17.0	3.8	0.22	680	3.8
DSOR341S1	47.89830	118.13670	Sediment	22.0	4.3	0.20	790	3.8
Midnite Mine tributary:								
DSOR129S1	47.92980	118.09870	Sediment	58.0	43.6	0.75	840	3.6
DSOR137S1	47.92470	118.08960	Sediment	91.0	139	1.53	16,550	5.0
DSOR313S1	47.93570	118.10190	Sediment	36.0	208	5.78	1,310	4.7
DSOR314S1	47.94210	118.09950	Sediment	11.0	9.4	0.85	860	2.4
DSOR443S1	47.93950	118.08320	Sediment	10.0	4.2	0.42	570	2.6
DSOR460S1	47.93180	118.09490	Sediment	30.0	102	3.4	1,110	3.1
Oyachen Creek tributaries:								
DSOR100S1	47.92360	118.04220	Sediment	16.0	3.2	0.20	750	3.0
DSOR101S1	47.92160	118.05460	Soil	22.0	4.1	0.19	940	3.0
DSOR102S1	47.91560	118.05410	Sediment	24.0	30.4	1.27	640	3.2
DSOR118S1	47.91400	118.07400	Sediment	13.0	5.3	0.41	410	3.1
DSOR119S1	47.91450	118.08360	Sediment	16.0	6.0	0.38	820	2.6
DSOR120S1	47.90440	118.08300	Sediment	35.0	15.2	0.43	500	3.4
DSOR121S1	47.89890	118.09450	Sediment	23.0	5.0	0.22	940	2.8
DSOR126S1	47.88900	118.10150	Soil	11.0	3.2	0.29	780	2.7
DSOR127S1	47.88980	118.10750	Sediment	22.0	4.1	0.19	1,270	2.7
Sand Creek tributaries:								
DSOR315S1	47.94070	118.11190	Sediment	14.0	5.2	0.37	570	3.0
DSOR376S1	47.99510	118.05580	Sediment	14.0	4.3	0.31	590	3.4
DSOR378S1	47.96490	118.12680	Sediment	14.0	4.2	0.30	640	3.4
DSOR379S1	47.97090	118.12740	Sediment	0.0	< 1	--	< 20	0.0
DSOR387S1	47.96500	118.11690	Sediment	10.0	4.1	0.41	690	5.0
DSOR388S1	47.97140	118.10750	Sediment	< 3	4.0	--	420	0.3
DSOR389S1	47.98200	118.10730	Sediment	19.0	6.3	0.33	700	5.7
DSOR395S1	47.95350	118.12600	Sediment	13.0	3.6	0.28	390	3.8
DSOR398S1	47.97020	118.09850	Sediment	8.0	3.9	0.49	2,520	5.1
DSOR399S1	47.97780	118.10210	Sediment	12.0	3.1	0.26	950	2.7
DSOR400S1	47.96070	118.09850	Sediment	10.0	3.8	0.38	720	3.7
DSOR414S1	47.98120	118.04210	Sediment	23.0	34.8	1.51	1,130	3.1
DSOR415S1	47.98650	118.03880	Sediment	19.0	5.1	0.27	1,040	3.7
DSOR416S1	47.99130	118.04320	Sediment	24.0	17.0	0.71	680	3.0
DSOR417S1	47.99860	118.04330	Sediment	11.0	6.0	0.55	640	2.7
DSOR418S1	47.99860	118.03500	Sediment	10.0	3.0	0.30	780	2.7
DSOR438S1	47.95390	118.08040	Sediment	12.0	4.9	0.41	850	3.8
DSOR439S1	47.95830	118.07870	Sediment	13.0	4.2	0.32	450	3.1
DSOR440S1	47.96030	118.08270	Sediment	12.0	12.0	1.00	620	3.4
DSOR445S1	47.98400	118.05540	Sediment	22.0	3.9	0.18	600	3.7
DSOR446S1	47.97940	118.05700	Sediment	12.0	2.6	0.22	800	3.8
DSOR447S1	47.97440	118.06340	Sediment	6.0	8.5	1.42	620	3.2
DSOR448S1	47.96790	118.07090	Sediment	12.0	5.4	0.45	900	5.4
DSOR449S1	47.96440	118.06300	Sediment	32.0	8.2	0.26	1,400	3.0
DSOR450S1	47.98130	118.06960	Sediment	18.0	3.1	0.17	1,250	5.3
DSOR451S1	47.98600	118.07210	Sediment	9.0	5.1	0.57	580	4.1
DSOR452S1	47.99060	118.07960	Sediment	11.0	2.6	0.24	1,410	6.4
DSOR455S1	47.97710	118.08290	Sediment	16.0	3.6	0.23	540	3.2
DSOR456S1	47.97060	118.08940	Sediment	14.0	4.0	0.29	470	3.6
DSOR457S1	47.95280	118.10830	Sediment	14.0	4.9	0.35	120	2.9
DSOR458S1	47.95190	118.10030	Sediment	16.0	10.1	0.63	780	3.0
RZAH021S1	47.96520	118.12430	Sediment	15.0	4.1	0.27	741	4.1
RZAH024S1	47.98480	118.04200	Sediment	21.0	13.5	0.64	826	2.8

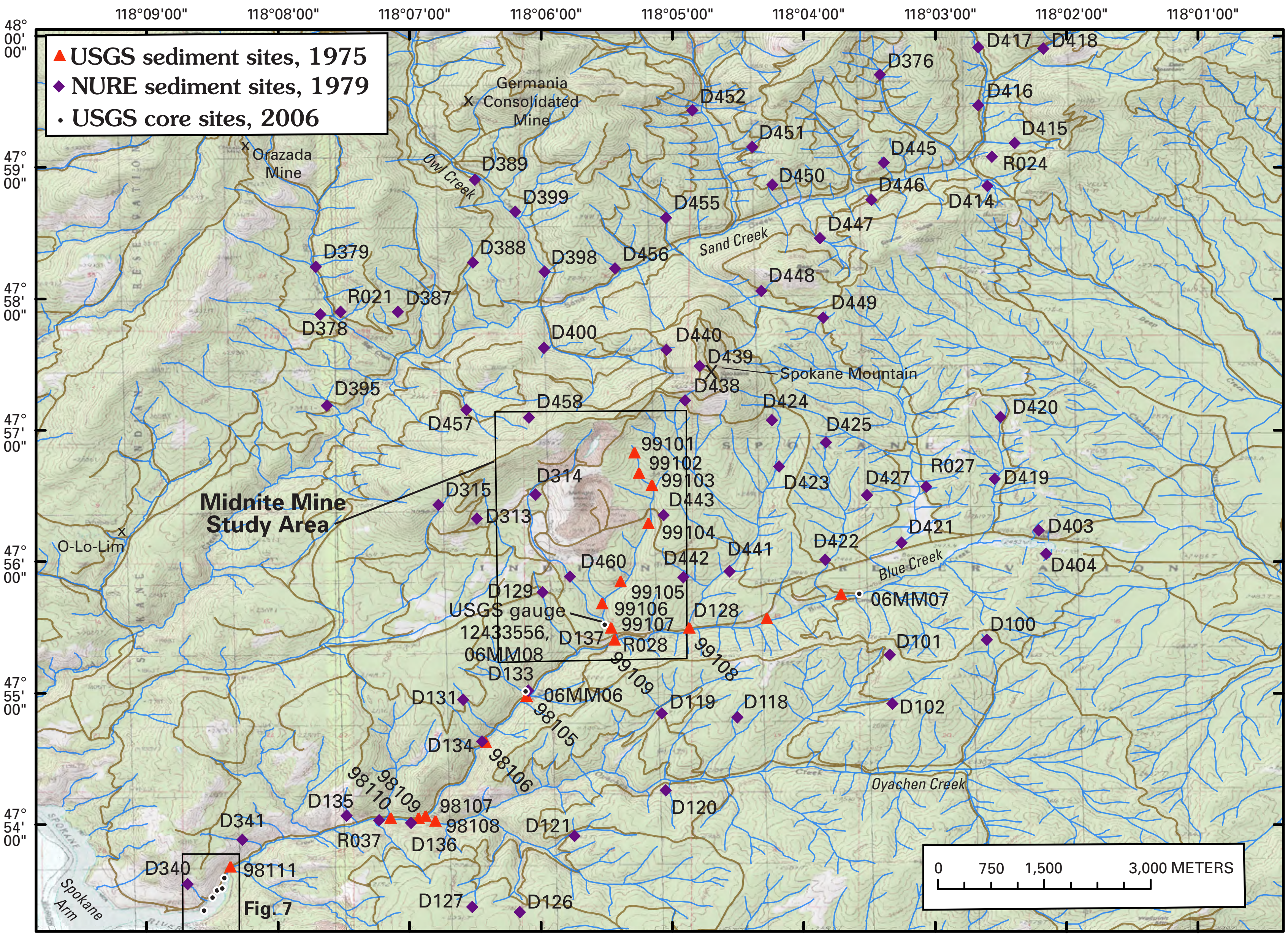


Figure 6. Sample locality map showing sites where sediment was collected for the 1975 USGS (U.S. Geological Survey) sediment survey (Otton, 1976), the 1979 NURE (National Uranium Resources Evaluation) sediment survey, and cores 06MM05–06MM08, this study. NURE site labels have been abbreviated to reduce clutter on the map. For example, site RZAH027S1 in table 3 is shown as sample site R027. Turtle Lake, near site D403 on the east portion of Blue Creek, is used as a reference point for downstream geochemical plots of the data. USGS gauge (# 12433556) is shown at the confluence of the Midnite Mine tributary on Blue Creek. Brown line, road.

Table 4. Geochemical data from sediment core CSA-8 (Cox and others, 2004) from the Spokane Arm of Lake Roosevelt, Wash.

[Data from Cox and others (2004); concentrations in parts per million (ppm) or in weight percent (wt. percent); 1963 ^{137}Cs date assigned to shaded interval in core]

Depth (cm)	As ppm	Cd ppm	Co ppm	Cr ppm	Cu ppm	Mo ppm	Ni ppm	Pb ppm	Th ppm	U ppm	U/Th	Zn ppm	Mn ppm	Fe ppm	Organic Carbon wt. percent
0-3	20	7	17	64	44	0.75	28	140	14	6.4	0.46	1,200	1,600	50,000	2.4
3-6	18	5.7	15	55	40	0.65	25	88	13	5.7	0.44	950	930	43,000	1.9
6-9	20	7.8	16	63	48	0.80	30	140	13	6.0	0.46	1,200	1,200	50,000	2.4
9-12	24	10	16	64	53	1.2	29	130	12	6.4	0.53	1,600	940	45,000	2.4
15-18	20	14	16	58	46	0.86	26	110	12	5.6	0.47	1,500	860	42,000	1.9
21-24	19	13	13	49	34	0.65	21	92	11	4.4	0.40	1,200	750	37,000	1.6
27-30	17	21	14	51	38	0.66	23	110	11	4.1	0.37	1,600	840	39,000	1.8
33-36	13	18	14	51	34	0.56	22	100	12	4.0	0.33	1,400	790	38,000	1.7
39-42	11	8.0	12	42	29	0.55	18	72	11	3.6	0.33	930	670	34,000	1.3
45-48	13	8.0	12	46	31	0.61	19	74	12	3.5	0.29	960	680	35,000	1.4
51-54	12	7.6	12	35	31	0.71	19	69	12	3.4	0.28	890	640	35,000	1.5
57-60	13	14	13	48	36	0.55	21	86	11	3.6	0.33	1,300	720	36,000	1.7
63-66	34	14	18	60	51	0.86	28	140	13	4.8	0.37	1,500	980	46,000	2.2
69-72	20	7.0	13	50	38	0.65	20	210	12	3.3	0.28	980	680	37,000	1.2
75-78	16	18	14	51	36	0.64	22	100	12	4.1	0.34	1,400	820	38,000	1.6
78-81	10	9.5	13	54	31	0.79	21	87	11	3.2	0.29	1,100	730	36,000	1.5
81-84	12	8.8	12	48	32	0.65	20	79	12	3.6	0.30	1,000	690	36,000	1.5
86-90	13	10	13	49	36	0.82	22	83	11	3.3	0.30	1,100	730	38,000	1.7

deionized water to remove any dust adhered to the inner walls of the tubing during transport. This procedure was used to prevent contamination of the core tubes during transit to the core site. Cores were taken using a sledge hammer to drive PVC pipe into the sediment to resistate. The core tubes were then extracted, sealed using chain-of-custody protocol, and shipped to the USGS laboratory in Denver, Colo., for processing (see Appendix B for further details). Core locations, elevations, length, recovery, compression, and brief sample-site descriptions are in table 6.

Core samples were taken from Blue Creek delta (06MM01–06MM04; fig. 7) when Lake Roosevelt was drawn down below the maximum pool (elevation was 1,234.9 ft, April 24, 2006). Sediment-sampling sites in the Blue Creek cove were exposed allowing the field crew to sample. Sediment consisted largely of poorly sorted gravel, which is rock fragments ranging in size from several centimeters in diameter (pebbles) down to coarse sand and silt. The base of the cored section exposed in the cove consists of coarse gravel containing large, poorly consolidated, moderately rounded boulders that existed prior to the filling of the reservoir and may be a part of the sequence mapped by Becraft and Weis (1963) as glacial deposits.

In the laboratory, the PVC pipe was scored with a tungsten-carbide blade, the cores split and the sediment exposed, photographed, and subsampled on the basis of stratigraphy. The core intervals were air dried and then sieved using new Tyler sieves at 10, 35, 60, 140, and 230 mesh, producing six different size fractions for each core interval (+2 mm, –2 mm to +500 µm, –500 µm to +250 µm, –250 µm to +100 µm, –100 µm to +63 µm, and <63 µm size fractions). Core intervals, sample descriptions, Munsell color values, and weights of the total sample and each sieved interval are given in Appendix A, tables A1–A8. No Native American artifacts were observed in any of the core intervals. Photographs of the cores showing the intervals sampled are in figures A1–A8 in Appendix A.

A tree core was sampled at site 06MM06 from a Douglas-fir using a standard tree corer. The sample was collected at a height of 3 ft to determine the age of the terrace surface. The tree core was removed and transferred into a large straw and the bark retained, so that the outer growth rings could be clearly identified. The sample was placed in a plastic tube, sealed using chain-of-custody protocol, and shipped to Denver, Colo., for dendrochronological age determination.

Description of Terrace Core Sampling Sites

Unlike samples taken from a natural lake where the water level is usually relatively constant, samples taken from a reservoir or from sediment catchments in surface streams and rivers generally will not contain a continuous or a complete record of sedimentation that occurred in the drainage basin. When sites in the reservoir are exposed, erosion and wave action may remove part of the record. In times of rapid precipitation, sites that are inundated could receive coarse sandy sediment. Thus, the geochemical data recorded at the sites must be interpreted on the basis of fluvial geomorphological processes, the record of precipitation in the basin, historical human activity, and geochemical principles.

Core 06MM01 is the first core downstream from the mouth of Blue Creek in Blue Creek cove. The site is located on a shallow terrace that causes a bend in the stream course (fig. 7). The collar elevation of the core site is at 1,275 ft. Examination of this feature in the field showed that this terrace deposit had buried an old beaver pond (fig. 8). The bend on the stream course is caused by the presence of the beaver dam exposed on the north bank of the stream. After probing the site to determine the extent of the buried beaver dam, we cored the terrace behind the buried beaver dam, penetrating the fine-grained beaver-pond sediment at a depth of 69 cm (see table A1 and fig. A1). Sediment in the lower part of the core is much less organic-rich and is interpreted to be pre-beaver dam sediment deposited by Blue Creek (below a depth of 105 cm). Total length of the core recovered was 127 cm; no depth corrections were applied for compression. Examination of the earliest aerial photographs (1936) of Blue Creek cove shows no evidence of this beaver pond. Lake Roosevelt was completely filled by 1942 and would have flooded the beaver pond, driving the beaver to a new location.

Cores 06MM03, 06MM04, and 06MM02 are samples collected from the exposed Blue Creek delta farther out into the reservoir (figs. 7, 9). Thus, cores 06MM02 and 06MM04 represent sediment deposition in a deeper water environment when the reservoir is filled to capacity. All three cores were driven to gravel beds that are present in the base of the sedimentary section (fig. 9). Core locality 06MM03 is farthest out into the delta and is located farthest from the thalweg (channel) of Blue Creek (see the core description, table A3). The collar elevation of the core site is 1,258.4 ft. Core 06MM03 recovered 148 cm of coarse to fine sand (table A3 and fig. A3). Core 06MM04 was driven into a younger (lower) terrace (fig. 9) that has been built following earlier down-cutting and erosion in the thalweg. This site was located in the thalweg at a collar elevation of 1,252.5 ft. The difference in elevation between core sites 06MM03 and 06MM04 is shown in figure 9*B*. Core 06MM04 recovered 129 cm of coarse to fine sand (table A4 and fig. A4). Core 06MM02 was collared at an elevation of 1,269.4 ft. Core 06MM02 recovered 211 cm of coarse to fine sand (table A2 and fig. A2). No corrections were made to any of these three cores for compression (table 6).

Core 06MM05 was taken at the mouth of Blue Creek in the stream (fig. 10), about 150 m upstream from core site 06MM01 (figs. 2, 7). The collar elevation of this core is 1,291.4 ft, which is just above the high water elevation of Lake Roosevelt (1,290 ft). Core 06MM05 recovered 61 cm of coarse to fine granitic sand (table A5 and fig. A5). No corrections were made for compression (table 6).

Core 06MM06 was taken on a small terrace on Blue Creek (fig. 11) downstream from the confluence with the Midnite Mine tributary (fig. 6). The terrace is an erosional

Table 5. Summary of dissolved constituents in surface water collected at the Midnite Mine site, 1984.

[Results in milligrams per liter (mg/L) for the major constituents (Ca, Mg, Na, K, SO_4, P) and in micrograms per liter (µg/L) for the trace constituents (Al, Cd, Cu, Fe, Mn, Ni, Zn, U); specific conductance in microsiemens per centimeter (µS/cm) at 25 ºC; pH in standard units at 25ºC; ^{222}Rn and ^{226}Ra in picocuries per liter (pCi/L); data are from Sumioka (1991). $^{238}U^*$ activities *calculated (in italics)* from measured U concentrations (0.33 pCi/µg $^{238}U^*$); --, no data. Total recoverable concentrations for metals Fe, Mn, Ni, Zn, Cd, Cu were higher, indicating metals were present as colloids]

Constituent	**Surface water from Blue Creek upstream of Midnite Mine tributary confluence Range of values**	**Surface water from Midnite Mine tributary (at gauge # 12433556) Range of values**	**Blue Creek downstream of Midnite Mine tributary confluence Range of values**	**Pit # 3 (from tables 8 - 9; Sumioka, 1991) Range of values**	**Pit # 4 (from tables 4 - 5; Sumioka, 1991) Range of values**	**Pollution Control Pond (from tables 11 - 12; Sumioka, 1991) Range of values**
Specific conductance	100 - 136	2,030 - 2,730	475 - 1,390	2,200 - 3,150	933 - 1,600	7,130 - 9,630
pH	7.2 - 7.9	5.4 - 7.7	6.9 - 7.8	4.5 - 4.7	6.8 - 7.6	3.6 - 3.8
Ca	12 - 18	260 - 380	50 - 180	240 - 370	130 - 260	440 - 590
Mg	2.7 - 2.9	140 - 180	23 - 80	110 - 170	28 - 49	810 - 1,100
Na	5.8 - 6.7	34 - 48	9.8 - 25	59 - 160	23 - 41	37 - 72
K	1.9 - 5.5	5.7 - 7.8	2.4 - 4.8	2.6 - 3.3	2.4 -4.0	4.0 - 4.9
SO_4	4.6 - 11	1,300 - 1,900	190 - 770	1,500 - 2,200	430 - 780	8,000 - 12,000
P	0.05 - 0.15	0.01 - 0.18	< 0.01 - 0.17	< 0.01 - 0.1	< 0.01	0.01
Al	<100 - 800	<100 - 1,500	<100 - 500	20,000 - 41,000	< 100	490,000 - 710.000
Cd	< 1	10 - 20	<1 - 9	22 - 60	< 1 - 1	< 1 - 500
Cu	<1 - 3	3 - 51	1 - 9	150 - 300	< 1 - 1	2 - 3,500
Fe	29 - 400	20 - 100	8 - 220	100 - 180	< 3 - 55	3,200 - 4,800
Mn	4 - 87	35,000 - 42,000	4,600 - 18,000	61,000 - 85,000	1,200 - 3,300	500,000 - 640,000
Ni	<1 - 4	170 - 690	70 - 240	860 - 1,100	38 - 85	56 - 11,000
Zn	4 - 28	510 - 1,100	82 - 300	1,800 - 3,100	16 - 55	26,000 - 34,000
U	2.0 - 4.2	300 - 1,200	140 - 400	3,700 - 16,000	1,700 - 10,000	160,000 - 180,000
$^{238}U^*$	*0.66 - 1.39*	*99 - 400*	*46 - 130*	*1,220 - 5,280*	*560 - 3,300*	*53,000 - 50,000*
^{222}Rn	4 - 105	38 - 149	28 - 111	1,240	--	--
^{226}Ra	< 0.1 - 0.2	1.5 - 3.6	< 0.6 - 1.4	20 - 47	1.0 - 8.3	48 - 63

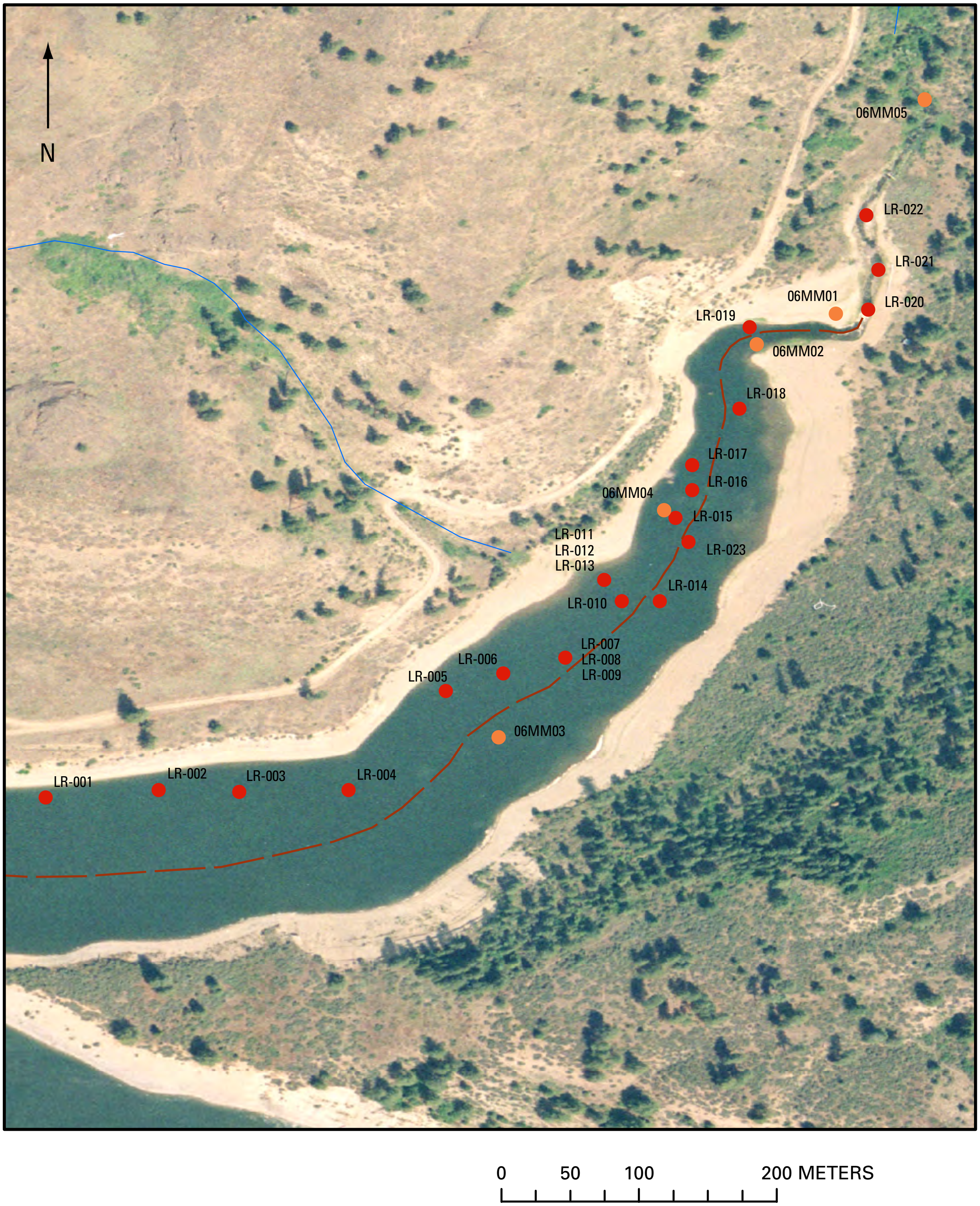


Figure 7. Aerial photograph of Blue Creek cove showing sample localities of the AESE, Inc., 2005 sediment samples (LR series) and the 2006 USGS cores (06MM series) collected at low water from Blue Creek delta. Flooded channel (thalweg) of Blue Creek in the delta is shown by dashed red line for reference. The 1,290-ft contour, which is the boundary between lands administered by the National Park Service and the Spokane Indian Reservation, is closely approximated by the vegetation–high-waterline boundary.

Table 6. Sample localities and site descriptions of USGS 2006 cores, Midnite Mine study area.

[Samples collected by S.E. Church and F.E. Kirschner, AESE, Inc., April 24 and 25, 2006, under chain-of-custody protocol; see text and Appendix B for sample collection methods. DD, decimal degrees, latitude north, longitude west. Core lengths, compression, and recovery measured in centimeters (cm)]

Core No.	Latitude DD	Longitude DD	Elevation of core site (ft)	Site description	Length of core (cm)	Compression (cm)	Recovery (cm)
06MM01	47.891992	118.139122	1,275.0	First core in Blue Creek cove delta downstream from mouth, core is in sediment 5 m upstream from potential buried beaver pond dam of unknown age.	169	43	126
06MM02	47.891793	118.139647	1,269.4	Core in Blue Creek cove delta about 50 m downstream from core 06MM01	282	66	216
06MM03	47.889252	118.141324	1,258.4	Core in Blue Creek cove delta, downstream from small southwest-flowing tributary, about 300 m downstream from 06MM01.	173	25	147
06MM04	47.890712	118.140232	1,252.5	Core in Blue Creek cove delta, new terrace, about 200 m downstream from core 06MM01, upstream from small southwest-flowing dry tributary.	163	30	132
06MM05	47.893390	118.138559	1,291.4	Core in Blue Creek 25 m upstream from mouth at low flow	79	15	64
06MM06	47.916623	118.100512	1,897.3	Old terrace on Blue Creek; Douglas-fir cored for dendrochronology to provide age control	74	22	52
06MM07	47.929489	118.058336	2,317.3	Core in coarse monzonite sandy gravel in upper Blue Creek upstream of confluence with tributary draining mine site and upstream of uppermost water crossing. Sediment easily fluidized in hyporheic zone, low recovery.	44	22	23
06MM08	47.925656	118.090631	2,138.9	Core from tributary draining mine site, about 50 m upstream from USGS gauge # 12433556, lots of organic material in core.	152	48	104

remnant of a large alluvial fan from a tributary drainage on the north side of Blue Creek. The toe of the alluvial fan has been eroded by recent down-cutting by Blue Creek. The sediment core was taken through the dissected alluvial fan material on the upstream side of the fan and penetrated sediment deposited by Blue Creek at depth. The material in the terrace is poorly consolidated fine-grained silt and sand (table A6 and fig. A6). Dendrochronology from a large Douglas-fir on the fan in Blue Creek gave an initial date of 1909, indicating that the eroded alluvial fan terrace surface predated mining activity at the Midnite Mine. No corrections were made for compression (table 6).

Core 06MM07 was taken on Blue Creek upstream of the Midnite Mine confluence to provide geochemical background data upstream of the Midnite Mine site (figs. 6, 12). The core penetrated 44 cm of coarse to medium granitic sand (table A7 and fig. A7). Even though a core catcher was used, only 22 cm of material was recovered because of the large amount of water moving through the sand in the hyporheic zone. No depth corrections were made for compression. The base of the core was the granitic sand derived from the Loon Lake Granite (Becraft and Weis, 1963).

Core 06MM08 was collected on the lower stem of the Midnite Mine tributary about 50 m upstream from the USGS gauge (# 12433556; figs. 6, 13). The riparian soils and other wetlands material exposed at the surface were saturated. The stratigraphy of this core is highly variable, ranging from coarse sand and gravel to fine sand to wetland sediment (see table A8 and fig. A8). No corrections were made for compression (table 6).

Analytical Methods

Sediment-Sample Digestion and Analytical Methods

Four separate data sets are used in this investigation: (1) surficial-sediment samples from Blue Creek delta collected by the Trustees and AESE, Inc., personnel in 2005; (2) terrace-sediment samples acquired by USGS and the Trustees via coring during April 2006; (3) surficial sediment sampled by USGS in 1975 (Otton, 1976); and (4) surficial sediment sampled by NURE in 1979 (Babcock and others, 1981) and reanalyzed in 2006 for this study.

Surficial-sediment samples collected by the Trustees and AESE, Inc., personnel in 2005 were analyzed as described in the Laboratory Services Contract for the Midnite Uranium Mine Natural Resource Trustee Council (2002, 60 p.). Material from the <63 μm fraction was digested using EPA standard method 3050 (Edgell, 1988) and analyzed using EPA protocol (EPA, 2000a). Radionuclides in the uranium and thorium decay chains were analyzed using several radiometric methods described in the Laboratory Services Contract for the Midnite Uranium Mine Natural Resource Trustee Council (2002, 60 p.). Laboratory methods employed in the 2005 Blue Creek delta sediment study were similar to those employed by EPA during the Remedial Investigation/Feasibility Study (RI/FS) for Midnite Mine Superfund Site (EPA, 1999, 2000a, b).

Figure 8. Core site 06MM01 (location, fig. 7). Core was taken at site indicated by arrow. Beaver pond dam diverts Blue Creek south of the abandoned beaver pond. The outer boundary of this sedimentary deposit is the limit of the beaver dam. Blue Creek flows along south side of beaver dam (fig. 7). Photograph by Fred E. Kirschner, AESE, Inc., Apr. 24, 2006.

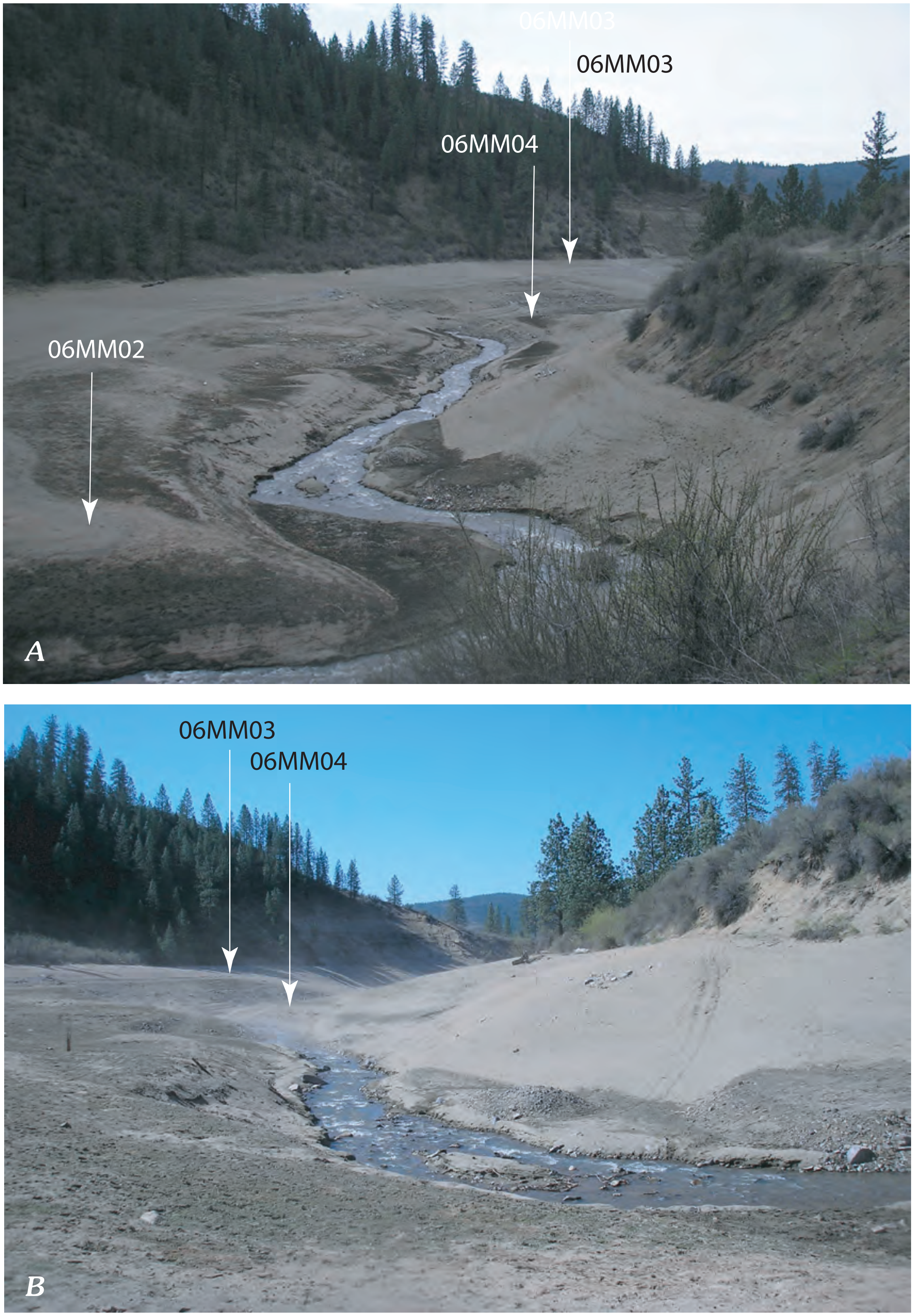


Figure 9. Blue Creek delta (fig. 7). *A*, Sites 06MM02–06MM04, Apr. 13, 2006. *B*, Sites 06MM03 and 06MM04 taken from site 06MM02, Apr. 24, 2006. Site 06MM03 is actually somewhat farther west than shown by arrow on photograph (fig. 7). Photographs by Fred E. Kirschner, AESE, Inc., Apr. 24, 2006.

Figure 10. Site 06MM05 at the mouth of Blue Creek (figs. 6, 7). Stan Church is preparing to extract core. Photograph by Fred E. Kirschner, AESE, Inc., Apr. 24, 2006.

Analytical results for the cored sediment samples acquired during this study are from digestion of a homogenized 0.5 g aliquot of the <63 µm fraction of each of the terrace-sediment samples prepared using the EPA SW846 Method 3050B procedure for ICP-MS analysis (U.S. EPA, 2007). When the <63 mesh fraction recovered was less than 0.5 g (tables A1–A8), material from the next size fraction (<100 µm) was added to obtain an adequate sample for analysis. The EPA 3050B procedure is not a total digestion technique for geological materials; however, it uses a strong acid leach that will dissolve a wide range of elements that could become environmentally available. Results are reported for 47 elements analyzed by ICP-MS (inductively coupled plasma–mass spectrometry; Lamothe and others, 2002). Analytical data are in tables A9–A16 in Appendix A.

The stream-sediment samples (minus-100-mesh, <150 µm) were collected in both the Blue Creek and the Sand Creek basins during the NURE program (Babcock and others, 1981). Samples in this NURE study were collected at a study-design density of one sample/km^2 to define the geochemical dispersion associated with the uranium deposits. Samples from the two drainage basins were retrieved from the U.S. Geological Survey archive and reanalyzed using the EPA SW846 Method 3050B procedure for this study. Results are reported for 47 elements analyzed by ICP-MS (inductively coupled plasma–mass spectrometry; Lamothe and others, 2002). Analytical data are in table A17 in Appendix A.

Total carbon was determined in selected samples from the USGS 2006 sediment cores using an automated carbon analyzer (Jackson and others, 1987). A weighed sample (approximately 0.20 g) is combusted in an oxygen atmosphere at 1,350°C to oxidize carbon (C) to carbon dioxide (CO_2). Moisture and dust are removed and the carbon dioxide gas is measured by a solid-state infrared detector. Analytical data are reported in tables A9–A16.

Figure 11. Site 06MM06 (fig. 6). Stan Church is capping core prior to extraction. Blue Creek in background. Photograph by Fred E. Kirschner, AESE, Inc., Apr. 25, 2006.

Figure 12. Site 06MM07, upper Blue Creek upstream from Midnite Mine tributary confluence (fig. 6). Core site is upstream (left) on small sand bar in willow thicket. Photograph by Fred E. Kirschner, AESE, Inc., Apr. 25, 2006.

Figure 13. Wetlands (*A*) at site 06MM08 in Midnite Mine tributary about 50 m upstream from gauge # 12433556 (fig. 6). Box shows field of view for *B*; blue flag marks core locality. *B*, Core site 06MM08. Stan Church is preparing to measure compression of core prior to extraction. Photographs by Fred E. Kirschner, AESE, Inc., Apr. 25, 2006.

Quality Assurance—Quality Control Data

For quality control purposes in the digestion of the terrace sediment and the NURE sediment samples, five internationally recognized standard reference materials (SRM) were digested with each batch of samples: NIST (National Institute of Standards and Technology) SRM 2709, SRM 2711, SRM 8704; CCRMP (Canadian Certified Reference Material Project) SY-2; and USGS-SDO-1. Two SRMs, 2709 and 2711, have values given by NIST for Method 3050B-leachable element concentrations in addition to certified values for total element compositions. The other three SRMs (8704, SY-2, SDO-1) only have certified values given for their total element concentrations. A statistical summary of the mean values obtained for the SRMs and comparisons with certified values for these standards is given in table 7. EPA Method 3050B-leachable recoveries of all elements in SRMs 2709 and 2711 were well within the acceptable range of 80–120 percent (that is, ±20 RPD, or relative percent difference) with the exception of phosphorus in SRM 2709 (75 percent) and titanium in SRM 2711 (132 percent). The mean recoveries of all other Method 3050B-leachable elements in SRMs 2709 and 2711 were 99 percent and 103 percent respectively, in good agreement with published SRM data (Potts and others, 1992).

In addition, 12 samples from the cores were run as blind duplicates (table 8). EPA Method 6020, analysis of sample solutions using ICP-MS, has an expected reproducibility of ±20 percent. Values for reproducibility (relative percent difference or RPD) in table 8 are generally less than 5.0 percent. Only 20 of the 336 values, or 6 percent, have a RPD greater than 10 percent, and only 5, or 1.5 percent, are greater than 20 percent RPD. Of these, one value is for Th, one for Na, one for Mn, and two are for Mo, both of which were detected at low concentrations within a factor of three of the limit of detection.

Nine samples from the NURE stream-sediment samples were run as blind duplicates (table 9). Values for reproducibility (RPD) in table 9 are generally less than 5.0 percent, indicating excellent agreement between the two analyses of the blind samples. Only 19 of the 252 values, or 7.5 percent, have a RPD greater than 10 percent, and only 5, or 2.0 percent, have RPD greater than 20 percent. Of these five samples, three are trace elements whose concentrations are near the limit of detection of the analytical method. The two samples that are out of compliance are the determination of thorium in sample DSOR100S1 and the determination of copper in DSOR129S1.

For samples analyzed on the MUMNRTC Laboratory Services Contract for the Midnite Uranium Mine Natural Resource Trustee Council (2002, 60 p.), two sets of three samples were run blind (table 10). Sample reproducibility data are also included in table 10. Values for reproducibility (RPD) in table 10 are generally less than 5.0 percent. Ten of the 57 values, or 17 percent, have a RPD greater than 10 percent, and 4, or 7 percent, have RPD greater than 20 percent. Of those with RPD > 20 percent, two values are for molybdenum, which is present at the reported detection limit, one is for calcium in the second set of samples, and one is for uranium in the second set of samples. Table A18 gives limits of detection and qualifiers as received from the MUMNRTC contract analytical laboratory.

Gamma-Ray Spectrometry Methods

Activity concentrations of ^{234}Th, ^{226}Ra, ^{214}Pb, ^{214}Bi, and ^{210}Pb were measured on selected core intervals using high-precision, gamma-ray spectrometry on 50–200 g samples. Sediment samples were sealed to allow equilibrium to be attained between ^{226}Ra and the daughter products (^{214}Pb and ^{214}Bi) and then packaged in clear acrylic petri dishes (8.5 cm diameter by 3.8 cm high) to ensure a constant geometry. The potential loss of radon gas due to insufficiently sealed containers was checked by measuring the Th-series nuclides ^{228}Ac, ^{212}Pb, and ^{212}Bi. Gamma-ray emissions from 0 to 2,000 keV (kiloelectron volts) energy were detected using either an EG&G Ortec GMX or Canberra REGE series detectors. Gamma-ray spectra were accumulated in a multi-channel analyzer (0.5 keV/channel) with counting times ranging from 24 to 72 hours/sample.

The equation used to convert the measured counts-per-minute (cpm) data for each photopeak to the desired values in disintegrations-per-minute per gram (dpm/g) is given by:

$$\text{dpm/g} = (\text{cpm-background}) / \text{Eff} * \text{Abs} * \text{BR} * \text{wt} \qquad (1)$$

where
Eff = absolute efficiency of the detector
Abs = absorption correction factor
BR = branching ratio
wt = sample weight (g)

Disintegrations-per-minute per gram (dpm/g) were converted to picocuries per gram (pCi/g) by dividing the measured values by a factor of 2.22.

The laboratory background for each photopeak was determined from spectra acquired with no samples near the detector (table 11). The absolute efficiency of the detector (Eff) at various gamma-ray energies was independently determined using a planar, multi-isotope, National Institute of Standards and Technology (NIST)-traceable source (SRM 4275). The matrix-dependent absorption correction factor (Abs) accounts for the self-absorption of gamma rays by the sample and is particularly important for low-energy (<100 keV) gamma rays. Adsorption of gamma rays of varying energies was based on a comparison of the counts recorded when the SRM 4275 source was placed on top of a container containing a sample, versus an empty container. The branching ratios (BR) used in equation (1) were obtained from published sources and indicate the fractional contribution of an individual gamma-ray emission to the total emissions from the nuclide. The nuclides measured in this study are presented in table 11 along with their energies, branching ratios, and the absolute efficiencies of the detectors. Additional details on the method are in Zielinski and Budahn (1998).

Table 7. Comparison of measured values for five International Reference Standards with literature values.

[Concentrations in parts per million (ppm); data for reference standards from Potts and others (1992); data are reported for the core samples analyzed under chain-of-custody protocol; --, no data]

Standard Statistical data	Al ppm	As ppm	Ba ppm	Be ppm	Ca ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cu ppm	Fe ppm	K ppm	La ppm	Li ppm	Mg ppm	Mn ppm
NIST-2709:																
Measured value	26,400	15.2	402	0.8	14,200	0.4	34.6	11.8	73.5	31.6	30,200	3,840	16.3	36.3	13,000	501
3050 Literature value	26,000	<20	398	--	15,000	< 1	--	12	79	32	30,000	3,200	--	--	14,000	470
Percent recovery of 3050 literature value	102%	--	101%	--	95%	--	--	98%	93%	99%	101%	120%	--	--	93%	107%
Accepted total digestion value	75,000	17.7	968	--	18,900	0.38	42	13.4	130	34.6	35,000	20,300	23	--	15,100	538
Percent recovery of total digestion value	35%	86%	42%	--	75%	98%	82%	88%	57%	91%	86%	19%	71%	--	86%	93%
NIST-2711:																
Measured value	19,600	95.2	201	1.0	20,600	41.1	52.0	8.1	20.6	109	21,000	4,550	25.8	15.3	7,690	524
3050 Literature value	18,000	90.0	200	--	21,000	40.0	--	8.2	20	100	22,000	3,800	--	--	8,100	490
Percent recovery of 3050 literature value	109%	106%	101%	--	98%	103%	--	98%	103%	109%	95%	120%	--	--	95%	107%
Accepted total digestion value	65,300	105.0	726	--	28,800	41.70	69.0	10.0	47	114.0	28,900	24,500	40.0	--	10,500	638
Percent recovery of total digestion value	30%	91%	28%	--	72%	98%	75%	81%	44%	96%	73%	19%	64%	--	73%	82%
NIST-8704:																
Measured value	13,200	14.8	91.3	0.7	23,300	3.1	23.9	11.7	72.8	87.1	31,100	1,790	10.0	28.7	8,890	495
Accepted total digestion value	61,000	17	413	--	26,410	2.94	66.5	13.57	121.9	--	39,700	20,010	--	--	12,000	544
Percent recovery of total digestion value	22%	87%	22%	--	88%	105%	36%	86%	60%	--	78%	9%	--	--	74%	91%
USGS-SDO-1:																
Measured value	10,400	58.4	53.4	1.4	6,840	0.3	26.5	43.5	14.7	55.0	54,900	4,250	10.4	15.5	5,140	276
Accepted total digestion value	64,955	68.5	397	3.3	7,505	--	79.3	46.8	66.4	60.2	65,315	27,800	38.5	28.6	9,288	325
Percent recovery of total digestion value	16%	85%	13%	44%	91%	--	33%	93%	22%	91%	84%	15%	27%	54%	55%	85%
CCRMP-SY-2:																
Measured value	3,050	16.2	24.0	9.4	28,400	0.1	157.8	3.7	2.9	2.9	18,100	1,420	68.2	40.0	7,450	1,000
Accepted total digestion value	63,737	17.3	460	22	56,898	0.21	175	8.6	--	--	44,126	36,929	75	95	16,200	2,479
Percent recovery of total digestion value	5%	93%	5%	43%	50%	56%	90%	43%	--	--	41%	4%	91%	42%	46%	40%

Table 7. Comparison of measured values for five International Reference Standards with literature values—Continued.

Standard Statistical data	Mo ppm	Na ppm	Nd ppm	Ni ppm	P ppm	Pb ppm	Rb ppm	Sr ppm	Th ppm	Ti ppm	Tl ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm
NIST-2709:																
Measured value	1.0	682	15.0	77.2	526	13.3	33.1	104	8.5	393	0.3	1.7	68.1	11.1	0.9	94.0
3050 Literature value	< 2	680	--	78	700	13.0	--	101	--	380	--	--	62	--	--	100
Percent recovery of 3050 literature value	--	100%	--	99%	75%	103%	--	103%	--	104%	--	--	110%	--	--	94%
Accepted total digestion value	2	11,600	19	88	620	18.9	96	231	11	3420	0.74	3	112	18	1.6	106
Percent recovery of total digestion value	52%	6%	79%	88%	85%	71%	35%	45%	77%	12%	41%	55%	61%	62%	59%	89%
NIST-2711:																
Measured value	1.1	245	22.8	17.1	715	1199	33.8	47.6	10.3	563	1.7	1.1	42.2	17.3	1.5	322
3050 Literature value	<2	260	--	16.0	880	1100	--	50	--	420	--	--	42	--	--	310
Percent recovery of 3050 literature value	--	94%	--	107%	81%	109%	--	95%	--	134%	--	--	100%	--	--	104%
Accepted total digestion value	1.60	11,400	31.0	20.6	860	1162	110	245	14.0	3,060	2.47	2.60	82	25.0	2.7	350
Percent recovery of total digestion value	67%	2%	74%	83%	83%	103%	31%	19%	73%	18%	71%	44%	52%	69%	57%	92%
NIST-8704:																
Measured value	2.9	119	13.4	38.8	846	149	16.7	36.2	4.4	50	0.6	1.0	22.3	11.8	0.9	381
Accepted total digestion value	--	5,530	--	42.9	--	150	--	--	9.07	4,570	--	3.09	94.6	--	--	408
Percent recovery of total digestion value	--	2%	--	90%	--	99%	--	--	48%	1%	--	33%	24%	--	--	93%
USGS-SDO-1:																
Measured value	130	138	17.5	90.8	340	26.4	24.3	16.7	6.7	51	5.0	38.5	39.1	26.1	2.0	53.8
Accepted total digestion value	134	2,819	36.6	99.5	480	27.9	126	75.1	10.5	4,257	--	48.8	160	40.6	3.4	64.1
Percent recovery of total digestion value	97%	5%	48%	91%	71%	95%	19%	22%	64%	1%	--	79%	24%	64%	60%	84%
CCRMP-SY-2:																
Measured value	1.0	2,320	71.0	3.4	1,870	86.5	8.9	40.2	366	798	0.1	274	22.0	108	14.0	119
Accepted total digestion value	0.53	32,000	73	--	1,877	85	217	271	379	899	1.5	285	50	128	--	248
Percent recovery of total digestion value	188%	7%	97%	--	100%	102%	4%	15%	97%	89%	6%	96%	44%	84%	--	48%

Quality Assurance—Quality Control Data

Accuracy and precision of the gamma-ray spectrometry technique are monitored by the analysis of USGS and NIST-traceable standard reference materials. These include NIST-2710 (Montana soil) and NIST-1633b (Coal fly ash). In addition, in-house standards in four different weights (100 g, 150 g, 200 g, and 250 g) were routinely analyzed. This in-house standard was derived from the National Bureau of Standards (the predecessor to NIST) uranium ore standard SRM 2230 and contains 1,000 ppm uranium (parts per million or micrograms per gram).

Activity data were also determined on the 2005 AESE, Inc., sediment data set from Blue Creek cove. The analyses of two sets of samples analyzed in triplicate are in table A19. Much of the data for the radionuclide series was either below the lower limit of detection or had large counting errors due to their low concentrations.

Statistical Methods

Large data sets in this manuscript may become unwieldy if statistical data analysis methods are not used. In all data sets, descriptive statistics were determined and are included in the data tables. By descriptive statistics, we mean the range of the data (maximum and minimum) and some expression of the central tendency of the distribution of the population. Where the number of samples (n) is small, only the mean concentration is reported. However, as n becomes larger, the median value (50th percentile) is reported. Often, the 75th and 25th percentiles are also reported to provide an estimate of the total distribution of the population. In dealing with determination of the geochemical background, the populations are mixed, meaning that they contain material from several different rock units, that these rock units contain different mineral phases that behave differently during transport in the stream, and that they contain differing amounts of those minerals. In such cases, the populations are skewed and, particularly for the trace-elements, the metal concentrations closely approximate a lognormal distribution. In these cases, the geometric mean (GM) is a better estimate of the central tendency of the mixed population rather than the median or mean concentration. If the distribution were normal, the concentrations of the mean and the median would be nearly the same. If the distribution were lognormal, the median and the geometric mean concentrations would be nearly the same. The geometric mean value is used throughout this paper as the estimate of central tendency of the trace-element concentrations in the geochemical data and is indicated as follows: GM_{As}, to indicate the geometric mean concentration for arsenic, for example.

In cases where the population is sufficiently large ($n > 29$) where we determine the premining geochemical background, the stream-sediment data are a mixed population. As with most mixed populations, most of the elemental concentration data in the premining geochemical background data sets have positively skewed distributions as shown by the skewness and kurtosis statistics and are not normal as shown by the fact that the Shapiro-Wilks statistic is less than 1. A normal distribution would have a Shapiro-Wilks value close to 1, whereas a skewed distribution would have a value that is considerably less than 1. The Shapiro-Wilks statistic measures the scatter of data along a regression line through the data on a probability plot (concentration versus percentile). If the fit is poor, that is, the r-squared statistic is < 0.95 with a $p < 0.05$, then the data are not normal and statistics that require a normal distribution are calculated from log-transformed data. The coefficient of variation (CV; the standard deviation divided by the mean expressed in percent) gives more reliable results when calculated on a normal population. The UCL_{95} is the upper tolerance limit of the data, or the upper limit of the 90 percent confidence interval of the data. The calculation assumes a normal distribution, so the data were log-transformed prior to the calculation (U.S. EPA, 2002). The 90 percent confidence interval around the GM does not provide information about the mean. The Student's T test also assumes a normal population. Where used in this manuscript, any T statistic calculated will use the GM or the 95 percent confidence interval in the T test.

Results and Discussion

^{137}Cs Data from Cores 06MM01 and 06MM08

Cesium-137 is a thermonuclear byproduct of atmospheric testing in the 1950s and 1960s (Simon and others, 2004). Peak atmospheric thermonuclear activity occurred in 1963 and peak ^{137}Cs activity in sediment cores is assigned a date of 1963±2 yr (for example, Charles and Hites, 1987). Stratigraphic analysis indicated that only cores 06MM01 and 06MM08 contain enough fine material or clay that they would trap sufficient ^{137}Cs to provide a date. Sample intervals from cores 06MM01 and 06MM08 that contained substantial amounts of silt and clay were analyzed for their radionuclides (table 12).

Samples from the beaver-pond sediment from core 06MM01 all have pre-atmospheric-testing background concentrations of ^{137}Cs activity (that is, less than 0.05 pCi/g), indicating that the sediment in the beaver pond is older than 1954 (see discussion in Cox and others, 2004). This observation is corroborated by aerial photographs bounding the period from 1936 to 1946. Lake Roosevelt began filling early in 1939, and by July 1942, the water level had reached an elevation of 1,290 ft (fig. 14). The 1936 aerial photography predates the reservoir and shows that the beaver pond was not present. The 1946 aerial photography shows that the beaver pond had been built (elevation of 1,275 ft, table 6) and subsequently had been submerged by the rising lake level, which, in 1946, was at maximum pool at 1,290 ft (fig. 14). Sediment deposition continued through a period of several years following the flooding of the beaver pond by water in the reservoir. Elevation data

Table 8. Data and comparison of analyses of blind duplicate samples, cores 06MM01 - 06MM08 from Blue Creek basin.

[Concentrations reported in parts per million (ppm); Std. Dev., standard deviation of the duplicate sample; percent RSD, the relative standard deviation is calculated as the measured values divided by the average; percent RPD, relative percent difference is the absolute value of the difference between the two values divided by the average of the two values (EPA Method 6020)]

Sample and statistical measures	Al ppm	As ppm	Ba ppm	Ca ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cu ppm	Fe ppm	K ppm	La ppm	Li ppm	Mg ppm	Mn ppm	Mo ppm	Na ppm	Ni ppm	P ppm	Pb ppm	Sr ppm	Th ppm	Ti ppm	Tl ppm	U ppm	V ppm	Y ppm	Zn ppm
06MM08.06	25,400	8.8	106	4,640	3	71.8	13.3	18.4	26.5	20,200	2,530	38.6	45.4	3,780	5,710	2.5	152	110	578	13.5	23.6	28.4	867	0.26	103	28.8	38.3	200
Std. Dev.	928	0.2	3.0	171	0.02	0.6	0.4	0.3	1.1	146	15	0.0	2.7	136	144	0.1	0.3	4.0	10	0.0	0.0	0.0	24	0.001	0.4	0.2	0.7	1.9
Percent RSD	3.6%	2.3%	2.7%	3.6%	0.5%	0.8%	3.1%	1.9%	4.1%	0.7%	0.6%	0.1%	5.8%	3.5%	2.5%	5.5%	0.2%	3.6%	1.7%	0.3%	0.2%	0.1%	2.8%	0.6%	0.4%	0.5%	1.8%	1.0%
Percent RPD	5.0%	3.3%	3.8%	5.1%	0.8%	1.2%	4.4%	2.7%	5.9%	1.0%	0.9%	0.1%	8.1%	4.9%	3.5%	7.8%	0.2%	5.0%	2.4%	0.4%	0.2%	0.2%	4.0%	0.8%	0.5%	0.8%	2.6%	1.4%
06MM05.01	15,100	6.3	93	6,300	0.74	80.2	10.1	25.8	15.4	19,000	1,970	41.9	22.1	4,460	999	1.2	171	34.8	856	14.2	29.2	45.6	840	0.17	29.6	30.9	25.3	79.5
Std. Dev.	428	0.2	2.9	301	0.02	5.1	0.4	1.3	1.0	704	93	2.9	1.0	6	37	0.0	5.0	1.9	42	0.8	1.0	3.7	33	0.007	2.4	1.3	1.2	2.9
Percent RSD	2.8%	3.0%	3.1%	4.6%	2.7%	6.1%	3.7%	5.0%	6.2%	3.6%	4.6%	6.6%	4.2%	0.1%	3.6%	0.4%	2.9%	5.3%	4.8%	5.5%	3.3%	7.6%	3.8%	4.1%	7.7%	4.2%	4.6%	3.5%
Percent RPD	3.9%	4.3%	4.3%	6.5%	3.9%	8.6%	5.2%	7.0%	8.8%	5.1%	6.5%	9.3%	6.0%	0.2%	5.1%	0.6%	4.1%	7.5%	6.8%	7.8%	4.7%	10.7%	5.3%	5.8%	10.9%	5.9%	6.5%	5.0%
06MM03.01	18,400	8	129	5,780	1.8	56.7	10.8	20.8	22	24,500	2,820	27	21.1	7,720	528	0.45	269	19.6	947	41.3	27.3	10.5	1,030	0.25	4.52	31.6	14.6	546
Std. Dev.	95	0.1	1.9	28	0.04	1.4	0.4	0.1	0.3	631	24	0.7	0.4	135	14	0.0	43.1	0.4	18	1.3	0.5	0.4	23	0.009	0.3	0.6	0.3	5.8
Percent RSD	0.5%	1.3%	1.5%	0.5%	2.3%	2.5%	3.7%	0.6%	1.2%	2.6%	0.8%	2.6%	1.8%	1.8%	2.7%	8.6%	18.1%	2.2%	1.9%	3.1%	2.0%	3.8%	2.3%	3.8%	6.9%	2.0%	2.3%	1.1%
Percent RPD	0.7%	1.9%	2.1%	0.7%	3.3%	3.6%	5.2%	0.8%	1.7%	3.7%	1.2%	3.7%	2.5%	2.5%	3.8%	12.1%	25.6%	3.1%	2.7%	4.4%	2.8%	5.4%	3.2%	5.4%	9.7%	2.8%	3.2%	1.5%
06MM01.01	17,200	6.5	114	4,920	1	57.8	11.4	15.5	16.8	19,300	2,480	28.4	22.8	5,440	1,020	0.73	174	31.2	752	18.5	27.1	17.6	851	0.22	26	26.1	21	217
Std. Dev.	165	0.0	0.5	21	0.00	2.5	0.2	0.1	0.2	127	13	1.1	0.1	91	1	0.1	6.7	0.2	17	0.4	0.7	2.4	23	0.005	1.1	0.3	0.6	2.5
Percent RSD	1.0%	0.2%	0.4%	0.4%	0.4%	4.4%	2.1%	0.4%	1.0%	0.7%	0.5%	4.2%	0.6%	1.7%	0.1%	12.5%	4.0%	0.6%	2.4%	2.2%	2.6%	15.4%	2.8%	2.3%	4.5%	1.2%	3.0%	1.1%
Percent RPD	1.4%	0.3%	0.6%	0.6%	0.6%	6.2%	3.0%	0.5%	1.3%	0.9%	0.8%	5.9%	0.9%	2.4%	0.1%	17.6%	5.6%	0.9%	3.3%	3.1%	3.7%	21.8%	4.0%	3.3%	6.3%	1.6%	4.2%	1.6%
06MM02.01	15,500	8.4	155	4,890	1.2	79.4	22.2	123.00	22.7	22,600	2,880	38.9	22.4	6,630	3,060	2.7	185	120	914	17.2	26.1	33	946	0.25	26.7	30.3	29.7	201
Std. Dev.	674	0.1	6.0	120	0.04	1.6	1.2	3.8	1.3	843	108	1.7	0.7	304	187	0.1	4.7	4.0	12	1.2	1.1	1.3	27	0.012	2.7	0.8	1.5	3.7
Percent RSD	4.5%	1.6%	4.0%	2.5%	3.9%	2.0%	5.7%	3.2%	6.0%	3.8%	3.8%	4.4%	3.2%	4.7%	6.4%	4.2%	2.6%	3.4%	1.4%	7.1%	4.2%	4.0%	2.9%	5.0%	10.7%	2.8%	5.1%	1.9%
Percent RPD	6.3%	2.3%	5.6%	3.5%	5.5%	2.9%	8.0%	4.5%	8.5%	5.4%	5.4%	6.2%	4.6%	6.7%	9.0%	6.0%	3.7%	4.8%	1.9%	10.0%	5.9%	5.6%	4.1%	7.0%	15.2%	3.9%	7.2%	2.6%
06MM08.11	24,700	25.8	137	7,280	4.8	77.4	64.2	17.4	68.4	22,300	2,780	34.8	34.8	5,250	4,420	3	226	235	468	21.5	34.2	16.1	801	0.33	365	25.8	113	315
Std. Dev.	755	0.2	0.03	22	0.04	0.2	0.5	0.3	0.5	381	28	0.4	0.8	141	24	0.2	13.6	1.8	4	0.4	0.6	0.1	16	0.006	8.4	0.5	0.5	9.2
Percent RSD	3.1%	0.9%	0.0%	0.3%	0.9%	0.3%	0.8%	1.8%	0.7%	1.7%	1.0%	1.1%	2.4%	2.7%	0.5%	5.4%	6.3%	0.8%	0.9%	1.8%	1.8%	0.9%	2.0%	1.9%	2.3%	2.0%	0.5%	2.9%
Percent RPD	4.4%	1.3%	0.0%	0.4%	1.3%	0.4%	1.2%	2.5%	0.9%	2.4%	1.4%	1.6%	3.3%	3.9%	0.8%	7.6%	8.9%	1.1%	1.3%	2.5%	2.6%	1.3%	2.9%	2.7%	3.2%	2.8%	0.6%	4.1%
06MM01.23	17,200	20.1	152	4,630	0.16	69.3	7.6	16.9	23.8	27,700	2,990	29.8	21.3	6,670	482	0.8	150	13.5	719	21.4	27.9	15.9	860	0.2	4.48	34.2	17	73.9
Std. Dev.	504	0.4	0.1	40	0.01	2.8	0.0	0.2	0.3	347	9	1.2	0.4	151	11	0.0	4.0	0.5	1	0.1	0.4	0.8	12	0.007	0.2	0.3	0.5	2.1
Percent RSD	3.0%	1.7%	0.0%	0.9%	7.8%	4.2%	0.4%	1.2%	1.4%	1.2%	0.3%	4.2%	1.7%	2.3%	2.2%	2.4%	2.7%	3.8%	0.2%	0.5%	1.5%	4.9%	1.4%	3.6%	4.7%	0.8%	3.1%	2.8%
Percent RPD	4.2%	2.4%	0.1%	1.2%	11.0%	5.9%	0.6%	1.7%	1.9%	1.8%	0.4%	5.9%	2.4%	3.3%	3.1%	3.4%	3.9%	5.4%	0.2%	0.7%	2.2%	6.9%	2.0%	5.1%	6.6%	1.1%	4.4%	3.9%
06MM01.15	16,300	9.1	125	3,830	2.4	51.1	8.4	14.2	18.5	17,000	2,490	25.1	20.6	4,430	575	0.67	152	18.8	523	64	24.2	13.3	871	0.22	12.4	24.5	17.7	903
Std. Dev.	146	1.3	0.1	115	0.03	0.8	0.0	0.2	0.1	546	58	0.6	1.3	124	245	0.2	4.9	2.3	10	0.6	0.1	0.0	21	0.001	0.5	0.4	0.2	28.9
Percent RSD	0.9%	6.6%	0.1%	2.9%	1.4%	1.5%	0.2%	1.7%	0.5%	3.1%	2.3%	2.3%	6.6%	2.7%	60.9%	31.5%	3.1%	13.5%	1.9%	1.0%	0.5%	0.1%	2.3%	0.3%	4.0%	1.8%	1.1%	3.1%
Percent RPD	1.3%	9.3%	0.1%	4.2%	2.0%	2.1%	0.3%	2.4%	0.7%	4.4%	3.2%	3.3%	9.3%	3.9%	86.1%	44.5%	4.4%	19.2%	2.7%	1.4%	0.7%	0.1%	3.3%	0.5%	5.7%	2.5%	1.6%	4.4%
06MM08.01	23,000	10	229	11,900	13.6	58.8	31	31.2	21.9	19,200	2,520	35.6	37	5,210	34,900	15	246	456	549	12.9	50.2	9.36	781	0.37	119	26.2	60.7	505
Std. Dev.	778	0.1	9.5	525	0.71	0.4	1.9	1.6	1.0	1,091	111	0.4	0.1	237	1582	0.5	9.2	24.3	22	1.3	2.1	0.2	37	0.004	2.8	1.3	2.5	32.9
Percent RSD	3.3%	0.2%	4.0%	4.3%	5.0%	0.7%	6.0%	5.0%	4.2%	5.5%	4.3%	1.1%	0.2%	4.4%	4.4%	3.1%	3.6%	5.1%	3.9%	9.3%	4.1%	2.0%	4.5%	1.1%	2.3%	4.7%	4.0%	6.2%
Percent RPD	4.7%	0.3%	5.7%	6.1%	7.1%	1.0%	8.5%	7.1%	6.0%	7.7%	6.1%	1.5%	0.3%	6.2%	6.2%	4.4%	5.2%	7.3%	5.6%	13.1%	5.8%	2.8%	6.4%	1.6%	3.3%	6.6%	5.6%	8.8%
06MM04.01	21,300	11.9	178	5,030	1.8	65.1	14.9	21.5	25	27,200	3,230	30.2	27.4	7,310	1,360	0.58	187	39.1	881	33	28.6	13.3	1,040	0.27	18.2	32.9	22.2	382
Std. Dev.	765	0.4	4.7	141	0.10	6.5	0.8	1.6	1.0	1,349	141	2.5	3.2	92	50	0.1	6.3	1.2	13	1.4	1.8	0.8	31	0.015	0.6	2.3	1.1	16.9
Percent RSD	3.7%	3.8%	2.7%	2.9%	6.0%	10.7%	5.9%	8.1%	4.2%	5.1%	4.5%	8.7%	12.8%	1.3%	3.8%	21.4%	3.4%	3.1%	1.5%	4.5%	6.5%	6.5%	3.1%	5.7%	3.2%	7.4%	5.1%	4.6%
Percent RPD	5.2%	5.4%	3.8%	4.1%	8.4%	15.1%	8.4%	11.4%	6.0%	7.3%	6.4%	12.3%	18.1%	1.8%	5.4%	30.2%	4.8%	4.5%	2.1%	6.3%	9.2%	9.1%	4.4%	8.1%	4.5%	10.4%	7.1%	6.5%
06MM02.13	13,500	7.9	99.5	3,980	0.94	74.2	22.5	11.3	15.3	16,200	2,100	34	18.8	3,920	2,940	1.1	145	46.6	642	14.3	23.2	27.1	710	0.18	31.4	23.1	27.7	123
Std. Dev.	263	0.0	1.5	9	0.01	0.8	0.1	0.1	0.2	341	24	0.1	2.0	69	41	0.0	2.2	0.9	14	0.2	0.7	2.4	5	0.001	0.4	0.2	0.0	2.1
Percent RSD	1.9%	0.5%	1.5%	0.2%	0.8%	1.0%	0.4%	0.5%	1.6%	2.1%	1.1%	0.2%	11.3%	1.7%	1.4%	3.1%	1.5%	1.9%	2.2%	1.6%	2.9%	8.4%	0.7%	0.8%	1.4%	0.7%	0.1%	1.7%
Percent RPD	2.7%	0.7%	2.1%	0.3%	1.1%	1.5%	0.6%	0.8%	2.3%	2.9%	1.6%	0.2%	15.9%	2.4%	2.0%	4.4%	2.1%	2.6%	3.1%	2.3%	4.1%	11.9%	0.9%	1.1%	2.0%	1.0%	0.1%	2.4%
06MM01.11	20,900	8.5	108	3,900	2.8	75.8	31.4	15.3	23.8	19,000	2,960	34.1	25	5,240	1,660	1.9	174	97.3	529	16.4	22.9	20.2	865	0.33	142	26.6	41.7	286
Std. Dev.	44	0.0	0.3	11	0.03	0.7	0.2	0.0	0.3	28	5	0.3	0.3	14	3	0.1	2.1	0.3	1	0.2	0.1	0.2	5	0.006	1.7	0.3	0.3	3.0
Percent RSD	0.2%	0.4%	0.3%	0.3%	1.0%	1.0%	0.7%	0.0%	1.1%	0.1%	0.2%	0.8%	1.1%	0.3%	0.2%	4.7%	1.2%	0.3%	0.1%	1.2%	0.6%	0.9%	0.6%	1.9%	1.2%	1.0%	0.6%	1.0%
Percent RPD	0.3%	0.5%	0.4%	0.4%	1.4%	1.4%	1.0%	0.0%	1.6%	0.2%	0.2%	1.1%	1.5%	0.4%	0.2%	6.7%	1.7%	0.5%	0.1%	1.7%	0.9%	1.2%	0.8%	2.7%	1.7%	1.3%	0.9%	1.5%

Table 9. Data and comparison of analyses of blind duplicate NURE stream-sediment samples, Blue Creek and Sand Creek basins.

[Concentrations reported in parts per million (ppm); Std. Dev., standard deviation of the duplicate sample; --, no data; percent RSD, the relative standard deviation is calculated as the measured values divided by the average; percent RPD, relative percent difference is the absolute value of the difference between the two values divided by the average of the two values (EPA Method 6020)]

Sample No.	Al	As	Ba	Ca	Cd	Ce	Co	Cr	Cu	Fe	K	La	Li	Mg	Mn	Mo	Na	Ni	P	Pb	Sr	Th	Ti	Tl	U	V	Y	Zn
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DSOR100S1	17,800	3.6	154	2,740	0.31	54.8	7.2	14.4	12.9	17,300	3,100	28.3	18.3	3,250	674	0.48	171	12.4	473	18.1	26.1	11.5	1,180	0.25	1.38	30.8	10.4	61.6
DSOR100S1-Dup	18,600	3.5	154	2,820	0.31	54.7	7.4	14.7	13.0	17,900	3,230	28.0	18.5	3,320	691	0.48	177	12.6	487	18.1	26.0	16.4	1,210	0.26	1.57	31.4	10.6	62.2
DSOR100S1-Mean	18,200	3.6	154	2,780	0.31	54.8	7.3	14.6	13.0	17,600	3,165	28.2	18.4	3,285	683	0.48	174	12.5	480	18.1	26.1	14.0	1,195	0.26	1.48	31.1	10.5	61.9
Std. Dev.	566	0.1	0.0	57	--	0.1	0.1	0.2	0.1	424	92	0.2	0.1	49	12	0.0	4.2	0.1	10	--	0.1	3.5	21	0.01	0.1	0.4	0.1	0.4
Percent RSD	3.1%	2.0%	0.0%	2.0%	--	0.1%	1.9%	1.5%	0.5%	2.4%	2.9%	0.8%	0.8%	1.5%	1.8%	0.0%	2.4%	1.1%	2.1%	--	0.3%	24.8%	1.8%	2.8%	9.1%	1.4%	1.3%	0.7%
Percent RPD	4.4%	2.8%	0.0%	2.9%	--	0.2%	2.7%	2.1%	0.8%	3.4%	4.1%	1.1%	1.1%	2.1%	2.5%	0.0%	3.4%	1.6%	2.9%	--	0.4%	35.1%	2.5%	3.9%	12.9%	1.9%	1.9%	1.0%
DSOR129S1	13,100	7.7	95.4	14,300	0.15	78.9	5.6	11.3	10.8	16,000	2,290	37.0	15.9	3,720	648	1.6	258	8.1	495	12.1	32.2	41.0	680	0.24	43.6	33.0	21.2	42.8
DSOR129S1-Dup	13,400	7.2	95.7	14,500	0.14	83.6	5.9	11.4	21.7	16,500	2,360	39.9	16.1	3,800	669	1.5	270	8.9	507	12.5	32.8	43.0	703	0.24	46.5	32.6	20.4	44.0
DSOR129S1-Mean	13,250	7.5	95.6	14,400	0.15	81.3	5.8	11.4	16.3	16,250	2,325	38.5	16.0	3,760	659	1.6	264	8.5	501	12.3	32.5	42.0	692	0.24	45.1	32.8	20.8	43.4
Std. Dev.	212	0.4	0.2	141	0.0	3.3	0.2	0.1	7.7	354	49	2.1	0.1	57	15	0.1	8	0.6	8	0.3	0.4	1.4	16	--	2.1	0.3	0.6	0.8
Percent RSD	1.6%	4.7%	0.2%	1.0%	4.9%	4.1%	3.7%	0.6%	47.4%	2.2%	2.1%	5.3%	0.9%	1.5%	2.3%	4.6%	3.2%	6.7%	1.7%	2.3%	1.3%	3.4%	2.4%	--	4.6%	0.9%	2.7%	2.0%
Percent RPD	2.3%	6.7%	0.3%	1.4%	6.9%	5.8%	5.2%	0.9%	67.1%	3.1%	3.0%	7.5%	1.3%	2.1%	3.2%	6.5%	4.5%	9.4%	2.4%	3.3%	1.8%	4.8%	3.3%	--	6.4%	1.2%	3.8%	2.8%
DSOR134S1	17,200	5.3	104	3,180	0.24	79.6	4.8	11.9	13.7	19,400	2,980	37.2	39.0	4,100	427	0.30	182	9.3	456	17.1	26.3	22.4	939	0.23	9.52	28.1	18.2	98.1
DSOR134S1-Dup	17,600	5.3	105	3,340	0.22	90.4	4.8	12.3	13.8	19,400	3,060	42.1	38.9	3,870	439	0.31	177	9.1	469	17.2	26.4	25.3	1,000	0.23	9.27	29.2	18.4	98.0
DSOR134S1-Mean	17,400	5.3	105	3,260	0.23	85.0	4.8	12.1	13.8	19,400	3,020	39.7	39.0	3,985	433	0.31	180	9.2	463	17.2	26.4	23.9	970	0.23	9.40	28.7	18.3	98.1
Std. Dev.	283	--	0.7	113	0.01	7.6	0.0	0.3	0.1	0.0	57	3.5	0.1	163	8	0.0	3.5	0.1	9	0.1	0.1	2.1	43	--	0.2	0.8	0.1	0.1
Percent RSD	1.6%	--	0.7%	3.5%	6.1%	9.0%	0.0%	2.3%	0.5%	0.0%	1.9%	8.7%	0.2%	4.1%	2.0%	2.3%	2.0%	1.5%	2.0%	0.4%	0.3%	8.6%	4.4%	--	1.9%	2.7%	0.8%	0.1%
Percent RPD	2.3%	--	1.0%	4.9%	8.7%	12.7%	0.0%	3.3%	0.7%	0.0%	2.6%	12.4%	0.3%	5.8%	2.8%	3.3%	2.8%	2.2%	2.8%	0.6%	0.4%	12.2%	6.3%	--	2.7%	3.8%	1.1%	0.1%
DSOR313S1	30,200	23.9	156	4,820	0.20	65.4	13.6	26.4	28.3	28,700	4,610	31.8	41.0	5,390	871	3.8	227	24.3	559	19.5	36.6	28.8	1,080	0.52	198	45.4	32.9	72.9
DSOR313S1-Dup	28,800	24.0	162	4,850	0.20	65.3	13.0	25.9	28.7	28,000	4,540	31.7	41.0	5,280	856	4.0	224	23.7	549	19.3	37.7	26.1	1,070	0.52	192	43.9	33.2	74.9
DSOR313S1-Mean	29,500	24	159	4,835	0.20	65.4	13.3	26.2	28.5	28,350	4,575	31.8	41.0	5,335	864	3.9	226	24.0	554	19.4	37.2	27.5	1,075	0.52	195	44.7	33.1	73.9
Std. Dev.	990	0.1	4.2	21	--	0.1	0.4	0.4	0.3	495	49	0.1	0.0	78	11	0.1	2.1	0.4	7	0.1	0.8	1.9	7	0.0	4.2	1.1	0.2	1.4
Percent RSD	3.4%	0.3%	2.7%	0.4%	--	0.1%	3.2%	1.4%	1.0%	1.7%	1.1%	0.2%	0.0%	1.5%	1.2%	3.6%	0.9%	1.8%	1.3%	0.7%	2.1%	7.0%	0.7%	0.0%	2.2%	2.4%	0.6%	1.9%
Percent RPD	4.7%	0.4%	3.8%	0.6%	--	0.2%	4.5%	1.9%	1.4%	2.5%	1.5%	0.3%	0.0%	2.1%	1.7%	5.1%	1.3%	2.5%	1.8%	1.0%	3.0%	9.8%	0.9%	0.0%	3.1%	3.4%	0.9%	2.7%
DSOR451S1	29,200	25.2	199	4,170	0.20	81.0	12.0	25.5	26.5	27,100	5,870	44.7	29.3	5,860	597	0.47	253	23.7	645	14.0	34.5	11.5	1,500	0.40	4.70	35.4	22.3	55.1
DSOR451S1-Dup	26,700	23.0	184	3,840	0.17	79.3	10.6	23.5	24.2	24,000	5,550	43.7	27.4	5,390	531	0.50	254	21.5	590	13.0	32.0	10.8	1,430	0.39	4.28	33.0	20.4	49.1
DSOR451S1-Mean	27,950	24.1	192	4,000	0.19	80.2	11.3	24.5	25.4	25,550	5,710	44.2	28.4	5,625	564	0.49	254	22.6	618	13.5	33.3	11.2	1,465	0.40	4.49	34.2	21.4	52.1
Std. Dev.	1,768	1.6	10.6	233	0.02	1.2	1.0	1.4	1.6	2,192	226	0.7	1.3	332	47	0.02	0.7	1.6	39	0.7	1.8	0.5	49	0.01	0.3	1.7	1.3	4.2
Percent RSD	6.3%	6.5%	5.5%	5.8%	11.5%	1.5%	8.8%	5.8%	6.4%	8.6%	4.0%	1.6%	4.7%	5.9%	8.3%	4.4%	0.3%	6.9%	6.3%	5.2%	5.3%	4.4%	3.4%	1.8%	6.6%	5.0%	6.3%	8.1%
Percent RPD	8.9%	9.1%	7.8%	8.3%	16.2%	2.1%	12.4%	8.2%	9.1%	12.1%	5.6%	2.3%	6.7%	8.4%	11.7%	6.2%	0.4%	9.7%	8.9%	7.4%	7.5%	6.3%	4.8%	2.5%	9.4%	7.0%	8.9%	11.5%
DSOR455S1	16,600	21.3	110	1,910	0.06	57.4	7.5	14.6	20.1	19,700	4,380	28.7	13.1	3,480	300	0.45	183	14.2	425	7.4	22.2	10.0	1,070	0.35	1.49	25.3	9.2	33.5
DSOR455S1-Dup	16,700	21.4	108	1,940	0.10	55.1	7.0	14.5	19.4	19,000	4,320	28.2	13.1	3,420	289	0.40	185	13.6	424	8.0	21.6	9.2	1,080	0.34	1.41	25.2	8.8	32.0
DSOR455S1-Mean	16,650	21.4	109	1,925	0.08	56.3	7.3	14.6	19.8	19,350	4,350	28.5	13.1	3,450	295	0.43	184	13.9	425	7.7	21.9	9.6	1,075	0.35	1.45	25.3	9.0	32.8
Std. Dev.	71	0.1	1.4	21	0.03	1.6	0.4	0.1	0.5	495	42	0.35	--	42	8	0.04	1.4	0.4	1	0.4	0.4	0.6	7	0.01	0.06	0.07	0.3	1.1
Percent RSD	0.4%	0.3%	1.3%	1.1%	35.4%	2.9%	4.9%	0.5%	2.5%	2.6%	1.0%	1.2%	--	1.2%	2.6%	8.3%	0.8%	3.1%	0.2%	5.2%	1.9%	6.0%	0.7%	2.0%	3.9%	0.3%	3.1%	3.2%
Percent RPD	0.6%	0.5%	1.8%	1.6%	50.0%	4.1%	6.9%	0.7%	3.5%	3.6%	1.4%	1.8%	--	1.7%	3.7%	11.8%	1.1%	4.3%	0.2%	7.4%	2.7%	8.4%	0.9%	2.9%	5.5%	0.4%	4.4%	4.6%
DSOR457S1	13,400	12.4	34	887	0.06	69.7	7.3	15.3	55.2	24,500	4,040	44.5	6.7	2,670	91	0.79	35	10.3	190	4.8	8.2	13.4	626	0.60	3.64	21.7	8.0	16.0
DSOR457S1-Dup	15,200	13.4	38	890	0.15	78.6	7.6	16.5	58.3	25,900	4,210	48.4	7.2	2,710	96	0.98	34	11.3	201	4.9	8.5	14.5	683	0.62	3.93	23.3	8.9	17.0
DSOR457S1-Mean	14,300	12.9	36	889	0.11	74.2	7.5	15.9	56.8	25,200	4,125	46.5	7.0	2,690	93	0.89	35	10.8	196	4.8	8.4	14.0	655	0.61	3.79	22.5	8.5	16.5
Std. Dev.	1,273	0.7	2.2	2	0.06	6.3	0.2	0.8	2.2	990	120	2.8	0.4	28	3	0.1	0.2	0.7	8	0.1	0.2	0.8	40	0.0	0.2	1.1	0.6	0.7
Percent RSD	8.9%	5.5%	6.1%	0.2%	60.6%	8.5%	2.8%	5.3%	3.9%	3.9%	2.9%	5.9%	5.1%	1.1%	3.5%	15.2%	0.6%	6.5%	4.0%	2.8%	2.5%	5.6%	6.2%	2.3%	5.4%	5.0%	7.5%	4.3%
Percent RPD	12.6%	7.8%	8.6%	0.3%	85.7%	12.0%	4.0%	7.5%	5.5%	5.6%	4.1%	8.4%	7.2%	1.5%	4.9%	21.5%	0.9%	9.3%	5.6%	3.9%	3.6%	7.9%	8.7%	3.3%	7.7%	7.1%	10.7%	6.1%
DSOR458S1	25,100	97.4	197	3,210	0.21	78.3	21.6	21.0	39.1	33,300	3,890	39.8	23.2	3,940	780	8.6	88	34.4	592	14.8	31.3	19.1	1,070	0.42	7.88	40.2	23.2	52.4
DSOR458S1-Dup	25,100	99.4	201	3,170	0.22	77.0	21.8	21.6	40.3	33,200	3,880	38.8	25.0	3,800	775	9.2	87	35.6	576	15.6	32.6	19.4	1,120	0.44	8.16	41.4	23.9	53.7
DSOR458S1-Mean	25,100	98.4	199	3,190	0.22	77.7	21.7	21.3	39.7	33,250	3,885	39.3	24.1	3,870	778	8.9	87	35.0	584	15.2	32.0	19.3	1,095	0.43	8.02	40.8	23.6	53.1
Std. Dev.	--	1.4	2.8	28	0.0	0.9	0.1	0.4	0.8	71	7	0.7	1.3	99	4	0.4	0.6	0.8	11	0.6	0.9	0.2	35	0.01	0.2	0.8	0.5	0.9
Percent RSD	--	1.4%	1.4%	0.9%	3.3%	1.2%	0.7%	2.0%	2.1%	0.2%	0.2%	1.8%	5.3%	2.6%	0.5%	4.8%	0.6%	2.4%	1.9%	3.7%	2.9%	1.1%	3.2%	3.3%	2.5%	2.1%	2.1%	1.7%
Percent RPD	--	2.0%	2.0%	1.3%	4.7%	1.7%	0.9%	2.8%	3.0%	0.3%	0.3%	2.5%	7.5%	3.6%	0.6%	6.7%	0.9%	3.4%	2.7%	5.3%	4.1%	1.6%	4.6%	4.7%	3.5%	2.9%	3.0%	2.5%
RZAH021S1	21,500	39.1	111	3,760	0.08	87.2	15.0	21.2	32.1	26,100	3,300	41.2	16.6	4,320	628	0.54	152	17.6	431	13.8	24.7	11.6	1,500	0.26	1.76	46.7	17.1	38.3
RZAH021S1-Dup	19,700	40.4	111	3,590	0.08	87.8	14.8	20.9	32.7	25,600	3,150	42.2	17.8	4,090	609	0.54	130	18.3	412	15.0	25.0	11.7	1,340	0.28	1.81	46.2	17.9	37.9
RZAH021S1-Mean	20,600	39.8	111	3,675	0.08	87.5	14.9	21.1	32.4	25,850	3,225	41.7	17.2	4,205	619	0.54	141	18.0	422	14.4	24.9	11.7	1,420	0.27	1.79	46.5	17.5	38.1
Std. Dev.	1,273	0.9	0.0	120	--	0.4	0.1	0.2	0.4	354	106	0.7	0.8	163	13	--	15.6	0.5	13	0.8	0.2	0.1	113	0.01	0.04	0.4	0.6	0.3
Percent RSD	6.2%	2.3%	0.0%	3.3%	--	0.5%	0.9%	1.0%	1.3%	1.4%	3.3%	1.7%	4.9%	3.9%	2.2%	--	11.0%	2.8%	3.2%	5.9%	0.9%	0.6%	8.0%	5.2%	2.0%	0.8%	3.2%	0.7%
Percent RPD	8.7%	3.3%	0.0%	4.6%	--	0.7%	1.3%	1.4%	1.9%	1.9%	4.7%	2.4%	7.0%	5.5%	3.1%	--	15.6%	3.9%	4.5%	8.3%	1.2%	0.9%	11.3%	7.4%	2.8%	1.1%	4.6%	1.0%

Table 10. Data and comparison of analyses of blind duplicate samples, Blue Creek delta (May 2005).

[Concentrations reported in parts per million (ppm); Std. Dev., standard deviation of the duplicate sample; percent RSD, the relative standard deviation is calculated as the measured value divided by the average; percent RPD, relative percent difference is the absolute value of the difference between the maximum and the minimum values divided by the average of the three values (EPA Method 6020)]

Sample No.	Al ppm	As ppm	Ba ppm	Ca ppm	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe ppm	K ppm	Mg ppm	Mn ppm	Mo ppm	Na ppm	Ni ppm	Pb ppm	U ppm	V ppm	Zn ppm
LR05092005-007	26,500	11.5	166	6,980	2.65	15	24	26	31,100	3,870	7,940	847	2	300	27	54.6	9.63	42.6	749
LR05092005-008	26,000	11.8	162	6,350	2.71	14	23	26	31,000	3,810	7,830	768	2	300	24	55.5	7.98	41	715
LR05092005-009	28,000	11.8	164	7,000	3.13	15	24	28	32,100	3,970	7,910	887	1	300	29	56.4	9.38	43	746
Mean	26,833	11.7	164	6,777	2.83	14.7	23.7	26.7	31,400	3,883	7,893	834	1.7	300	26.7	55.5	9.00	42.2	737
Std. Dev.	1,041	0.17	2.0	370	0.26	0.58	0.58	1.15	608	81	57	61	0.58	0	2.52	0.90	0.89	1.06	19
Percent RSD	3.9	1.5	1.2	5.5	9.2	3.9	2.4	4.3	1.9	2.1	0.7	7.3	34.6	0.0	9.4	1.6	9.9	2.5	2.6
Percent RPD	7.5	2.6	2.4	9.6	17.0	6.8	4.2	7.5	3.5	4.1	1.4	14.3	60.0	0.0	18.8	3.2	18.3	4.7	4.6
LR05092005-011	23,100	22.6	177	6,550	2.76	10	23	28	39,500	4,070	8,280	403	2	260	17	48	3.47	42	593
LR05092005-012	22,300	20.6	179	5,720	2.38	10	23	26	39,100	3,910	8,060	355	1	270	17	45.1	2.85	41	551
LR05092005-013	22,800	21.2	184	5,360	2.48	11	24	29	40,200	3,960	8,190	340	1	280	18	47.3	2.99	41.4	614
Mean	22,733	21.5	180	5,877	2.54	10.3	23.3	27.7	39,600	3,980	8,177	366	1.3	270	17.3	46.8	3.10	41.5	586
Std. Dev.	404	1.0	3.6	610	0.20	0.58	0.58	1.53	557	82	111	32.9	0.58	10	0.58	1.51	0.33	0.50	32
Percent RSD	1.8	4.8	2.0	10.4	7.8	5.6	2.5	5.5	1.4	2.1	1.4	9.0	43.3	3.7	3.3	3.2	10.5	1.2	5.5
Percent RPD	3.5	9.3	3.9	20.2	15.0	9.7	4.3	10.8	2.8	4.0	2.7	17.2	75.0	7.4	5.8	6.2	20.0	2.4	10.8

Table 11. Parameters used to calculate radionuclide concentrations from gamma-ray spectrometry data.

[Branching ratio data from ICRP (1983); efficiency determined using NIST-traceable radiometric standard; keV, kiloelectron volts]

Radionuclide	Energy keV	Branching ratio	Efficiency (20 g sample) Canberra detector	Efficiency (20 g sample) EG & G Ortec detector
^{210}Pb	46.6	0.0405	0.0888	0.107
^{234}Th	63.3	0.0380	0.0888	0.107
^{234}Th	92.5	0.0540	0.0888	0.107
^{226}Ra	186.0	0.0360	0.0523	0.0630
^{214}Pb	352.0	0.3670	0.0275	0.0368
^{214}Bi	609.0	0.4690	0.0158	0.0231
^{137}Cs	661.7	0.8500	0.0145	0.0215

for the maximum pool (fig. 14) show that the water level of the reservoir dropped below maximum capacity infrequently until 1952, when reservoir management practices apparently changed and the level of the lake was annually lowered during the winter to accommodate spring runoff.

In core 06MM08, ^{137}Cs activity is first seen in interval 13 (from 56 to 48.5 cm depth, table A8) with increasing activity reaching a maximum in interval 11 (from 43.5 to 38.5 cm depth; fig. 15). An unconformity occurs in the core at interval 10 at depth of 38.5 cm. Radiometric measurements were not made on materials from intervals 10 through 6 (from 38.5 to 17 cm depth) because these materials are fine to coarse sand with too little clay material to capture ^{137}Cs efficiently (Charles and Hites, 1987). Cesium-137 activity was measured in the upper five intervals (from 17 cm to surface) at post-atmospheric-testing levels. The magnitude of the ^{137}Cs peak in core interval 06MM08.11 (0.55 pCi/g) is only slightly lower than the ^{137}Cs activity peaks observed in Lake Roosevelt sediment cores (0.7 to 1.7 pCi/g; Cox and others, 2004) and represents the ^{137}Cs activity peak in the core. We assign a date of 1963±2 yr to sediment in interval 11 (from 43.5 to 38.5 cm depth, table A8). Because of the presence of the unconformity in the core at 38.5 cm depth, the actual age of the core at interval 11 could be slightly older than 1963 if the ^{137}Cs were sequestered from hyporheic flow in the coarse sand in interval 10.

Geochemical Data from Terrace Cores, Blue Creek

Core localities are shown in figures 6 and 7. The discussion of the sediment geochemical data starts with core 06MM08 nearest the Midnite Mine and follows sequentially down-gradient by discussion of the geochemical data from cores 06MM06 and 06MM05, both from Blue Creek. The geochemical data are interpreted in terms of both their geochemical character and the stratigraphy of the cores. Core 06MM03 (p. 40), whose locality was farthest out into the reservoir, consists almost entirely of premining sediment. Cores 06MM01, 06MM02, and 06MM04 are grouped and discussed in order of their locality in Blue Creek cove (figs. 7, 9). Core 06MM01 is the closest to the mouth of Blue Creek, whereas core 06MM04 is collared deeper in the reservoir near the thalweg of Blue Creek at an elevation of 1,252.5 ft (table 6). This means that the terrace represented by 06MM04 was submerged for longer periods of time when compared to those represented by cores 06MM01 and 06MM02, which were exposed when the lake elevation was below that altitude (figs. 14, 16). In other words, if depositional and erosional rates are comparable, the terrace represented by core 06MM04 has the greatest chance of containing the largest portion of sediment from Blue Creek preserved in the post-Lake Roosevelt depositional record. This effect is shown graphically in figure 16 where we plot lake elevations for each month by year for each of the four core sites.

Sediment Geochemistry, Core 06MM08

Core 06MM08 from the Midnite Mine tributary (fig. 13) recovered wetland and sandy sediment from a site just upstream from the gauge station, # 12433556 (fig. 6). Geochemical data from intervals in the core separated on the basis of sedimentological characteristics have elevated concentrations in a selected suite of elements above 66.5 cm depth (table A8 and fig. 17). Only those elements that show major changes in concentration as a result of mining activity at the Midnite Mine are in table 13. A complete compilation of all the sediment geochemical data is in Appendix A, table A16. Note that the concentration axis for some of these trace elements associated with the Midnite Mine (Mn, Co, Ni, Zn, and U) is plotted using a log scale (fig. 17).

Public records of mining activity at the Midnite Mine are relatively sparse. The following summary of mining activity from the period of discovery through 1982, following the cessation of mining at the site, is taken largely from an unpublished report by D.C. Peters (1999, Interpretation of historical aerial photographs (IHAP) of the Midnite Mine: Unpublished Report #ST/BLM-1, 137 p.). Mine history was interpreted from a series of aerial photograph stereo pairs, from the few published references, and from mine maps and records from Dawn Mining Co. provided to D.C. Peters. A map of the Midnite Mine site (fig. 4) shows locations of mine pits and mine-waste dumps referred to throughout this discussion. Waste from mining the calc-silicate and phyllite rock in the roof pendant that hosts a part of the Midnite Mine deposit (fig. 3) provides important geochemical markers that will be used to interpret the timing and effects of mining on sediment geochemistry. Concentration of the trace elements Mn, Co, Ni, Pb, Zn, and U, and U/Th value are most diagnostic of the changes in sediment geochemistry that occurred in core 06MM08 during the period of active mining (fig. 17 and table 13). The concentrations of Ca and Mg are diagnostic of mining the calc-silicate unit. Significant changes are noted beginning with interval 15 in core 06MM08 (table 13).

Early exploration drilling at the mine site caused a large amount of surface disturbance during the preparation of the drill pads. Most of the ore body was completely delineated during this early phase of drilling prior to stripping in 1956 (D.C. Peters, 1999, Interpretation of historical aerial photographs (IHAP) of the Midnite Mine: Unpublished Report #ST/BLM-1, 137 p.). Early excavation of ore from the Boyd Pit (fig. 4) intersected the calc-silicate rock (fig. 3) as shown by the 1957 aerial photographs of the mine site. Mine wastes from the 1957 excavation were dumped south of the mine site (South Spoils, fig. 4) where material could have entered either the west or the central reach of the Midnite Mine tributary. Concentrations of Mn, Co, Ni, and Zn gradually increase in the core with decreasing depth. The initial concentrations of uranium and the U/Th value increase dramatically above interval 14 in the core (fig. 17, from a depth of 60–50 cm). A 1962 mine map (Dawn Mining Co., referenced by D.C. Peters, 1999, Interpretation of historical aerial photographs (IHAP) of

Table 12. ^{137}Cs activity data from selected black silt samples, cores 06MM01 and 06MM08.

[Gamma ray spectroscopy by J.R. Budahn; data reported in disintegrations per minute per gram (dpm/g), which can be converted to picocuries per gram (pCi/g) by dividing by 2.22; --, no data; core intervals shown in italics were not counted because they contained no carbonaceous material to sequester radionuclides. See tables A1 and A8 for Munsell colors of sediment. Peak ^{137}Cs activity indicated by shading of data for sample interval 06MM08.11]

Sample interval	Sample Description	^{137}Cs dpm/g	^{137}Cs pCi/g
06MM01.13	silt	0.01	0.005
06MM01.14	fine sand with iron-oxide staining between 63 and 65	--	--
06MM01.15	black silt (beaver pond)	0.03	0.014
06MM01.16	black silt (beaver pond)	0.02	0.009
06MM01.17	black silt (beaver pond)	0.05	0.023
06MM01.18	black silt (beaver pond)	0.02	0.009
06MM01.19	black silt (beaver pond)	0.05	0.023
06MM01.20	black silt (beaver pond)	0.02	0.009
06MM01.21	black silt (beaver pond) iron oxide at base	0.01	0.005
06MM01.22	gray silt with iron-oxide staining	0.01	0.005
06MM01.23	gray silt with iron-oxide staining, large wood fragment (1x1x3 cm) removed at 113 cm	0.01	0.005
06MM01.24	gray silt with iron-oxide staining	0.01	0.005
06MM01.25	gray silt with iron-oxide staining, bottom 2 cm is coarse sand	0.02	0.009
06MM08.01	black to dark-brown silty clay with solid root mass throughout (wetland sediment)	0.17	0.077
06MM08.02	black to dark-brown silty clay with many root fragments (wetland sediment)	0.26	0.12
06MM08.03	black to dark-brown silty clay with many root fragments (wetland sediment)	0.40	0.18
06MM08.04	black silty clay with many root fragments (wetland sediment)	0.33	0.15
06MM08.05	dark-brown silty clay with many twig and some root fragments (wetland sediment)	0.17	0.077
06MM08.06-10	*fine to coarse sand with little organic content*	--	--
06MM08.11	black silt and clay	1.21	0.55
06MM08.12	black silt and clay	0.71	0.32
06MM08.13	black silt and clay, angular contact from 52 to 60 cm	0.13	0.059
06MM08.14-16	*gravel fining downward into fine sand*	--	--
06MM08.17	dark-brown fine sand and silt and clay	0.03	0.014
06MM08.18	dark-brown to dark-gray silt-clay with small amount of fine sand	0.03	0.014
06MM08.19	dark-brown to dark-gray silt-clay with small amount of fine sand	0.01	0.005
06MM08.20	dark-brown to dark-gray fine sand and silt-clay	0.01	0.005

the Midnite Mine: Unpublished Report #ST/BLM-1, 137 p.) shows a high-lime protore pile from the calc-silicate rock unit identified on the mine map. Aerial photographic evidence (D.C. Peters, 1999, Interpretation of historical aerial photographs (IHAP) of the Midnite Mine: Unpublished Report #ST/BLM-1, 137 p.) indicates that calc-silicate rock was also excavated when the Boyd Pit # 2 was expanded at the mine site in the early 1960s (fig. 4). Both Nash and Lehrman (1975) and Babcock and others (1981) also indicated that the calc-silicate rock was excavated from the Boyd Pit #2. Mine waste from the Boyd Pit #2, which contained calc-silicate rock on the east side of the pit, was dumped on the South Spoils waste dump in the west Midnite Mine tributary drainage (fig. 4). Aerial photographic evidence (D.C. Peters, 1999, Interpretation of historical aerial photographs (IHAP) of the Midnite Mine: Unpublished Report #ST/BLM-1, 137 p.) indicated that uranium ore in the phyllite was the primary target during the early period of mining (1957–1965). Maximum concentrations of uranium and increases in U/Th occurred at a depth of 48.5 to 38.5 cm in core 06MM08, which corresponds to mining activity during the early 1960s, based upon the ^{137}Cs date from core 06MM08. Mining continued through late 1965 when the mine shut down temporarily due to a depressed uranium market (Newton and others, 2006).

Aerial photographs taken in 1968, during the period when the mine was inactive (late 1965–early 1969), indicate that slope failure began on the south side of the South Spoils waste dump (fig. 4; D.C. Peters, 1999, Interpretation of historical aerial photographs (IHAP) of the Midnite Mine: Unpublished Report #ST/BLM-1, 137 p.). Material from this slope failure would have been eroded into the central Midnite Mine tributary and is interpreted to have caused the change in sediment character from silt to sand in intervals 10 through 6, from 38.5 to 17 cm depth (table A8). Although there was some water in the pits at the mine site, there is no visual evidence from the aerial photographs that water escaped impacting surface drainages during this shut-down period. However, the water from the Old Pit # 3 and the Boyd Pit # 2 may have leaked out of the pits, as indicated by the presence of wet ground south of the pits in the 1968 aerial photographs (D.C. Peters, 1999, Interpretation of historical aerial photographs (IHAP) of the Midnite Mine: Unpublished Report #ST/BLM-1, 137 p.).

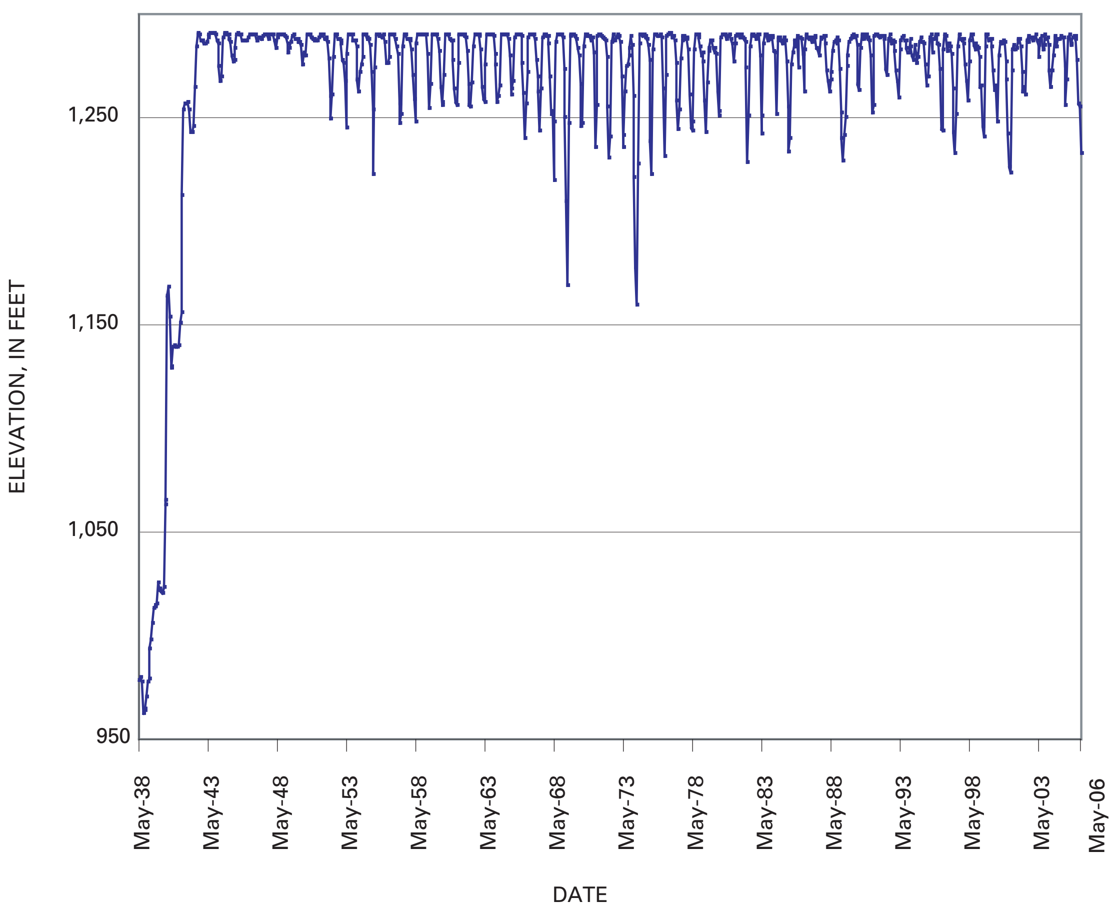


Figure 14. Monthly changes in maximum water elevation measured at Grand Coulee Dam (gauge # 12436000), May 1938 through May 2006. Data are available at URL: http://waterdata.usgs.gov/nwis/inventory/?site_no=12436000&amp.

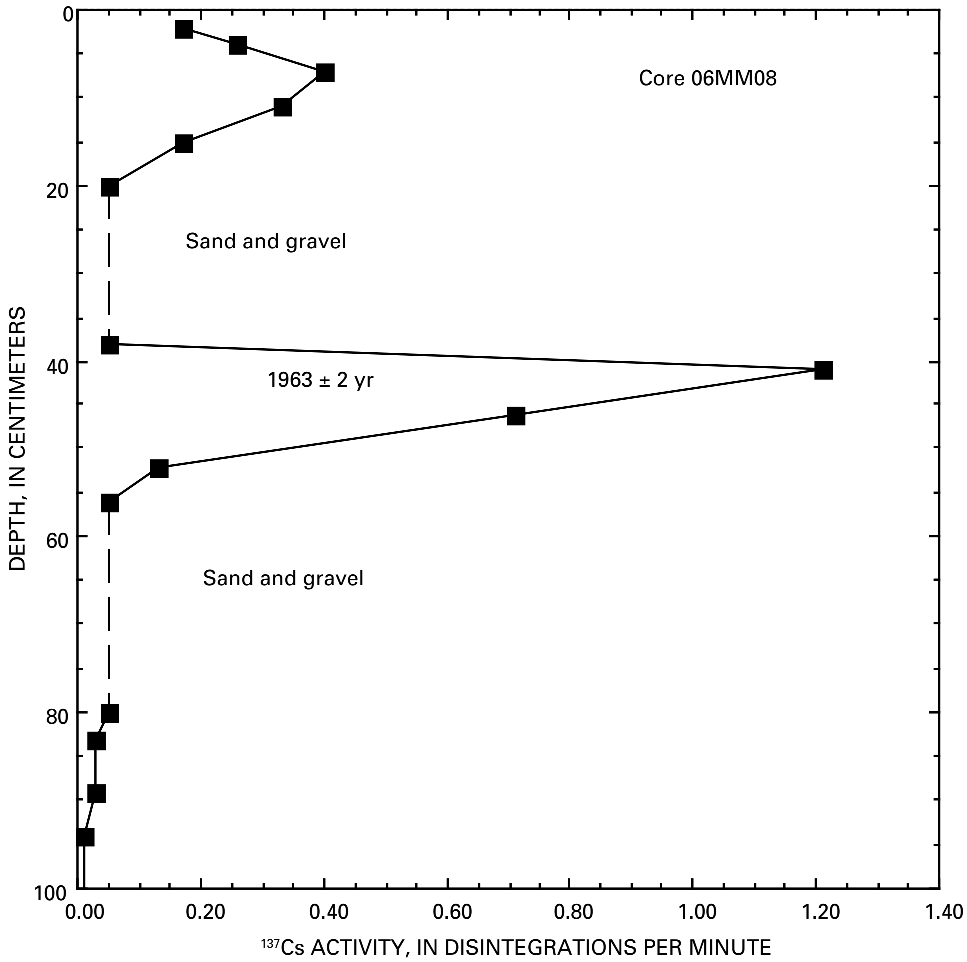


Figure 15. ^{137}Cs activity (disintegrations per minute per gram, dpm/g, table 12) versus depth (in centimeters). ^{137}Cs activity maximum occurs in interval 11 (from 38.5 to 43.5 cm depth) and is interpreted to be the 1963±2 year timeline in core 06MM08. Dashed lines indicate intervals with no data.

The pits were dewatered prior to re-initiation of mining in late 1969. Aerial photographs from August 1970 (D.C. Peters, 1999, Interpretation of historical aerial photographs (IHAP) of the Midnite Mine: Unpublished Report #ST/BLM-1, 137 p.) indicate that, by 1970, mining at the site had intersected the ground-water table and that mine-pit water was draining into the central Midnite Mine tributary. We tentatively identify the reopening of the mine in core 06MM08 by the small increases in concentrations of P, U, Co, Ce, Mg, and Mn in the core in interval 9 from 35.5 to 29 cm depth (fig. 17 and table 13). A large debris flow occurred on the South Spoils waste dump that would have resulted in erosion of mine-waste debris into the west Midnite Mine tributary drainage (fig. 4), possibly providing sandy material to the Midnite Mine tributary. During the period from 1974 through 1977, mining activity increased substantially, and two new pits were opened: Pit # 3 in 1974 and Pit # 4 in about 1976 (fig. 4). Another large slope failure on the South Spoils mine-waste dump moved mine waste into the west Midnite Mine tributary in September 1977. Dawn Mining Co. built buttresses of mine-waste material containing calc-silicate rock stripped from the east side of Pit # 3 to halt the slumping of South Spoils mine-waste dumps into the west and central reaches of the Midnite Mine tributary (D.C. Peters, 1999, Interpretation of historical aerial photographs (IHAP) of the Midnite Mine: Unpublished Report #ST/BLM-1, 137 p.). The buttresses on the South Spoils mine-waste dump were completed by July 1978 (fig. 4). Mine wastes stripped from Pit # 4 were dumped on the Hillside Dump (fig. 4).

In 1978, the pollution control pond (fig. 4) first appeared on aerial photographs of the mine site (D.C. Peters, 1999, Interpretation of historical aerial photographs (IHAP) of the Midnite Mine: Unpublished Report #ST/BLM-1, 137 p.). This feature was built in response to seeps that appeared on the mine-waste dumps (Dawn Mining Company, 1996, Midnite Mine Reclamation Plan, Spokane Indian Reservation: submitted to BLM Spokane District Office, report prepared by Shepherd Miller, Inc., June 3, 1996). Additional seeps developed later and were collected and pumped to the pollution control pond or into Pit # 3 when the flow was too large to be contained in the pollution control pond (fig. 4). According to D.C. Peters (1999, Interpretation of historical aerial photographs (IHAP) of the Midnite Mine: Unpublished Report #ST/BLM-1, 137 p.), stains indicating leaks in the pipeline carrying water from Pit # 3 to the pollution control pond can be seen in these historical aerial photographs. The break in sedimentation from sand to a wetlands depositional environment in core 06MM08 (fig. 17; table A8, depth of 17 cm) occurred at this time. The large increases in Ca, Mn, Co, Ni, Zn, and U concentrations and the increase in U/Th in this segment of core 06MM08 indicate that these elements were being transported by acidic ground water (table 5) and they were sequestered in the reducing wetlands environment. As shown previously by the study of Williams and others (1996), numerous plausible ground-water flow paths from the mine site probably entered the headwaters of the Midnite Mine tributary and could have provided contaminants from the mine site to surface water.

Postmining geochemical concentrations in sediment for many elements (intervals 1–3, above 9 cm depth, table A8) are elevated above the premining geochemical background (table 13). The most dramatic changes occurred in concentrations of Ba, Ca, Cd, Co, Mg, Mn, Mo, Na, Ni, P, Sr, Th, and Zn (table 13). Both Ca and Ba are introduced in the precipitation step at the water treatment facility once the water treatment plant went into operation in 1991. Increases in the concentrations of barium in the core at this time (table 13) are indicative of the addition of barium as a carrier at the water treatment plant to precipitate radioactive $RaSO_4$ (radium sulfate) to break the ^{238}U decay chain (fig. 18). Change in concentrations of Ba and Ca in interval 5 (from 17–13 cm) may be an indication of the current ground-water flow regime encountered at site 06MM08. Postmining concentrations of uranium in sediment of core 06MM08 average 107 ppm and are similar to premining concentrations, albeit the number of premining samples is too small to be statistically rigorous ($n = 6$; GM_U = 106 ppm; table 13).

Radionuclide Data, Core 06MM08

Radionuclides formed by radioactive decay of the ^{238}U-decay series are alpha (α), beta (β), and gamma (γ) -ray emitters. To test whether aqueous geochemical transport has been at least partially responsible for the uranium geochemical anomalies found in core 06MM08, the activity of some of these radionuclides has been measured using gamma-ray emission spectroscopy (table 14). In closed systems, the activities of daughter radionuclides in the ^{238}U-decay series (table 14) should be in equilibrium and have activity ratios of 1 (fig. 18). In near-surface weathering, however, like that documented at the Midnite Mine (Sheldon, 1959), aqueous dissolution and transport of uranium and some of its daughter isotopes results in secular disequilibrium. The activity of ^{234}Th is routinely measured as a proxy for ^{238}U. This approach presumes that ^{238}U and ^{234}Th are in secular equilibrium. This presumption is generally valid since the half-life of ^{234}Th is only 24 days and radioactive equilibrium is achieved in 100–120 days (4 to 5 half-lives). Additional alpha spectroscopy work would be necessary to show that the ^{238}U and ^{234}Th are in secular isotopic equilibrium.

The activity of ^{226}Ra is more difficult to measure accurately. Note that the counting errors for ^{226}Ra in table 14 are about 50 percent, and ^{226}Ra also must be corrected for a large interference from ^{235}U. This interference results from the ^{235}U peak at 185.7 keV that cannot be resolved by gamma-ray spectroscopy. However, the $^{238}U/^{235}U$ mass ratio is known to be constant in nature ($^{238}U/^{235}U = 137.88$). Therefore, an empirical correction can be made to the total peak at 186 keV using the 63.3 keV peak from ^{234}Th. The ^{226}Ra values in table 14 reflect these corrections for the ^{235}U activity in each sample. Two radionuclides, ^{214}Pb and ^{214}Bi, are good proxies for ^{226}Ra activity and are in short-term equilibrium as shown by their activity ratio, which is very close to 1 ($^{214}Bi/^{214}Pb = 0.99 \pm 0.031$, table 14). Using these radionuclide data (that is, $^{226}Ra^{*}/^{234}Th$), the activity ratio of $^{226}Ra/^{238}U$, as shown by the proxy $^{226}Ra^{*}/^{234}Th$, is much less than 1, and generally less than 0.1 (table 14 and fig. 19), indicating entrapment of uranium via aqueous transport of uranium in all of the wetlands sediment intervals in core 06MM08.

Aqueous transport of uranium and the daughter isotopes in the ^{238}U-decay series is interrupted because ^{230}Th, which has a half life of 75,200 years (fig. 18), is not soluble in mildly acidic water and is left behind at the site of dissolution (Zielinski and others, 1986). In addition, $RaSO_4$ is very insoluble, so uranium transport in the aqueous medium also results in a lowering of $^{226}Ra/^{238}U$. Thus, "young" uranium is not detectable by some radiometric methods because radioactive equilibrium is assumed for these radiometric methods. For example, aero-radiometric gamma spectrometry measures the ^{214}Bi and ^{214}Pb activities, and the combined gamma-ray data are used to compute the ^{238}U concentration maps assuming secular equilibrium. Thus, "young" U, especially in wetlands or peat-bog environments like that at site 06MM08, is not detected by these radiometric methods (Owen and others, 1992). The lack of radionuclide equilibrium in the sediment in core 06MM08 shows that uranium has been transported into the wetlands environment recently in solution. In other words, the mechanism for uranium enrichment in modern wetlands sediment is aqueous transport of uranium followed by sorption to decaying plant material.

Comparison of the calculated uranium concentrations in the bulk sample used for the radioisotope measurements also routinely shows higher uranium concentrations in the bulk sample than in the <63 μm component of the sediment (table 14). Uranium concentrations in the <63 μm fraction in the premining portion of core 06MM08 (table 14), however, are higher than in the bulk sediment. These data indicate that small detrital rock fragments containing uranium minerals exist in the larger grain sized fractions of the core intervals as well,

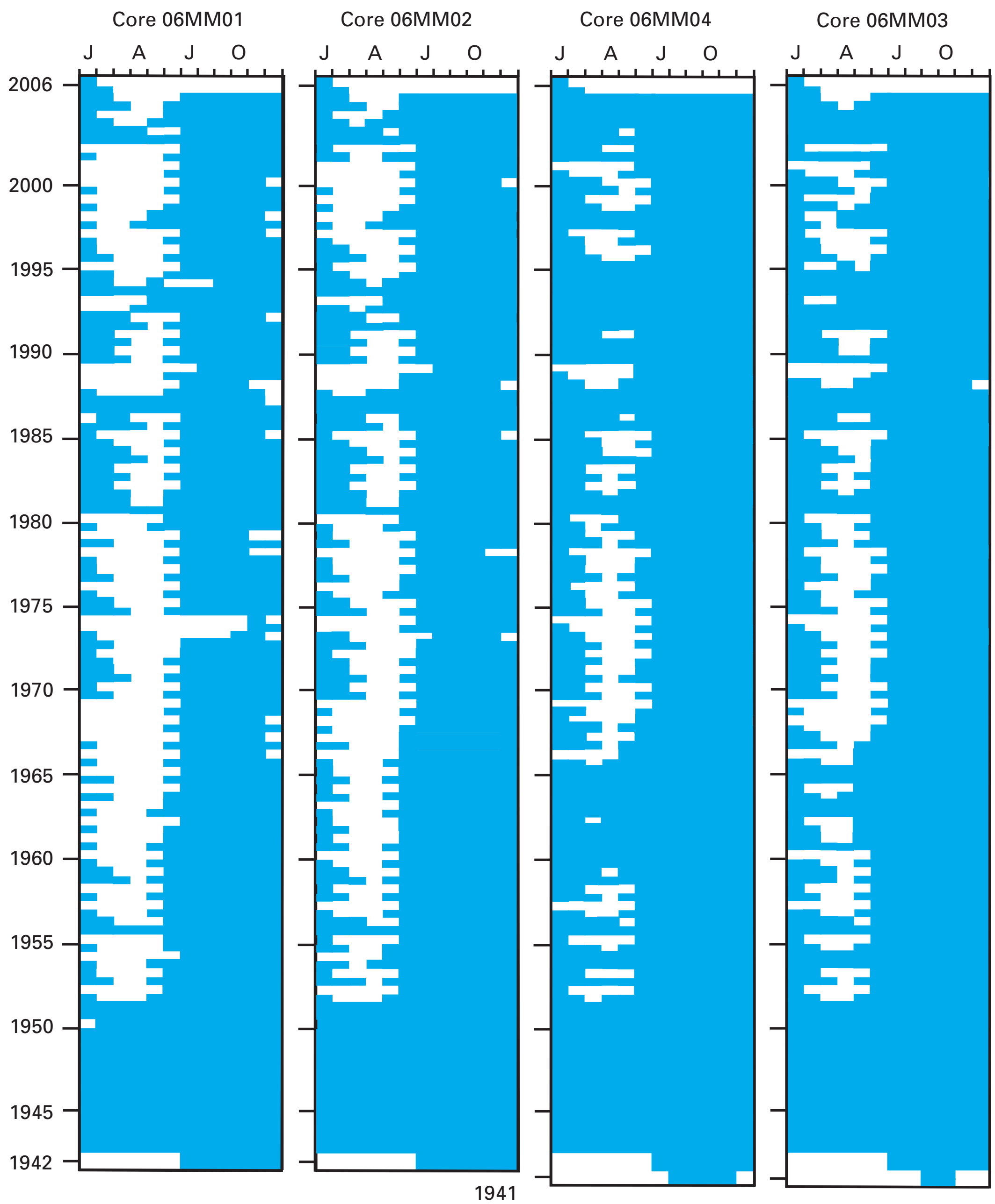


Figure 16. Plot showing time periods when core sites 06MM01–06MM04 were submerged by water in Lake Roosevelt. Minimum and maximum lake elevations were evaluated for each site by month. If a site was submerged for the entire month, the box for that month is completely filled; if submerged for only part of the month, the lower half of the box is filled. Thus, filled boxes (blue) indicate time periods when sedimentation or erosion at the site could have occurred. Conversely, white boxes indicate time periods when the site was exposed and dry; wind erosion could have occurred.

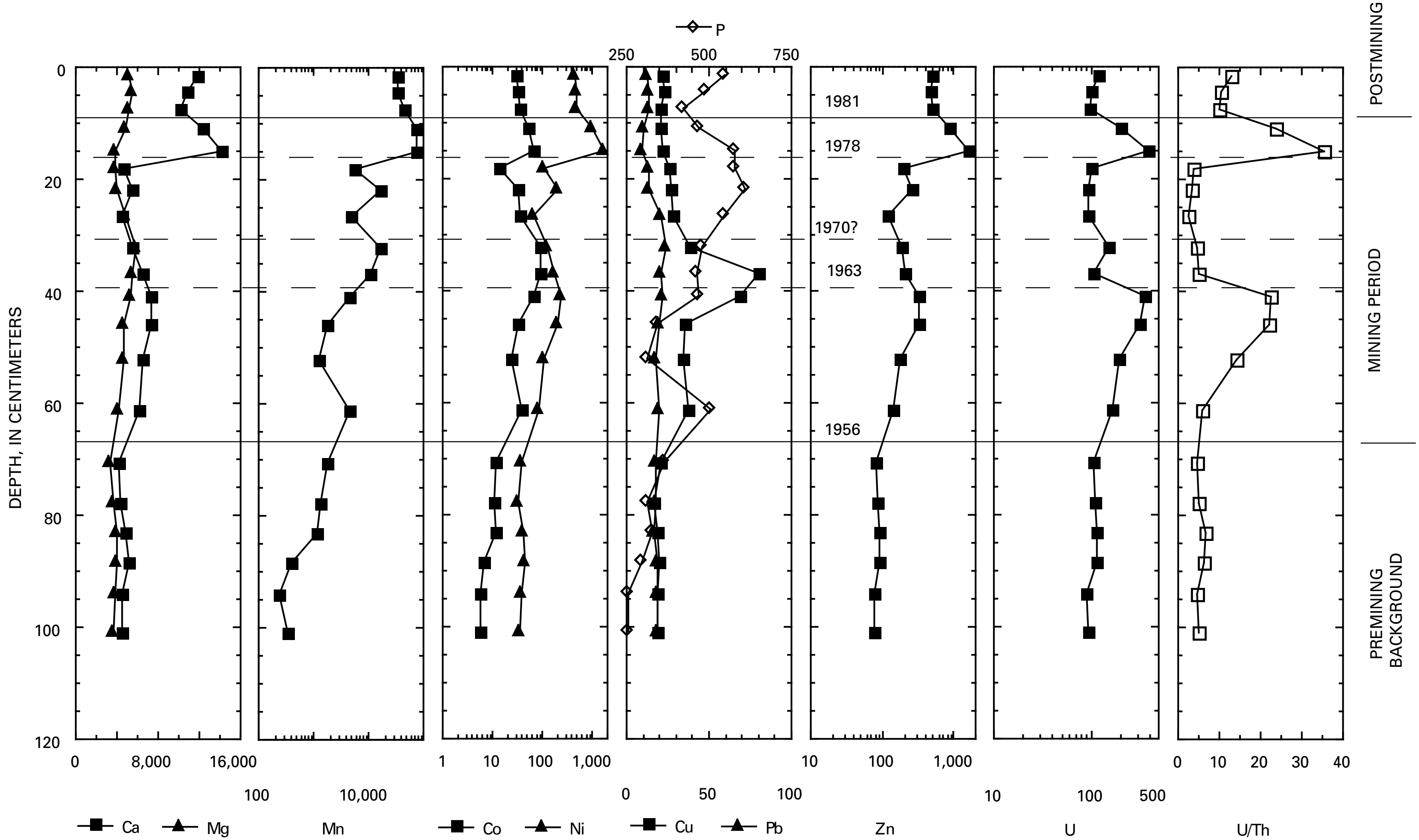


Figure 17. Geochemical plots of the concentrations of calcium (Ca), magnesium (Mg), manganese (Mn), cobalt (Co), nickel (Ni), phosphorus (P, concentrations shown at top of figure), copper (Cu), lead (Pb), zinc (Zn), uranium (U), all in parts per million (ppm or µg/g), and the U/Th value (uranium/thorium) versus depth (in centimeters) for core 06MM08. The 1963 timeline was determined by ^{137}Cs chronometry (fig. 15). The 1956, 1970?, 1978, and 1981 timelines are interpreted from changes observed in the geochemical profiles and the expected response from mining practices and activity recorded at the Midnite Mine site (D.C. Peters, 1999, Interpretation of historical aerial photographs (IHAP) of the Midnite Mine: Unpublished Report #ST/BLM-1, 137 p.).

Table 13. Selected geochemical data and statistical summary, core 06MM08.

[Complete list of all geochemical data is in table A16; depth reported in centimeters (cm); concentrations reported in parts per million (ppm) or weight percent (wt. percent); Std. Dev., standard deviation; --, no data]

Sample interval	Depth (cm)	As ppm	Ba ppm	Ca ppm	Cd ppm	Co ppm	Cu ppm	Fe ppm	K ppm	Mg ppm	Mn ppm	Mo ppm	Na ppm	Ni ppm	P ppm	Pb ppm	Sr ppm	Th ppm	Ti ppm	U ppm	Zn ppm	U/Th	Total Carbon wt. percent
06MM08.01	0-3	10.0	229	11,900	13.6	31.0	21.9	19,200	2,520	5,210	34,900	15.0	246	456	549	12.9	50.2	9.36	781	119	505	12.7	4.89
06MM08.02	3-6	10.6	230	10,800	11.7	31.4	22.6	20,600	2,720	5,430	33,900	14.4	234	466	488	13.9	46.0	9.54	865	101	471	10.6	3.84
06MM08.03	6-9	10.2	295	10,200	12.3	35.3	21.2	19,800	2,680	5,100	44,100	20.4	218	468	420	13.1	49.8	10.0	839	99.8	499	10.0	2.72
06MM08.04	9-13	11.6	442	12,400	14.6	51.1	21.0	17,800	2,540	4,890	77,000	24.5	220	1,000	470	10.7	61.9	8.45	763	202	888	23.9	3.43
06MM08.05	13-17	15.7	739	14,200	20.4	65.4	22.0	14,100	2,160	3,900	77,000	34.7	193	1,750	578	9.7	70.9	11.0	584	391	1,640	35.5	3.57
06MM08.06	17-19.5	8.8	106	4,640	3.0	13.3	26.5	20,200	2,530	3,780	5,710	2.5	152	110	578	13.5	23.6	28.4	867	103	200	3.6	--
06MM08.07	19.5-24	10.4	150	5,580	3.4	31.8	27.0	18,200	2,300	4,070	16,200	4.9	182	208	609	13.9	26.9	28.8	748	92.6	258	3.2	--
06MM08.08	24-29	17.1	124	4,490	1.2	36.6	27.8	23,900	3,440	4,790	4,980	4.2	172	64	548	20.6	25.0	34.5	806	92.5	119	2.7	--
06MM08.09	29-35.5	22.0	150	5,440	2.8	94.1	38.8	27,900	3,790	5,800	16,600	6.2	204	129	478	23.7	33.0	34.3	799	154	190	4.5	--
06MM08.10	35.5-38.5	24.0	154	6,580	1.7	92.7	79.7	23,600	3,100	5,480	11,100	3.7	209	172	463	20.6	37.6	22.4	774	108	206	4.8	--
06MM08.11	38.5-43.5	25.8	137	7,280	4.8	64.2	68.4	22,300	2,780	5,250	4,420	3.0	226	235	468	21.5	34.2	16.1	801	365	315	22.7	3.15
06MM08.12	43.5-48.5	13.2	134	7,360	4.1	33.4	34.9	22,200	2,690	4,590	1,800	2.3	239	197	345	20.0	30.8	14.6	849	320	316	21.9	3.40
06MM08.13	48.5-56	9.2	166	6,560	1.5	23.0	34.4	22,900	2,960	4,620	1,230	1.4	239	110	313	17.3	30.3	13.9	906	198	175	14.2	2.34
06MM08.14	56-66.5	12.5	146	6,110	1.4	39.5	37.7	25,300	3,260	4,220	4,650	3.0	203	86	506	19.5	27.7	28.4	910	169	138	6.0	--
06MM08.15	66.5-75	11.9	92.9	4,110	0.57	11.9	20.8	22,200	3,020	3,260	1,820	2.8	158	37	363	18.0	20.9	23.6	915	108	82.4	4.6	--
06MM08.16	75-80.5	10.3	138	4,330	0.66	10.8	16.8	22,400	2,910	3,670	1,350	1.7	185	33	312	17.2	23.9	21.2	1,040	109	88.0	5.1	--
06MM08.17	80.5-86	15.4	169	4,760	0.48	11.2	18.5	26,000	2,890	3,920	1,180	1.6	164	42	330	16.2	24.7	17.2	996	117	91.7	6.8	1.29
06MM08.18	86-91	10.6	112	5,090	0.52	6.6	19.8	25,600	2,970	3,930	388	1.0	162	44	295	18.3	23.2	18.8	944	117	88.8	6.2	1.54
06MM08.19	91-97	5.6	90.4	4,500	0.42	5.8	18.7	21,000	2,960	3,820	239	0.83	163	37	255	18.4	20.8	19.4	981	91.8	75.2	4.7	1.29
06MM08.20	97-105	5.0	87.5	4,450	0.47	5.8	19.0	20,600	2,940	3,720	344	0.89	156	36	257	18.7	20.5	18.9	958	94.2	75.8	5.0	1.32
Postmining Period (Intervals 01-03, *n* = 3)																							
Minimum		10.0	229	10,200	12	31	21.2	19,200	2,520	5,100	33,900	14	218	456	420	12.9	46	9.4	781	100	471	10.7	2.72
Maximum		10.6	295	11,900	14	35	22.6	20,600	2,720	5,430	44,100	20	246	468	549	13.9	50	10.0	865	119	505	11.9	4.89
Mean		10.3	251	10,967	13	33	21.9	19,867	2,640	5,247	37,633	17	233	463	486	13.3	49	9.6	828	107	492	11.1	3.82
Premining Period (Intervals 15-20, *n* = 6)																							
Minimum		5.0	88	4,110	0.4	6	16.8	20,600	2,890	3,260	239	0.8	156	33	255	16.2	21	17.2	915	92	75	5.3	1.29
Maximum		15.4	169	5,090	0.7	12	20.8	26,000	3,020	3,930	1,820	2.8	185	44	363	18.7	25	23.6	1,040	117	92	5.0	1.54
Median		10.5	102	4,475	0.5	9	18.9	22,300	2,950	3,770	784	1.3	163	37	304	18.2	22	19.2	970	109	85	5.7	1.31
Geometric Mean		9.1	111	4,529	0.5	8	18.9	22,873	2,948	3,713	672	1.3	164	38	300	17.8	22	19.7	972	106	83	5.4	1.36
Mean		9.8	115	4,540	0.5	9	18.9	22,967	2,948	3,720	887	1.5	165	38	302	17.8	22	19.9	972	106	84	5.3	1.36
Std. Dev.		3.9	33	343	0.1	2.9	1.3	2,303	46	248	653	0.7	10	4	42	0.9	1.8	2.2	44	10.9	7	4.9	0.12
Mining Period (Intervals 04-14, *n* = 11)																							
Minimum		8.8	106	4,490	1.2	13	21.0	14,100	2,160	3,780	1,230	1.4	152	64	313	9.7	24	8.5	584	93	119	10.9	--
Maximum		25.8	739	14,200	20	94	79.7	27,900	3,790	5,800	77,000	35	239	1,750	609	23.7	71	34.5	910	391	1,640	11.3	--
Median		13.2	150	6,560	3.0	40	34.4	22,300	2,780	4,620	5,710	3.7	204	172	478	19.5	31	22.4	801	169	206	7.5	--
Geometric Mean		14.5	180	6,856	3.4	43	34.7	21,333	2,830	4,631	8,746	4.8	202	204	478	16.7	34	19.8	796	174	280	8.8	--
Mean		15.5	223	7,331	5.4	50	38.0	21,673	2,868	4,672	20,063	8.2	204	369	487	17.4	37	21.9	801	200	404	9.1	--
Std. Dev.		6.0	194	3,122	6.3	27	18.9	3,865	498	655	28,627	11	27	527	93	4.7	15	9.5	90	111	462	11.7	--

especially during the mining and post-mining periods (table 13 and fig. 17). Therefore, some but not all of the uranium concentration peaks in each interval in core 06MM08 (figs. 17, 19) resulted from aqueous transport of uranium. Work by numerous investigators has shown that soluble uranium is strongly sequestered from acidic to neutral waters (pH 3.5–7) by organic matter in wetland settings (K_D > 10,000; Owen and others (1992) and references therein). The pH values recorded by Sumioka (1991, table 5) show that the pit waters are mildly acidic (Pit # 3, pH was 4.5 to 4.7) to near neutral (Pit # 4, pH was 6.8–7.6) and that activity ratios in water from both pits are strongly out of secular equilibrium (Pit # 4, ^{226}Ra/^{238}U = 0.00018–0.00028; Pit # 3, ^{226}Ra/^{238}U = 0.001–0.0018). The water in the pollution control pond is more acidic (pH 3.6–3.8) and has ^{226}Ra/^{238}U = 0.0001–0.00012. Using the disequilibrium ratios measured in the core intervals (^{226}Ra*/^{234}Th; table 14 and fig. 19) would indicate that between 81 and more than 95 percent of the ^{238}U present in core intervals (table 14) was transported to the Blue Creek wetlands at site 06MM08 in the aqueous phase. There is also a strong correlation between total carbon and uranium concentration measured in the core intervals in the upper part of the core (table 13 and fig. 20) as indicated by the strong sorbtion of uranium in the core sediment during the mining period (intervals 13 through 5, from 56 to 13 cm depth) in core 06MM08.

Examination of the activities of ^{226}Ra, ^{214}Pb, and ^{214}Bi in the upper part of core 06MM08 (intervals 4 and 5, from 17 to 13 and 13 to 9 cm depth, table A8) and comparison with the activity of ^{234}Th (fig. 19 and table 14) show that the activity peaks in this core interval are offset. Since all radioisotope measurements were made simultaneously on each core interval, this difference is real. Further, the differences in activities are large. The data indicate that “young” uranium is being added to interval 5. Interval 5 is the base of the wetlands sediment, which overlies a 21.5-cm-thick sand unit (intervals 10 to 6, from 38.5 to 17 cm depth, table A8). It contains coarse woody debris. Thus, there is good circulation with the water in the underlying sand unit. The most plausible explanation for

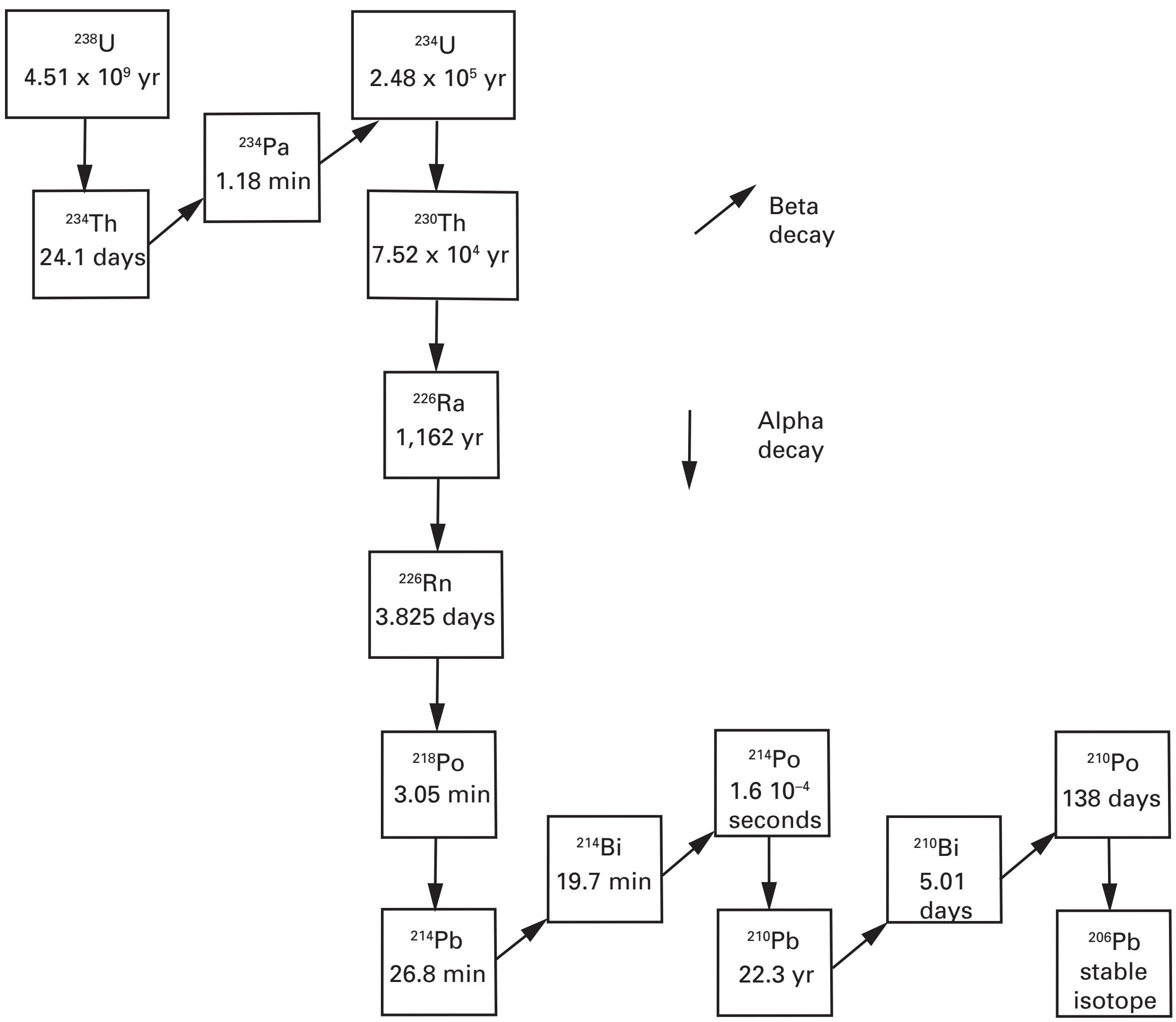


Figure 18. ^{238}U decay series showing alpha and beta decay mechanisms and giving half-lives for each of the radionuclides. Small branching decay chains are not shown.

the elevated ^{234}Th data in interval 5 is that "young" uranium is actively being transported in the hyporheic zone and sequestered at the base of the peat section. Nowhere else in core 06MM08 are the activity peaks of the ^{226}Ra daughter isotopes offset from the ^{234}Th activity. Zielinski and others (1986) described another setting in Flodelle Creek, Stevens County, Wash., where uraniferous waters have deposited uranium and ^{238}U-series daughters (fig. 18) in a young peat where the ^{238}U-series daughter isotope activities show similar disequilibrium effects.

Sediment Geochemistry, Core 06MM06

Core 06MM06 (figs. 6, 11) was collected on the upstream side of an eroded alluvial fan as it enters Blue Creek. Selected element concentrations that show major changes as a result of mining activity at the Midnite Mine in core 06MM06, as defined from core 06MM08, are in table 15. A complete compilation of all the sediment geochemical data from core 06MM06 is in Appendix A, table A14. The core penetrated the base of the alluvial fan and intersected premining sediment of Blue Creek in the basal intervals of the core. This basal section (intervals 12–10, from 50.5 to 31 cm depth in the hyporheic zone) has elevated concentrations of uranium and elevated U/Th in the bottom three intervals of the core (table A6 and fig. 21). Intervals 1–8 (above 25 cm depth) are samples of alluvial fan material entering the Blue Creek drainage from an unnamed tributary from the north (fig. 6). The aforementioned dendrochronological results obtained from a Douglas-fir tree growing on the eroded alluvial fan deposit predate mining (1956; the tree is dated at 1909, A.E. Koenig, written commun., 2006). Interval 9 (from 31 to 25 cm depth) is transitional between the two material types and is not included in the statistical analysis of the data (table 15). Elevated concentrations of Mn, Co, Ni, and U occur only at the basal intervals of the core, indicating that no sediment from Blue Creek was deposited at the site during the mining period. Both data sets represent premining geochemical background. The upper part of the core is sediment from unmineralized granitic rock eroded from the headwaters of the unnamed south-flowing tributary (fig. 6), whereas the data from the lower interval represent premining sediment from Blue Creek downstream from the mineralized area of the Midnite Mine. On the basis of these limited geochemical data, the geochemical background for uranium in sediment of Blue Creek at this distance from the mine site about 100 years ago is approximately 70 ppm. Concentrations of Ba and K are lower, and concentrations of Cu, Fe, Na, Th, and Zn are higher in sediment from Blue Creek than in the granitic alluvial fan material.

Spikes in the concentrations of U, Zn, P, and Mn and the U/Th value suggest some possible reworking of sediment in the top 12 cm (intervals 1–5, tables 15 and A6, and fig. 21) with addition of metals released from the Midnite Mine site. Data in the upper five intervals have not been excluded from the statistical summary of the alluvial fan data (table 15). We see no evidence of postmining sediment in the core from this site.

Sediment Geochemistry, Core 06MM05

Core 06MM05 taken at the mouth of Blue Creek (figs 6, 7, and 10) recovered sandy sediment (table A5) that is mostly postmining in age (intervals 1–6, above 41 cm depth, table A5). Selected element concentrations that show major changes as a result of mining activity at the Midnite Mine in core 06MM05, as shown by comparison and correlation with the geochemical data from core 06MM08, are in table 16. A complete compilation of all the sediment geochemical data from core 06MM05 is in Appendix A, table A13. Relative to the data from core 06MM08 (table 13), postmining concentrations of all elements are lower in sediment from core 06MM05 (table 16) reflecting dilution by unmineralized granitic rock elsewhere in the Blue Creek drainage (fig. 2). Concentrations of Ca, Cd, Co, Cu, Fe, Mg, Mn, Ni, P, U, and Zn are elevated relative to the alluvial fan material in core 06MM06, indicating that mining at the Midnite Mine site had an effect on material at the mouth of Blue Creek. Postmining uranium concentration in sediment at the mouth of Blue Creek is 44±9 ppm (table 16, $n = 6$). The large uranium peak at a depth of 50–55 cm in core 06MM05 is interpreted to be the 1978 uranium peak identified late in the mining history in core 06MM08 (fig. 17). The geochemical data in core 06MM05 (fig. 22) correlate well with that in core 06MM08 (fig. 17) with peak concentrations in Ca, Mn, Co, Ni, P, U and high U/Th values in intervals 7 and 8 (from 55 to 41 cm depth). No premining geochemical data were obtained from site 06MM05.

Sediment Geochemistry, Cores from the Blue Creek Delta

Core 06MM03 is located on a high beach terrace in the Blue Creek cove that is elevated above and south of the active channel of Blue Creek (figs. 7, 9). In contrast, cores 06MM01, 06MM02, and 06MM04 are located in the cove near the mouth of Blue Creek in the active channel (figs. 7, 9). As a result, they collectively contain a more complete historical record of sedimentation from Blue Creek (fig. 16). Core 06MM01 is the closest to the mouth of Blue Creek (fig. 8), whereas core 06MM04 (fig. 9) is collared on a low terrace in the thalweg of Blue Creek and appears to contain the most complete sedimentological record of deposition during the mining period.

Sediment Geochemistry, Core 06MM03

Selected geochemical data from most of core 06MM03, as shown by comparison and correlation with the geochemical data from core 06MM08 (intervals 5–20, table 17) represent sediment eroded from the upstream drainage area and deposited in the delta prior to mining and prior to the formation of Lake Roosevelt. A complete compilation of the sediment geochemical data from core 06MM03 is in Appendix A, table A11. This core intersected a long interval of fine to

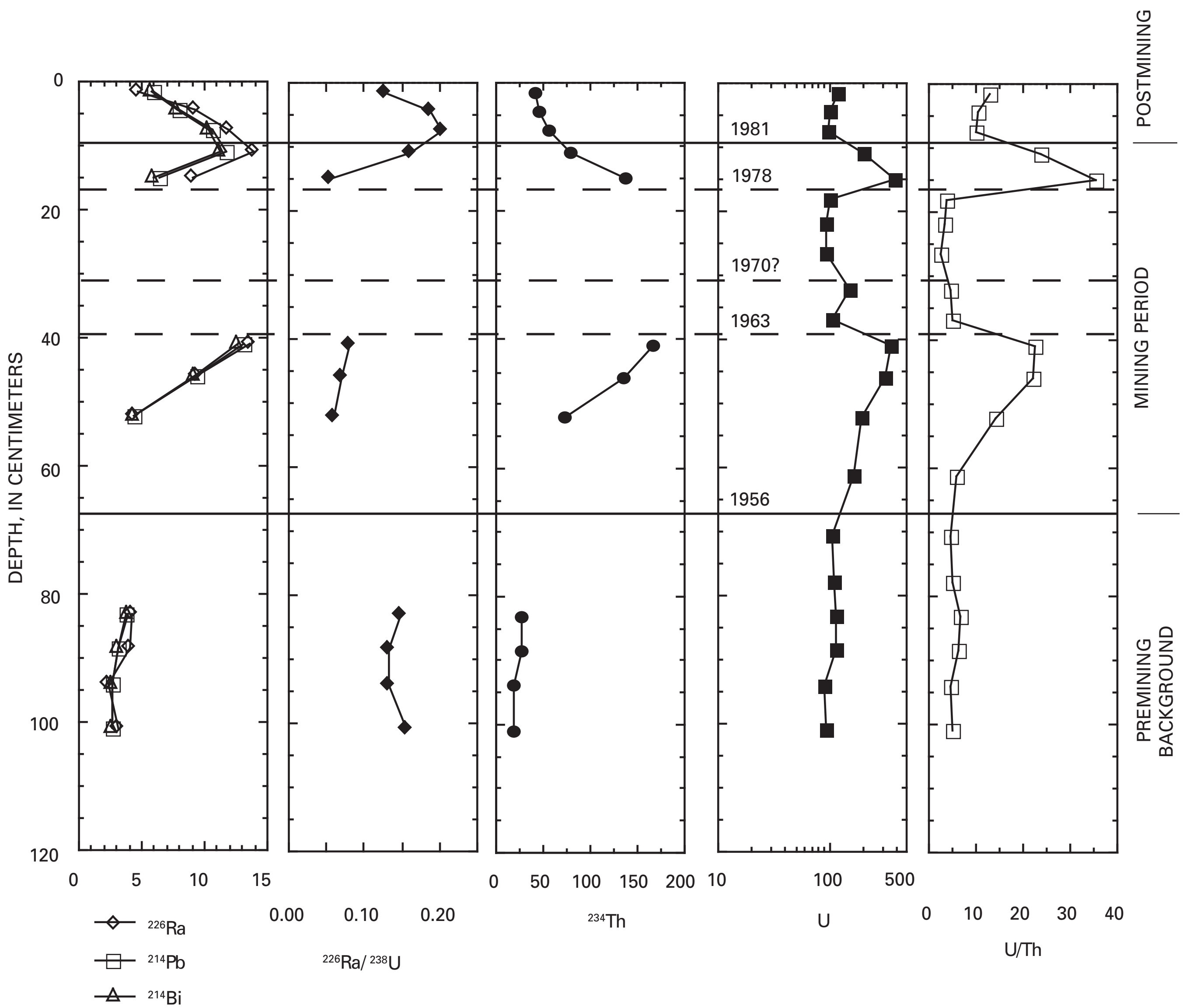


Figure 19. Radionuclide activities (pCi/g) measured in core 06MM08 for ^{226}Ra, ^{214}Pb, ^{214}Bi, and ^{234}Th; activity ratios for $^{226}Ra/^{238}U$; concentrations of uranium (log scale); and the U/Th value versus depth (in centimeters). Since there are large counting errors associated with the direct measurement of the ^{226}Ra activity, the $^{226}Ra/^{238}U$ value is calculated from the activities of ^{214}Pb and ^{214}Bi. Because of the long half-life of ^{230}Th (fig. 18), the activity of ^{234}Th is used as a proxy for the ^{238}U activity. This ratio is used to demonstrate that the activity of the two isotopes ($^{226}Ra/^{238}U$) is out of equilibrium. This disequilibrium is caused by aqueous transport of ^{238}U and subsequent deposition at another site.

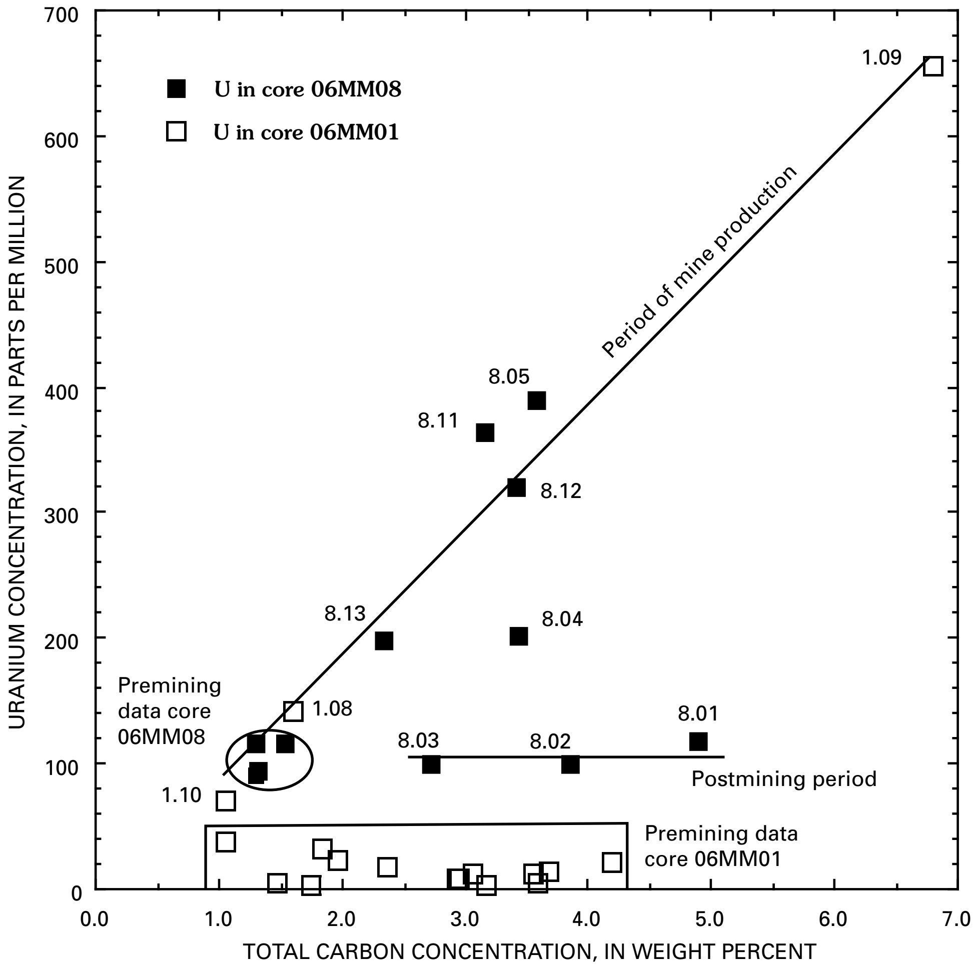


Figure 20. Plot of the measured total carbon concentration (in weight percent) versus the measured uranium (U) concentration (in parts per million) in organic-rich sediment from cores 06MM01 and 06MM08. Sample points indicate core interval: 8.03 is plot of data from core 06MM08, interval 3.

medium sand (table A3) that predates mining at the Midnite Mine, that is, pre-1942 as indicated by the elevated Cu-Pb-Zn contamination introduced by the filling of the reservoir and subsequent contamination from the water in the Spokane River (Grosbois and others, 2002; Horowitz and others, 1993, 1995; Cox and others, 2004). Profiles of the geochemical data are in figure 23. The premining geochemical data from core 06MM03 do not reflect any enrichment of the metal suite associated with mining activity at the Midnite Mine site (core 06MM08, table 13). This indicates that, despite the fact that the site is submerged most of the year throughout the history of the reservoir (fig. 16), either the site has been outside the depositional area of influence of Blue Creek since mining began or erosion has removed the young sedimentary record. Premining uranium concentrations in sediment deposited prior to filling of the reservoir (Oct.–Nov. 1941; fig. 16) averaged 2.4±0.58 ppm (n = 15, intervals 20 through 6, from 148 to 24 cm depth, table 17). Concentrations of Co and Ni are also uniformly low, 8±1.6 and 19±3.4 ppm, and are similar to the concentrations from the alluvial fan material from core 06MM06 (10.5 and 17 ppm, table 15). Sediment in core 06MM03 probably contains a larger component of the glacial granitic sediment in the terrace material that crops out along the shore of the reservoir (Becraft and Weis, 1963). Although U/Th rises in the upper 24 cm of the core, the U/Th value does not exceed 0.7 and is in the range of premining background values from the NURE sediment study (0.19 to 0.66, table 3). In contrast, the U/Th value in premining sediment from core 06MM08 from the Midnite Mine tributary is 5.41±0.89 (n = 6); during the mining period, U/Th exceeded 20 due to aqueous release of uranium from the mine site (fig. 17).

Table 14. Radioisotope data from selected black silt samples, cores 06MM01 and 06MM08.

[U content (in parts per million; ppm) based on the ^{234}Th activity data, which are in picocuries per gram (pCi/g), was calculated using a conversion factor of 0.333 pCi/g (picocuries per gram). U concentration data from tables A9 and A16. Average concentration of U shown in italics from table A16 in missing data intervals from core 06MM08; --, no data. See tables A1 and A8 for Munsell colors of sediment. ^{226}Ra*/^{234}Th is the activity ratio calculated from the measured ^{214}Pb and ^{214}Bi activities]

Sample interval	Sample description	U (ppm) (Based on ^{234}Th activity)	U ppm[1]	^{234}Th pCi/g ± 0.34	^{226}Ra pCi/g ± 0.60	^{214}Pb pCi/g ± 0.11	^{214}Bi pCi/g ± 0.11	^{210}Pb pCi/g ± 0.23	^{214}Bi/^{214}Pb	^{210}Pb/^{214}Pb	^{226}Ra*/^{234}Th
06MM01.13	silt	15	18.8	5.0	1.2	1.5	1.6	1.9	1.00	1.25	0.311
06MM01.14	fine sand with iron-oxide staining between 63 and 65	--	11.4	--	--	--	--	--	--	--	--
06MM01.15	black silt (beaver pond)	20	12.4	6.8	1.4	1.8	1.7	2.1	0.93	1.12	0.263
06MM01.16	black silt (beaver pond)	14.7	8.54	4.9	1.4	1.7	1.6	2.4	0.96	1.45	0.338
06MM01.17	black silt (beaver pond)	12.3	9.04	4.1	1.7	1.7	1.8	2.0	1.03	1.15	0.424
06MM01.18	black silt (beaver pond)	18.0	13.2	6.0	1.7	1.8	1.8	2.4	0.99	1.32	0.299
06MM01.19	black silt (beaver pond)	36	22.3	12	2.7	2.2	2.2	2.8	1.00	1.26	0.185
06MM01.20	black silt (beaver pond)	19.9	14.2	6.6	1.8	1.8	1.9	2.2	1.07	1.24	0.284
06MM01.21	black silt (beaver pond) iron oxide at base	8.3	5.72	2.8	1.3	1.5	1.6	2.0	1.06	1.29	0.564
06MM01.22	gray silt with iron-oxide staining	5.7	4.27	1.9	0.9	1.2	1.3	1.7	1.05	1.40	0.664
06MM01.23	gray silt with iron-oxide staining	4.7	4.48	1.6	1.1	1.3	1.3	1.5	1.03	1.16	0.836
06MM01.24	gray silt with iron-oxide staining	6.0	5.38	2.0	1.0	1.3	1.3	1.4	1.06	1.14	0.647
06MM01.25	gray silt with iron-oxide staining, bottom 2 cm are coarse sand	15	33.7	4.9	0.7	1.4	1.4	1.6	1.04	1.18	0.288
06MM08.01	black to dark-brown silty clay with solid root mass throughout (wetland sediment)	125	119	41.7	4.7	5.9	5.8	9.7	0.98	1.64	0.141
06MM08.02	black to dark-brown silty clay with many root fragments (wetland sediment)	137	101	45	9.2	7.9	7.7	11	0.98	1.41	0.172
06MM08.03	black to dark-brown silty clay with many root fragments (wetland sediment)	166	100	55	12	11	10	11	0.97	1.05	0.190
06MM08.04	black silty clay with many root fragments (wetland sediment)	240	202	80	14	12	11	10	0.97	0.90	0.144
06MM08.05	dark-brown silty clay with many twig and some root fragments (wetland sediment)	414	391	138	9.0	6.4	6.0	8.7	0.94	1.37	0.045
06MM08.06-10	*fine to coarse sand with little organic content*	--	*110*	--	--	--	--	--	--	--	--
06MM08.11	black silt and clay	498	365	166	14	13	13	20	0.97	1.50	0.078
06MM08.12	black silt and clay	404	320	135	9.4	9.4	9.3	14	0.98	1.47	0.069
06MM08.13	black silt and clay, angular contact from 52 to 60 cm	219	198	73	4.4	4.4	4.4	7.4	1.02	1.69	0.060
06MM08.14-16	*gravel fining downward into fine sand*	--	*129*	--	--	--	--	--	--	--	--
06MM08.17	dark-brown fine sand and silt and clay	81	117	27	4.3	3.7	3.8	5.1	1.03	1.36	0.140
06MM08.18	dark-brown to black silt-clay with small amount of fine sand	82	117	27	4.1	3.1	3.2	4.6	1.04	1.51	0.115
06MM08.19	dark-brown to black silt-clay with small amount of fine sand	58	92	19	2.4	2.7	2.7	3.6	1.00	1.33	0.140
06MM08.20	dark-brown to black fine sand and silt-clay	54	94	18	3.0	2.6	2.7	4.1	1.03	1.55	0.147

[1]Uranium concentrations from the <63 μm fraction, tables 13 and 20.

Table 15. Selected geochemical data and statistical summary, core 06MM06.

[Complete list of all geochemical data is in table A14; depth reported in centimeters (cm); concentrations reported in parts per million (ppm); Std. Dev., standard deviation]

Sample interval	Depth (cm)	As ppm	Ba ppm	Ca ppm	Cd ppm	Co ppm	Cu ppm	Fe ppm	K ppm	Mg ppm	Mn ppm	Mo ppm	Na ppm	Ni ppm	P ppm	Pb ppm	Sr ppm	Th ppm	Ti ppm	U ppm	Zn ppm	U/Th
06MM06.01	0-2.5	2.9	144	5,600	0.23	5.2	13.0	17,300	3,170	3,520	631	0.90	196	13	696	20.6	36.9	18.3	858	11.4	63.4	0.62
06MM06.02	2.5-5.5	3.7	187	6,440	0.26	5.8	13.8	18,100	3,390	3,900	694	0.88	190	11	682	20.8	41.0	20.5	919	18.5	55.5	0.90
06MM06.03	5.5-8.5	4.2	171	5,530	0.15	5.9	13.6	18,100	3,100	3,400	567	0.87	197	11	588	17.8	39.6	23.8	860	28.6	46.4	1.20
06MM06.04	8.5-10	3.7	157	4,410	0.12	5.2	12.3	16,000	2,780	2,810	509	1.1	190	10	395	14.0	33.6	24.4	831	19.4	37.2	0.80
06MM06.05	10-12	3.8	238	5,560	0.19	6.4	18.9	17,400	2,860	2,780	710	1.4	164	16	462	16.6	43.6	21.8	811	18.1	41.2	0.83
06MM06.06	12-15.5	4.4	151	3,940	0.12	5.4	13.8	17,900	3,000	2,900	396	1.3	148	11	386	15.0	32.5	30.6	911	13.8	41.4	0.45
06MM06.07	15.5-20	4.4	165	4,870	0.14	6.3	20.0	20,300	3,360	3,640	464	1.1	166	15	390	17.0	41.5	29.0	1,050	28.8	50.9	0.99
06MM06.08	20-25	5.2	106	3,830	0.08	5.6	13.9	18,000	2,920	3,100	323	1.4	131	11	316	14.3	30.0	25.7	941	30.5	42.6	1.19
06MM06.09	25-31	5.4	101	4,230	0.11	6.1	19.4	20,600	2,840	3,340	370	1.2	161	14	315	15.4	31.3	23.4	955	50.8	46.6	2.17
06MM06.10	31-36.5	4.7	106	5,400	0.11	5.5	22.7	25,400	3,010	3,770	326	0.66	208	16	354	17.8	38.7	33.2	1,100	69.1	57.3	2.08
06MM06.11	36.5-42	4.0	96.7	5,790	0.07	3.7	21.0	25,100	2,820	3,610	213	0.47	205	12	470	16.7	38.4	49.8	1,020	72.4	59.6	1.45
06MM06.12	42-50.5	7.7	133	5,570	0.17	10.3	20.4	28,300	2,760	3,510	1,130	1.4	226	21	708	24.2	36.3	62.0	861	69.0	64.8	1.11
Alluvial fan material (Intervals 01-08, *n* = 8)																						
Minimum		2.9	106	3,830	0.08	5.2	12	16,000	2,780	2,780	323	0.9	131	10	316	14	30	18	811	11	37	0.62
Maximum		5.2	238	6,440	0.26	6.4	20	20,300	3,390	3,900	710	1.4	197	16	696	21	44	31	1,050	31	63	1.00
Median		4.0	161	5,200	0.15	5.7	14	17,950	3,050	3,250	538	1.1	178	11	429	17	38	24	886	19	45	0.79
Geometric Mean		4.0	161	4,948	0.15	5.7	15	17,853	3,065	3,233	520	1.1	171	12	471	17	37	24	895	20	47	0.84
Mean		4.0	165	5,023	0.16	5.7	15	17,888	3,073	3,256	537	1.1	173	12	489	17	37	24	898	21	47	0.87
Std. Dev.		0.7	38	917	0.06	0.5	2.9	1,199	225	419	139	0.23	24	2.1	146	2.6	4.9	4.2	76	7.3	8.8	1.75
Premining Period, Blue Creek sediment (Intervals 10-12, *n* = 3)																						
Minimum		4.0	97	5,400	0.07	3.7	20	25,100	2,760	3,510	213	0.5	205	12	354	17	36	33	861	69	57	2.08
Maximum		7.7	133	5,790	0.17	10.3	23	28,300	3,010	3,770	1,130	1.4	226	21	708	24	39	62	1,100	72	65	1.17
Mean		5.5	112	5,587	0.12	6.5	21	26,267	2,863	3,630	556	0.8	213	17	511	20	38	48	994	70	61	1.45

Sediment Geochemistry, Core 06MM04

Selected geochemical data from core 06MM04, as shown by comparison and correlation with the geochemical data from core 06MM08, along with statistical summaries are in table 18 and figure 24. A complete compilation of the sediment geochemical data from core 06MM04 is in Appendix A, table A12. This core intersected a long interval of fine to medium sand (intervals 22 through 4, from 128.5 to 18 cm depth, table A4) and has the most complete sedimentological record from the mining period. Reservoir water elevation data indicate that this core site was initially submerged in the fall of 1941. Beginning in 1952, the reservoir was lowered and the core site exposed in many, although not all, years between February and April to accommodate anticipated spring runoff (figs. 14, 16). There are three prominent uranium concentration peaks in the profile of the geochemical data (fig. 24). Peaks in the geochemical data from core 06MM04 are tentatively matched with those in core 06MM08 (fig. 17). The initiation of mining, recorded in interval 20 (from 115.5 to 110 cm depth), matched the geochemical profile in core 06MM08 well. A substantial uranium peak, a large increase in U/Th, and small but gradual increases in the concentrations of Zn, Cu, P, Co, Ni, Mn, and Ca relative to Mg mark the onset of mining in core 06MM08 (fig. 17). Those same characteristics mark the onset of mining in 1956 in core 06MM04 (fig. 24). The next uranium peak concentration at interval 9 (from 64 to 57 cm depth) is correlated with the 1963 timeline in core 06MM08 (fig. 17). In core 06MM08, the 1963 ^{137}Cs timeline occurs just above a large increase in uranium concentration, a large U/Th value, and peak concentrations of Ca, Ni, and Zn profiles and just below peak concentrations of Mn, Co, P, and Cu. These concentration peaks mark the 1963 timeline in core 06MM04 (fig. 24) and closely mimic that same geochemical profile. The startup of mining in late 1969–1970 is better recorded in core 06MM04 than in 06MM08. There is a large increase in uranium concentration and U/Th value, and increases in concentrations of Mn, Ca, P, Ni, and Cu in core 06MM04 at depths of 49 to 45 cm (tables 18 and A4). These geochemical data are correlated with the more subtle features tentatively identified with the startup of mining in core 06MM08 (fig. 17) and reflect the increase in excavation of the new pits and removal of large amounts of calc-silicate rock during this period (D.C. Peters, 1999, Interpretation of historical aerial photographs (IHAP) of the Midnite Mine: Unpublished Report #ST/BLM-1, 137 p.). The last peak in uranium concentration may be associated with the 1978 event identified in core 06MM08. Increases in the concentration of uranium, the U/Th value, large increases in zinc concentration, increases in nickel, cobalt, and manganese concentrations, and the decrease in phosphorus concentration appear to correlate well with the geochemical features identified in core 06MM08 (fig. 17). The period of cessation of mining in 1981 may not be recorded in core 06MM04 (fig. 24). This would suggest that part of the sedimentary record from core 06MM04 may have been removed by erosion prior to the 1978 event. However, the top core interval appears to be postmining in age. The increase in phosphorus concentration in particular appears to have the same profile as the top of core 06MM05 (fig. 22) and core 06MM03 (fig. 23). Geochemical data in interval 1 (core 06MM04) have not been included in the statistical data summary for the mining period in table 18.

The premining period is represented by only the lower two intervals, 22 and 21, from 128.5 to 115 cm depth (table A4). Although only represented by two sample intervals, the range of premining uranium concentrations is low, 8.5 to 14 ppm. The higher value of uranium in the basal layer is the result of concentration of heavy minerals in the sediment rather than mining, as indicated by the fact that there is no change in the U/Th value, which is less than 1 (fig. 24 and table 18), and the sediment in the intervals is coarse sand (table A4).

Sediment Geochemistry, Core 06MM02

Selected geochemical data from core 06MM02, as shown by comparison and correlation with the geochemical data from core 06MM08, along with statistical summaries are in table 19 and figure 25. Peak concentrations in the geochemical profiles from core 06MM02 (fig. 25) can be matched with those in core 06MM04 (fig. 24). The U/Th value at the base of the core is high, 4.4, and U/Th falls below 1 only once (0.77 in interval 19, from 140 to 130 cm depth, table 19) throughout the entire mining period interval of the core (fig. 25*B*). No premining sediment can be identified in the core from this site. Because this core site was exposed to the air and therefore to erosion almost every year in the February to April time frame (fig. 16), deposition was not as continuous as at site 06MM04. Postmining sediment in core 06MM02 is limited to the upper two intervals (above 20 cm, table A2). Metal concentrations are elevated throughout the mining period sequence (table 19). Concentrations of U, Zn, Ni, Co, and Mn are similar in the mining period intervals in cores 06MM02 and 06MM04 (tables 18 and 19). In contrast, concentrations of these metals in the premining geochemical background intervals in core 06MM03 (table 17) are much lower.

Sediment Geochemistry, Core 06MM01

Selected geochemical data from core 06MM01, as shown by comparison and correlation with the geochemical data from core 06MM08, along with statistical summaries are in table 20 and figure 26. Radioisotope data from selected core intervals for the U-decay series are in table 14. A complete compilation of all the sediment geochemical data from core 06MM01 is in Appendix A, table A9. This core intersected a short interval of fine to medium sand at the base of the core (table A1), an interval of beaver pond sediment, and a short interval of premining sediment from Blue Creek. Some concentration peaks in the geochemical profiles from core 06MM01 (fig. 26) match well with those from core 06MM04 (fig. 24). The onset

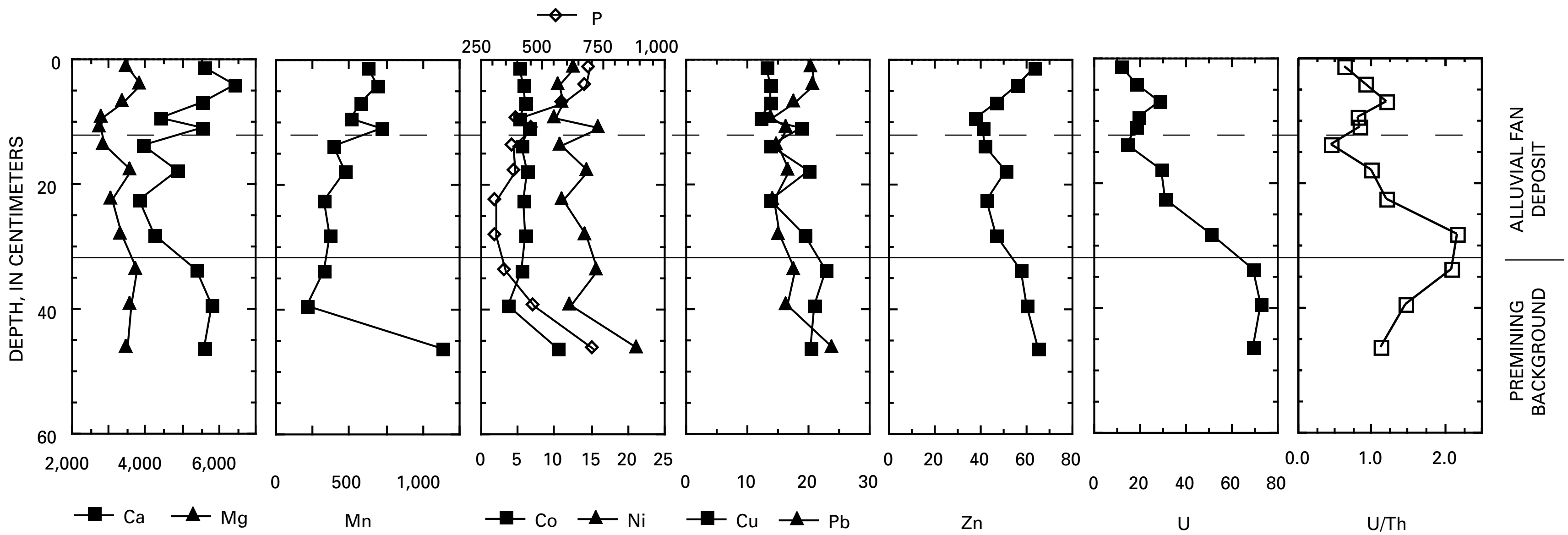


Figure 21. Geochemical plots of the concentrations of calcium (Ca), magnesium (Mg), manganese (Mn), cobalt (Co), nickel (Ni), phosphorus (P, concentrations shown at top of figure), copper (Cu), lead (Pb), zinc (Zn), uranium (U), in parts per million (ppm or µg/g), and the U/Th value (uranium/thorium) versus depth (in centimeters) for core 06MM06. The core penetrated 31 cm of granitic alluvial fan material deposited by an unnamed south-flowing tributary to Blue Creek (fig. 6). Dendrochronology from a large Douglas-fir growing on this eroded terrace surface gave an age of 1909, indicating that the terrace is at least that old, if not older. This alluvial fan material has been dissected by erosion and subsequently contaminated by uranium-bearing sediment from the mining period. No particular timelines can be identified. The geochemical data from the lower portion of the core (31 to 50.5 cm depth, table A6) represent sediment from Blue Creek deposited prior to 1909.

Table 16. Selected geochemical data and statistical summary, core 06MM05.

[Complete list of all geochemical data is in table A13; depth reported in centimeters (cm); concentrations reported in parts per million (ppm); Std. Dev., standard deviation]

Sample interval	Depth (cm)	As ppm	Ba ppm	Ca ppm	Cd ppm	Co ppm	Cu ppm	Fe ppm	K ppm	Mg ppm	Mn ppm	Mo ppm	Na ppm	Ni ppm	P ppm	Pb ppm	Sr ppm	Th ppm	Ti ppm	U ppm	Zn ppm	U/Th
06MM05.01	0-11	6.3	93.0	6,300	0.74	10.1	15.4	19,000	1,970	4,460	999	1.2	171	35	856	14.2	29.2	45.6	840	29.6	79.5	0.65
06MM05.02	11-14.5	7.0	116	6,090	0.98	10.5	18.8	19,100	2,340	4,880	1,310	0.95	188	36	706	16.8	35.8	24.1	829	44.8	94.6	1.86
06MM05.03	14.5-19	7.7	131	6,640	1.2	14.4	20.6	19,700	2,390	5,000	2,380	1.2	175	43	712	18.2	38.2	20.6	822	53.9	110	2.62
06MM05.04	19-25.5	8.0	124	7,360	1.0	12.3	20.2	21,400	2,680	6,110	1,550	0.91	201	36	762	19.0	38.1	18.8	915	43.7	102	2.32
06MM05.05	25.5-32	8.0	98.6	6,920	0.95	11.2	22.5	23,200	2,860	6,320	315	1.1	200	45	719	20.7	38.0	18.9	968	52.8	103	2.79
06MM05.06	32-41	9.6	109	6,670	0.97	19.7	21.6	24,600	2,710	5,330	385	1.0	199	35	875	20.2	37.8	30.5	960	39.0	110	1.28
06MM05.07	41-50.5	25.8	232	6,090	1.3	42.4	19.6	26,900	2,440	5,300	3,580	2.3	183	70	1,220	16.3	34.1	22.7	824	40.5	131	1.78
06MM05.08	50.5-55	6.3	172	6,980	1.7	18.2	27.0	19,500	2,480	5,080	1,400	1.2	200	71	725	17.7	36.4	24.5	862	122	170	4.98
06MM05.09	55-61	8.3	147	5,150	0.84	17.3	19.9	20,200	2,290	4,920	489	0.94	180	38	694	17.9	28.1	28.8	854	56.7	117	1.97
Postmining Period (Intervals 01-06, *n* = 6)																						
Minimum		6.3	93	6,090	0.7	10	15	19,000	1,970	4,460	315	0.9	171	35	706	14	29	19	822	30	80	1.57
Maximum		9.6	131	7,360	1.2	20	23	24,600	2,860	6,320	2,380	1.2	201	45	875	21	38	46	968	54	110	1.18
Median		7.9	113	6,655	1.0	12	20	20,550	2,535	5,165	1,155	1.1	194	36	741	19	38	22	878	44	103	1.98
Geometric Mean		7.7	111	6,651	1.0	13	20	21,063	2,473	5,309	915	1.1	189	38	769	18	36	25	887	43	99	1.72
Mean		7.8	112	6,663	1.0	13	20	21,167	2,492	5,350	1,157	1.1	189	38	772	18	36	26	889	44	100	1.66
Std. Dev.		1.1	15	450	0.15	3.6	2.5	2,328	324	729	775	0.13	13	4.5	76	2.4	3.5	10	67	9.0	12	0.87

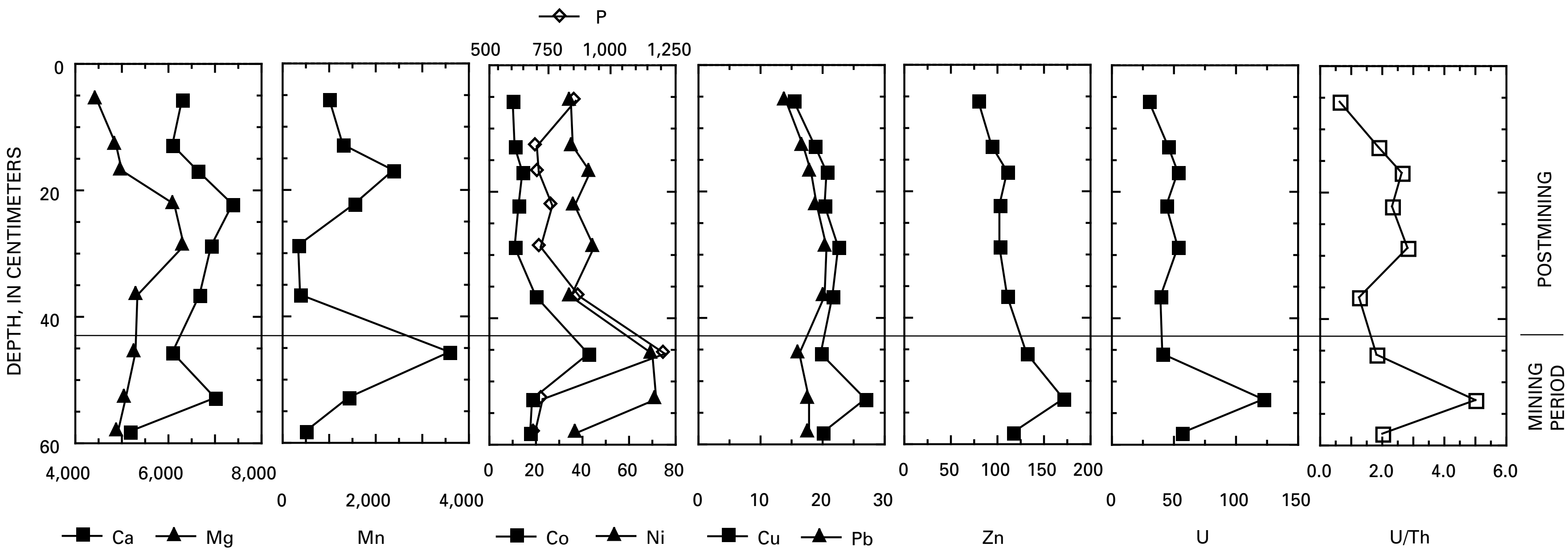


Figure 22. Geochemical plots of the concentrations of calcium (Ca), magnesium (Mg), manganese (Mn), cobalt (Co), nickel (Ni), phosphorus (P, concentrations shown at top of figure), copper (Cu), lead (Pb), zinc (Zn), uranium (U), in parts per million (ppm or μg/g), and the U/Th value (uranium/thorium) versus depth (in centimeters) for core 06MM05. Timeline showing end of mining period determined from abrupt changes in metal concentrations in the geochemical profiles and by comparison with the data from core 06MM08 (fig. 17).

Table 17. Selected geochemical data and statistical summary, core 06MM03.

[Complete list of all geochemical data is in table A11; depth reported in centimeters (cm); concentrations reported in parts per million (ppm); Std. Dev., standard deviation]

Sample interval	Depth (cm)	As ppm	Ba ppm	Ca ppm	Cd ppm	Co ppm	Cu ppm	Fe ppm	K ppm	Mg ppm	Mn ppm	Mo ppm	Na ppm	Ni ppm	P ppm	Pb ppm	Sr ppm	Th ppm	Ti ppm	U ppm	Zn ppm	U/Th
06MM03.01	0-3	8.0	129	5,780	1.8	10.8	22.0	24,500	2,820	7,720	528	0.45	269	20	947	41.3	27.3	10.5	1,030	4.52	546	0.43
06MM03.02	3-7	10.8	155	5,230	3.9	13.4	29.7	29,900	3,620	8,430	358	0.53	249	33	837	62.4	28.2	11.8	1,220	7.40	905	0.63
06MM03.03	7-11	8.3	116	4,620	2.6	8.8	26.1	23,600	3,150	7,340	240	0.39	208	18	763	51.6	25.0	14.2	1,100	5.03	750	0.35
06MM03.04	11-16.5	12.1	134	4,700	3.4	9.5	27.1	25,500	3,390	6,880	256	0.46	195	17	644	63.2	23.4	12.9	1,150	6.52	605	0.51
06MM03.05	16.5-24	7.7	127	4,880	1.8	8.0	36.1	23,200	3,940	8,320	217	0.36	274	18	633	70.4	26.7	9.79	1,340	4.37	388	0.45
06MM03.06	24-32	9.9	116	4,340	0.25	6.5	28.5	21,900	3,870	8,440	219	0.30	255	16	615	15.8	24.2	9.15	1,160	2.29	83.1	0.25
06MM03.07	32-40	14.4	117	4,490	0.19	6.2	27.5	23,400	3,870	8,800	236	0.39	206	20	627	15.9	24.6	9.02	1,120	2.21	78.8	0.25
06MM03.08	40-48	14.9	133	4,380	0.17	6.8	27.5	26,800	4,180	9,080	264	0.53	200	23	655	17.5	26.4	12.0	1,400	2.59	82.5	0.22
06MM03.09	48-52	13.7	125	4,210	0.15	6.0	24.7	24,200	3,830	8,210	240	0.48	159	18	579	17.2	26.5	10.2	1,260	3.00	75.8	0.29
06MM03.10	56-64	15.1	130	3,790	0.12	5.9	24.7	25,000	3,840	8,210	280	0.36	146	16	610	15.3	24.7	10.6	1,230	1.89	73.8	0.18
06MM03.11	64-72	15.9	129	3,940	0.08	6.5	23.3	25,800	3,600	8,170	336	0.50	141	20	695	15.1	24.5	12.8	1,180	2.02	68.2	0.16
06MM03.12	72-80	16.7	128	4,410	0.09	7.3	22.0	26,600	3,560	8,740	418	0.58	149	23	893	16.1	25.9	14.3	1,120	3.61	69.2	0.25
06MM03.13	80-88	15.0	121	4,600	0.08	7.8	19.4	26,200	3,460	9,230	493	0.36	159	14	944	16.1	25.0	14.1	1,110	1.99	64.3	0.14
06MM03.14	88-96	15.5	126	4,670	0.10	8.3	19.4	25,800	3,470	9,360	577	0.48	171	23	916	17.0	25.4	13.3	1,100	1.91	65.0	0.14
06MM03.15	96-104	16.6	133	4,920	0.12	9.1	19.7	26,800	3,440	9,740	668	0.39	187	15	946	18.2	26.7	12.9	1,150	1.80	67.6	0.14
06MM03.16	104-112	18.8	135	5,150	0.12	10.5	21.2	28,500	3,420	10,400	789	0.40	200	16	1,010	21.2	28.9	15.6	1,170	3.18	70.9	0.20
06MM03.17	112-120	17.2	118	4,740	0.12	9.3	19.3	24,900	2,910	9,150	694	0.37	163	15	909	18.0	24.9	13.3	992	1.94	63.9	0.15
06MM03.18	120-128	18.2	124	4,980	0.14	10.0	20.2	27,000	3,150	10,100	701	0.46	180	16	914	18.4	26.8	14.8	1,120	2.38	67.8	0.16
06MM03.19	128-138	17.2	125	4,700	0.11	10.2	18.8	26,700	3,130	10,400	730	0.48	183	22	850	17.6	25.4	14.2	1,110	1.70	66.0	0.12
06MM03.20	138-148	16.8	131	4,670	0.17	9.3	18.2	25,200	3,110	10,100	796	0.52	201	22	851	17.4	25.2	12.6	1,050	2.98	66.5	0.24
Premining Period (Intervals 01-05, n = 5, post 1942)																						
Minimum		7.7	116	4,620	1.8	8.0	22	23,200	2,820	6,880	217	0.4	195	17	633	41	23	10	1,030	4.4	388	0.45
Maximum		12	155	5,780	3.9	13	36	29,900	3,940	8,430	528	0.5	274	33	947	70	28	14	1,340	7.4	905	0.52
Median		8.3	129	4,880	2.6	10	27	24,500	3,390	7,720	256	0.5	249	18	763	62	27	12	1,150	5.0	605	0.43
Geometric Mean		9.2	132	5,025	2.6	10	28	25,232	3,362	7,716	302	0.4	237	20	756	57	26	12	1,163	5.4	614	0.46
Mean		9.4	132	5,042	2.7	10	28	25,340	3,384	7,738	320	0.4	239	21	765	58	26	12	1,168	5.6	639	0.47
Std. Dev.		2.0	14	475	0.94	2.1	5.2	2,699	429	654	128	0.07	36	6.7	133	11	1.9	1.8	119	1.3	197	0.75
Premining Period (Intervals 06-20, n = 15, pre 1942)																						
Minimum		10	116	3,790	0.08	5.9	18	21,900	2,910	8,170	219	0.3	141	14	579	15	24	9.0	992	1.7	64	0.19
Maximum		19	135	5,150	0.25	11	29	28,500	4,180	10,400	796	0.6	255	23	1,010	21	29	16	1,400	3.6	83	0.23
Median		16	126	4,600	0.12	7.8	21	25,800	3,470	9,150	493	0.5	180	18	851	17	25	13	1,120	2.2	68	0.17
Geometric Mean		16	126	4,518	0.13	7.8	22	25,603	3,506	9,177	446	0.4	178	18	787	17	26	12	1,148	2.3	71	0.19
Mean		16	126	4,533	0.13	8.0	22	25,653	3,523	9,209	496	0.4	180	19	801	17	26	13	1,151	2.4	71	0.19
Std. Dev.		2.1	6.0	371	0.05	1.6	3.5	1,634	352	793	222	0.08	30	3.4	151	1.5	1.2	2.0	95	0.58	6.4	0.29

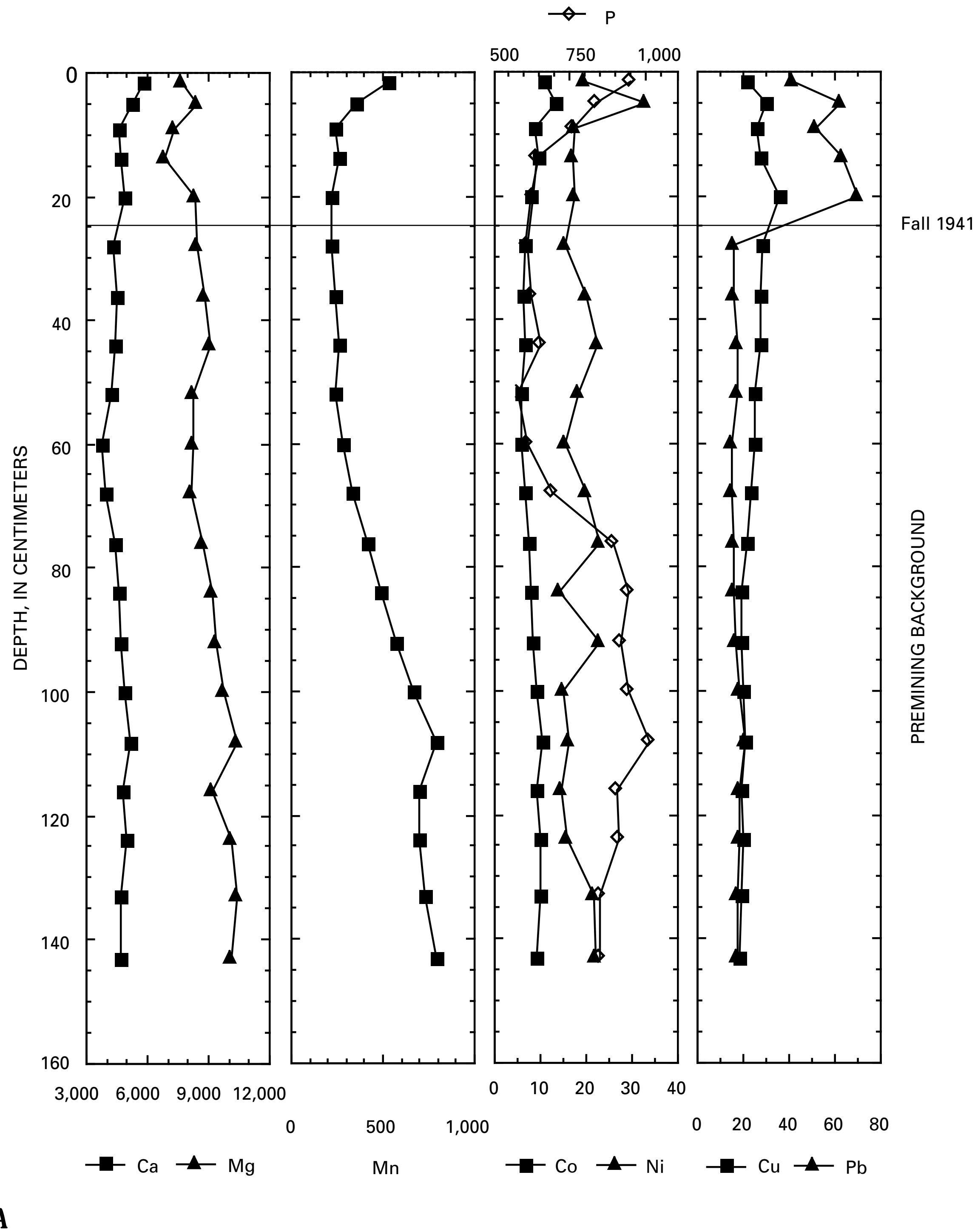
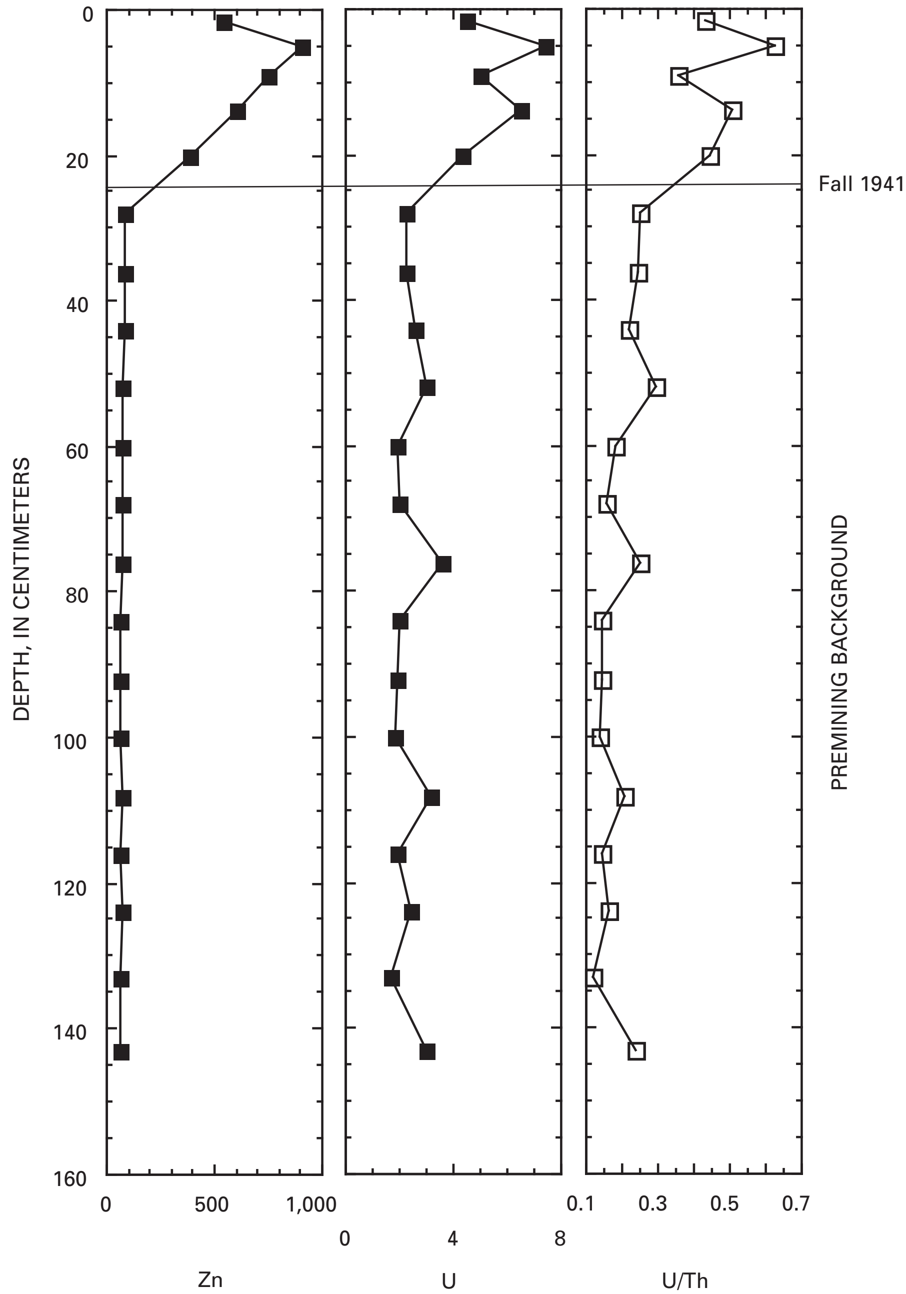


Figure 23. Geochemical plots of *A*, concentrations of calcium (Ca), magnesium (Mg), manganese (Mn), cobalt (Co), nickel (Ni), phosphorus (P, concentrations shown at top of figure), copper (Cu), and lead (Pb), in parts per million (ppm or µg/g) versus depth (in centimeters). *B*, concentrations of zinc (Zn), uranium (U), in parts per million (ppm or µg/g), and the U/Th value (uranium/thorium) versus depth (in centimeters) for core 06MM03. Timeline showing the change in concentrations of lead (Pb) and zinc (Zn) indicate flooding of the site by October 1941 by Lake Roosevelt (figs. 14, 16) and deposition of metals from the Coeur d'Alene mining district (Horowitz and others, 1993, 1995; Grosbois and others, 2002). Little sediment from Blue Creek has been deposited at this site, although there is a small increase in the U/Th value above 24 cm depth. Sediment in the core below a depth of 24 cm (table A3) is all premining and pre-reservoir sediment, probably from the glacial outwash deposits (Becraft and Weis, 1963).



B

Figure 23—Continued. Geochemical plots of *B*, concentrations of zinc (Zn), uranium (U), in parts per million (ppm or µg/g), and the U/Th value (uranium/thorium) versus depth (in centimeters) for core 06MM03. Timeline showing the change in concentrations of lead (Pb) and zinc (Zn) indicate flooding of the site by October 1941 by Lake Roosevelt (figs. 14, 16) and deposition of metals from the Coeur d'Alene mining district (Horowitz and others, 1993, 1995; Grosbois and others, 2002). Little sediment from Blue Creek has been deposited at this site, although there is a small increase in the U/Th value above 24 cm depth. Sediment in the core below a depth of 24 cm (table A3) is all premining and pre-reservoir sediment, probably from the glacial outwash deposits (Becraft and Weis, 1963).

of mining in 1956 is readily identified at a depth of 54 cm (interval 12) where the U/Th value increases dramatically from 1 to 2.5 and uranium concentration increases from 19 to 38 ppm (table 20). This interval is also marked by increases in Mg, Ca, Mn, Co, and Ni, allowing the assignment of dates to specific core intervals in core 06MM01.

Only part of the mining period is represented in core 06MM01. We correlate the large change in the U/Th value and the increases in concentrations of Cu and Ni in interval 9 (from 40.5 to 37.5 cm depth) with the geochemical profile from cores 06MM04 (fig. 24) and 06MM08 (fig. 17) that occurred in 1970. Sediment deposited in intervals 1–7 (above 34 cm depth) has low U/Th values and low concentrations of metals associated with the Midnite Mine. Sediment deposited after the 1970 timeline has been removed by erosion. Low concentrations of base metals and uranium and the low U/Th ratio and elevated concentrations of phosphorus indicate that young post-mining sediment is present at the top of the core.

Core 06MM01 penetrated sediment deposited in a different environment below the 1956 timeline established by the onset of mining. Intervals 14 and 13 (from 69 to 54 cm depth, table A1) penetrated sand and silt deposited in the early 1950s (post January 1952?) by Blue Creek prior to mining. Intervals 21 to 15 (from 105 to 69 cm depth, table A1) penetrated an abandoned beaver pond that served as a sediment catchment. Sediment collected in the beaver pond post-1942 flooding by Lake Roosevelt is organic rich (intervals 21–15, table 20) and represents detrital sediment deposited by Blue Creek as well as suspended sediment brought in by the Spokane River from the Coeur d'Alene mining district. The sediment in the beaver pond contains no elevated ^{137}Cs, indicating that it is older than the onset of atmospheric nuclear testing (that is pre-1954; Simon and others, 2004). Sediment deposited by Blue Creek prior to the 1942 flooding event accumulated at the site prior to and following the building of the beaver dam. There is a pronounced change in the total carbon content between intervals 23 and 22, which we attribute to the beaver. The premining uranium concentration in core 06MM01 was 4.7 ppm (intervals 24–20, $n = 5$, from 120 to 104.5 cm depth, table 20), but after flooding, the organic-rich sediment that accumulated in the abandoned beaver pond had total carbon concentrations of 3.3 wt. percent and uranium concentrations of about 12.3 ppm (intervals 24–20, $n = 4$, from 120 to 94 cm, table 20). Below 99 cm depth (intervals 25–20, table 20) premining sediment accumulated in Blue Creek before the beaver dam formed (intervals 25–22) and in the basal section of the beaver dam prior to flooding by Lake Roosevelt. Large increases in the concentrations of lead and zinc mark the onset of flooding by water impounded by Lake Roosevelt from July 1942 through January 1952 (figs. 14, 16). The beaver would have abandoned their pond quickly as the water depth was about 16 ft deep at the top of the beaver dam (fig. 8). The beaver pond then filled with sediment transported into the Spokane Arm from the Coeur d'Alene mining district. Uranium was concentrated in the organic-rich sediment that accumulated in the beaver pond after flooding and has an average concentration of 13 ppm. Part of this uranium appears to have been transported in the aqueous phase; however, most of the uranium was transported as detrital sediment grains containing uranium minerals deposited by Blue Creek in the flooded beaver pond in interval 19 (from 94 to 89 cm depth) indicating that the beaver pond was a sediment catchment for post-1942-premining sediment. Concentrations of uranium, however, were low and show no correlation with carbon concentrations in the sediment (fig. 20). The geochemical data indicate a low slope on the uranium versus total carbon plot of the premining geochemical data, quite unlike that for the mining period from core 06MM08. Premining behavior of uranium in sediment from Blue Creek contrasts with the median and geometric means of the uranium concentration measured in core 06MM01 during the mining period—120 and 125 ppm, respectively (table 20).

After the change in water-level management practices for Lake Roosevelt in 1952, erosion of sediment south of the beaver pond dam removed material deposited in the post-1952 era. Because we correlate concentration peaks in the geochemical profile of core 06MM01 (fig. 26) through 1970, presumably this new stream course is post-1970. We have no age control on the postmining sediment that exists in intervals 1–6 at the site. The U/Th values are generally low; four intervals have U/Th values less than 0.73, but three are between 1.2 and 1.5 (table 20). Postmining mean uranium concentration in sediment of Blue Creek in core 06MM01 is 23±8.2 ppm ($n = 7$).

Radionuclide Data, Core 06MM01

Radionuclide activity concentration data from the carbon-rich silts from core 06MM01 are in tables 12 and 14 and figure 27. Unlike the activity concentration data from core 06MM08 (fig. 19), activity ratios for $^{214}Bi/^{214}Pb$ are very close to secular equilibrium (1.02±0.04) and the $^{210}Pb/^{214}Pb$ are much closer to secular equilibrium (1.32±0.19, intervals 13–25, table 14) in core 06MM01 than in core 06MM08. The activity peak for ^{234}Th and the maximum uranium concentration (36 ppm) in interval 19 indicates that uranium was transported via aqueous mechanisms at the time the beaver pond was flooded by Lake Roosevelt. The $^{226}Ra/^{238}U$ values in intervals 24–21, deposited as stream-bed sediment prior to the building of the beaver pond, are greater than 0.5, indicating that the uranium was transported in detrital grains rather than by aqueous transport. Following the building of the beaver pond, aqueous uranium was sequestered by organic matter in the beaver pond sediment. However, following flooding and abandonment of the beaver pond in 1942, the decrease in the $^{226}Ra/^{238}U$ values indicates that more of the uranium present was transported as dissolved constituents before being deposited in the beaver pond sediment. Total carbon concentrations in the sediment in intervals 19–15 remained elevated (table 20) and are attributed to the presence of charcoal in these sediment intervals (table A1). The lower values of $^{226}Ra/^{238}U$ suggest that the uranium was sequestered by the organic matter, transported, and deposited

Table 18. Selected geochemical data and statistical summary, core 06MM04.

[Complete list of all geochemical data is in table A12; depth reported in centimeters (cm); concentrations reported in parts per million (ppm); Std. Dev., standard deviation]

Sample interval	Depth (cm)	As ppm	Ba ppm	Ca ppm	Cd ppm	Co ppm	Cu ppm	Fe ppm	K ppm	Mg ppm	Mn ppm	Mo ppm	Na ppm	Ni ppm	P ppm	Pb ppm	Sr ppm	Th ppm	Ti ppm	U ppm	Zn ppm	U/Th
06MM04.01	0-5	11.9	178	5,030	1.8	14.9	25.0	27,200	3,230	7,310	1,360	0.58	187	39	881	33.0	28.6	13.3	1,040	18.2	382	1.37
06MM04.02	5-10	8.4	178	5,010	2.0	17.9	25.2	25,300	3,060	6,940	940	0.45	184	58	714	30.6	25.9	14.1	1,050	33.8	411	2.40
06MM04.03	10-18	6.7	145	6,340	2.0	21.0	39.3	25,100	3,370	8,100	793	1.0	219	58	725	32.1	32.6	17.4	1,160	28.2	466	1.62
06MM04.04	18-26	10.9	111	19,100	0.70	15.6	21.7	22,800	2,670	8,610	1,120	1.1	168	40	807	17.7	45.0	26.6	958	7.39	155	0.28
06MM04.05	26-35	12.8	156	18,600	0.92	22.0	22.6	24,200	2,860	8,190	2,410	1.6	179	65	813	19.4	47.8	24.1	1,040	8.98	158	0.37
06MM04.06	35-45	17.1	214	19,300	2.1	31.7	34.4	24,000	2,760	8,420	5,820	2.2	206	87	813	22.1	54.2	29.6	956	14.2	212	0.48
06MM04.07	45-49	7.0	94.6	4,660	1.8	27.8	21.0	19,100	2,810	5,200	686	1.5	177	70	576	16.0	23.6	21.1	819	102	212	4.83
06MM04.08	49-57	8.8	92.6	8,890	1.4	23.3	30.7	23,100	3,100	7,200	651	1.3	210	61	624	25.7	34.9	22.5	991	40.5	210	1.80
06MM04.09	57-64	12.4	95.2	10,300	1.5	25.4	182	24,100	2,770	7,560	888	2.8	213	126	744	31.7	38.5	23.0	939	59.6	252	2.59
06MM04.10	64-67.5	5.9	91.0	9,040	1.3	34.7	27.1	18,400	2,890	6,160	811	1.2	203	92	545	21.2	33.3	20.1	878	108	200	5.37
06MM04.11	67.5-73	5.8	60.8	4,300	1.2	18.4	20.0	17,200	2,260	4,680	1,250	0.67	171	48	633	18.2	22.5	26.9	768	38.9	168	1.45
06MM04.12	73-78	14.7	144	4,520	1.2	27.7	69.5	20,400	2,400	5,270	4,110	1.6	187	71	748	26.0	28.5	30.3	798	24.0	169	0.79
06MM04.13	78-83	15.3	156	4,430	1.0	31.8	20.3	20,400	2,360	5,170	3,350	1.1	172	45	743	20.1	24.6	28.4	799	29.3	143	1.03
06MM04.14	83-88	16.1	169	4,080	1.1	27.0	19.0	19,000	2,130	4,580	2,890	0.95	172	40	718	18.8	24.3	34.0	715	30.6	151	0.90
06MM04.15	88-93	10.0	103	4,430	0.82	25.6	19.6	20,400	2,380	4,860	1,510	0.78	178	49	718	19.9	24.4	24.8	786	40.8	164	1.65
06MM04.16	93-98	7.4	120	4,460	1.0	23.3	19.2	19,700	2,320	4,720	2,040	0.82	175	46	700	19.5	23.9	30.5	805	34.1	161	1.12
06MM04.17	98-102.5	8.2	138	4,270	1.2	26.3	20.7	20,200	2,400	4,880	2,150	0.68	167	50	680	19.5	24.0	26.0	794	32.6	173	1.25
06MM04.18	102.5-106.5	7.5	131	4,590	1.8	25.4	22.0	18,600	2,500	4,820	1,940	0.99	172	60	616	16.7	24.4	23.5	805	85.0	188	3.62
06MM04.19	106.5-110.5	10.5	154	5,540	2.2	35.2	28.1	22,300	3,010	5,010	3,420	1.5	180	77	581	17.7	25.7	19.9	918	125	216	6.28
06MM04.20	110.5-115	5.0	123	6,060	0.79	23.7	20.8	17,900	2,330	5,570	381	0.58	170	48	638	19.0	26.3	27.6	790	38.1	159	1.38
06MM04.21	115-122	4.5	90.8	5,440	1.4	19.5	21.6	18,700	2,490	5,640	228	0.61	183	46	636	17.5	25.0	26.5	836	13.8	168	0.52
06MM04.22	122-128.5	10.4	109	8,100	0.73	12.3	89.2	23,900	2,990	8,580	289	1.3	198	59	803	24.5	33.8	25.8	1,020	8.52	265	0.33
Premining Period (Intervals 21-22, $n = 2$)																						
Minimum		4.5	91	5,440	0.7	12	22	18,700	2,490	5,640	228	0.6	183	46	636	18	25	26	836	8.5	168	0.33
Maximum		10	109	8,100	1.4	20	89	23,900	2,990	8,580	289	1.3	198	59	803	25	34	27	1,020	14	265	0.52
Mean		7.5	100	6,770	1.1	16	55	21,300	2,740	7,110	259	1.0	191	52	720	21	29	26	928	11	217	0.43
Mining Period (Intervals 02-20, $n = 19$)																						
Minimum		5.0	61	4,080	0.7	15.6	19.0	17,200	2,130	4,580	381	0.5	167	40	545	16.0	22.5	14.1	715	7.4	143	0.52
Maximum		17	214	19,300	2.2	35.2	182	25,300	3,370	8,610	5,820	2.8	219	126	813	32.1	54.2	34.0	1,160	125	466	3.68
Median		8.8	131.0	5,010	1.2	25.4	22.0	20,400	2,670	5,270	1,510	1.1	178	58	714	19.5	25.9	24.8	819	34.1	173	1.38
Geometric Mean		9.4	125.1	6,610	1.3	24.9	27.9	21,020	2,631	5,945	1,528	1.1	184	60	687	21.2	29.6	24.3	875	36.0	197	1.48
Mean		10.0	130.3	7,785	1.4	25.5	34.9	21,168	2,652	6,102	1,956	1.2	184	63	691	21.7	30.8	24.8	883	46.4	209	1.87
Std. Dev.		3.7	37	5,307	0.5	5.4	37.5	2,588	342	1,469	1,430	0.6	16.9	21.4	81.1	5.1	9.4	4.9	119	34.0	86	6.87

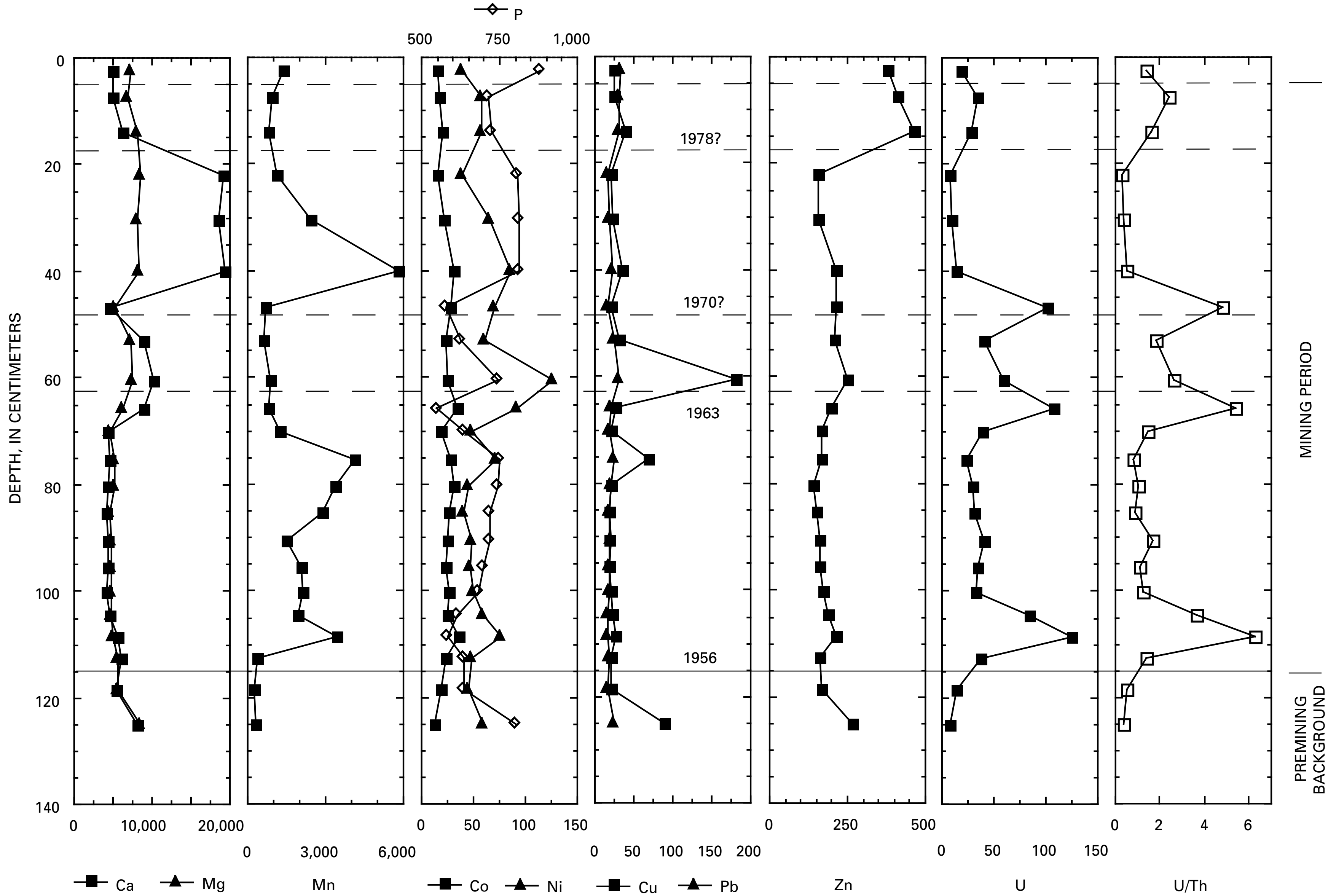


Figure 24. Geochemical plots of the concentrations of calcium (Ca), magnesium (Mg), manganese (Mn), cobalt (Co), nickel (Ni), phosphorus (P, concentrations shown at top of figure), copper (Cu), lead (Pb), zinc (Zn), uranium (U), in parts per million (ppm or µg/g), and the U/Th value (uranium/thorium) versus depth (in centimeters) for core 06MM04. Timelines were determined by comparison with the changes in the geochemical profiles in core 06MM08 (fig. 17) and the expected response from mining practices and activity recorded at the Midnite Mine site (D.C. Peters, 1999, Interpretation of historical aerial photographs (IHAP) of the Midnite Mine: Unpublished Report #ST/BLM-1, 137 p.).

Table 19. Selected geochemical data and statistical summary, core 06MM02.

[Complete list of all geochemical data is in table A10; depth reported in centimeters (cm); concentrations reported in parts per million (ppm); Std. Dev., standard deviation]

Sample interval	Depth (cm)	As ppm	Ba ppm	Ca ppm	Cd ppm	Ce ppm	Co ppm	Cu ppm	Fe ppm	K ppm	Mg ppm	Mn ppm	Mo ppm	Na ppm	Ni ppm	P ppm	Pb ppm	Sr ppm	Th ppm	Ti ppm	U ppm	Zn ppm	U/Th
06MM02.01	0-10	8.4	155	4,890	1.2	79.4	22.2	22.7	22,600	2,880	6,630	3,060	2.7	185	120	914	17.2	26.1	33.0	946	26.7	201	0.81
06MM02.02	10-20	6.2	91.5	3,270	0.56	82.0	15.1	9.2	18,000	1,890	4,170	1,900	0.94	104	36	564	12.3	16.4	52.7	625	11.2	98.4	0.21
06MM02.03	20-30	9.8	167	4,910	1.2	74.6	30.9	15.7	20,300	2,500	5,920	4,220	1.8	137	67	897	16.9	22.7	31.0	726	16.9	186	0.55
06MM02.04	30-45	10.5	199	4,590	1.7	81.7	36.9	16.0	18,600	2,280	4,700	6,320	2.1	150	86	798	16.1	25.0	32.1	585	40.1	172	1.25
06MM02.05	45-51.5	12.1	182	4,640	1.6	95.0	41.2	22.8	21,200	2,490	5,720	5,060	1.3	152	57	792	26.4	25.8	30.8	854	64.8	204	2.10
06MM02.06	51.5-55	5.7	83.8	3,230	1.2	82.4	13.9	14.3	14,600	1,730	3,060	754	0.90	148	35	665	13.9	19.5	35.1	642	91.3	112	2.60
06MM02.07	55-60	5.1	250	3,600	2.1	90.2	24.8	22.6	15,200	1,930	3,510	1,490	1.3	151	54	700	19.0	22.5	33.9	689	227	130	6.70
06MM02.08	60-65	11.0	202	3,330	1.8	89.8	28.2	20.6	17,800	1,890	3,460	2,020	1.6	141	55	717	18.6	22.6	37.5	667	93.3	130	2.49
06MM02.09	65-70	13.3	159	3,480	1.4	84.1	32.8	19.0	18,500	1,970	3,900	4,640	1.6	139	50	743	18.2	23.2	29.6	698	41.7	135	1.41
06MM02.10	70-75	11.1	153	3,600	1.2	83.6	28.1	18.9	18,300	2,140	4,250	6,840	1.7	145	47	719	18.4	26.5	28.1	719	33.4	132	1.19
06MM02.11	75-80	10.2	140	3,560	1.1	89.9	25.7	17.3	19,300	2,180	4,490	8,150	1.3	148	46	732	17.6	30.5	32.0	764	45.1	129	1.41
06MM02.12	80-86	10.4	135	4,180	1.2	90.8	28.3	22.5	20,400	2,380	4,820	8,040	1.4	149	63	742	21.3	31.3	34.5	803	49.5	157	1.43
06MM02.13	86-92	7.9	99.5	3,980	0.94	74.2	22.5	15.3	16,200	2,100	3,920	2,940	1.1	145	47	642	14.3	23.2	27.1	710	31.4	123	1.16
06MM02.14	92-92	6.3	115	4,730	2.1	79.5	32.8	26.0	18,300	2,710	4,770	2,920	1.2	165	82	623	15.8	28.2	20.0	830	173	211	8.65
06MM02.15	93-102	9.5	174	4,420	1.2	68.7	28.0	20.8	20,400	2,890	5,980	4,880	1.1	163	50	684	20.1	27.8	19.5	865	57.5	266	2.95
06MM02.16	102-110	10.2	140	4,680	0.99	78.2	22.7	15.6	22,300	2,910	6,800	3,060	1.3	178	44	835	18.7	28.4	22.8	828	34.8	233	1.53
06MM02.17	110-120	10.4	143	4,410	1.1	69.1	23.6	14.7	21,300	2,700	6,680	3,050	1.2	151	44	821	18.8	25.5	23.0	856	29.2	255	1.27
06MM02.18	120-130	11.0	154	4,700	1.2	79.9	26.6	16.3	20,600	2,650	6,180	3,660	1.5	134	53	805	18.8	25.2	25.8	766	32.4	232	1.26
06MM02.19	139-140	9.6	143	4,330	1.0	76.3	24.6	13.4	19,500	2,520	5,360	3,380	1.4	138	46	822	17.1	23.2	30.2	676	23.2	197	0.77
06MM02.20	140-1250	10.8	159	4,650	1.2	79.0	27.9	14.8	20,200	2,590	5,990	3,850	1.7	150	53	850	20.6	26.3	28.6	783	33.7	248	1.18
06MM02.21	150-160	9.9	179	4,290	1.5	78.8	32.9	23.1	18,300	2,300	4,670	5,280	2.1	148	68	808	30.0	24.6	29.4	615	33.6	223	1.14
06MM02.22	160-170	9.6	148	4,340	1.2	73.5	24.9	13.7	20,200	2,520	5,510	4,260	1.5	157	54	823	20.4	26.2	25.1	772	37.8	261	1.51
06MM02.23	170-180	8.5	217	4,250	2.2	81.8	37.2	15.2	16,900	2,250	4,310	7,200	2.1	149	103	762	17.1	24.9	33.7	534	66.7	292	1.98
06MM02.24	180-190	9.8	280	4,190	4.3	82.4	36.5	17.4	17,500	2,290	4,290	6,730	2.6	163	97	799	15.8	26.6	33.9	652	47.3	274	1.40
06MM02.25	190-206	20.7	138	4,300	0.93	82.2	34.8	17.0	20,700	2,180	3,670	3,360	3.3	158	43	945	18.9	22.5	31.7	530	67.8	190	2.14
06MM02.26	206-211	22.0	167	4,930	0.72	74.2	19.9	20.2	23,100	2,360	4,930	448	1.7	156	55	868	22.0	27.6	20.9	731	92.6	171	4.43
Postmining Period (intervals 01-02, *n* = 2)																							
Minimum		6.2	91.5	3,270	0.56	79.4	15.1	9.2	18,000	1,890	4,170	1,900	0.94	104	36	564	12.3	16.4	33.0	625	11.2	98	0.34
Maximum		8.4	155	4,890	1.2	82.0	22.2	22.7	22,600	2,880	6,630	3,060	2.7	185	120	914	17.2	26.1	52.7	946	26.7	201	0.51
Mining Period, Intervals 03-26, *n* = 24)																							
Minimum		5.1	83.8	3,230	0.72	68.7	13.9	13.4	14,600	1,730	3,060	448	0.9	134	35	623	13.9	19.5	19.5	530	16.9	112	0.87
Maximum		22.0	280	4,930	4.3	95.0	41.2	26.0	23,100	2,910	6,800	8,150	3.3	178	103	945	30.0	31.3	37.5	865	227	292	6.05
Median		10.2	156.5	4,315	1.2	80.8	28.1	17.15	19,400	2,330	4,735	4,035	1.5	150	54	795	18.7	25.4	29.9	723	43.4	194	1.45
Geometric Mean		10.1	158	4,191	1.4	80.6	27.9	17.7	19,037	2,333	4,761	3,579	1.5	150	56	771	18.7	25.3	28.6	714	49.8	187	1.74
Mean		10.6	164	4,222	1.5	80.8	28.6	18.1	19,154	2,353	4,870	4,273	1.6	151	58	775	19.0	25.4	29.0	721	61.0	194	2.10
Std. Dev.		3.8	43.8	506	0.7	6.9	6.3	3.5	2,118	310	1,050	2,140	0.5	10.1	17	81	3.5	2.8	5.0	97	48.5	55.4	9.61

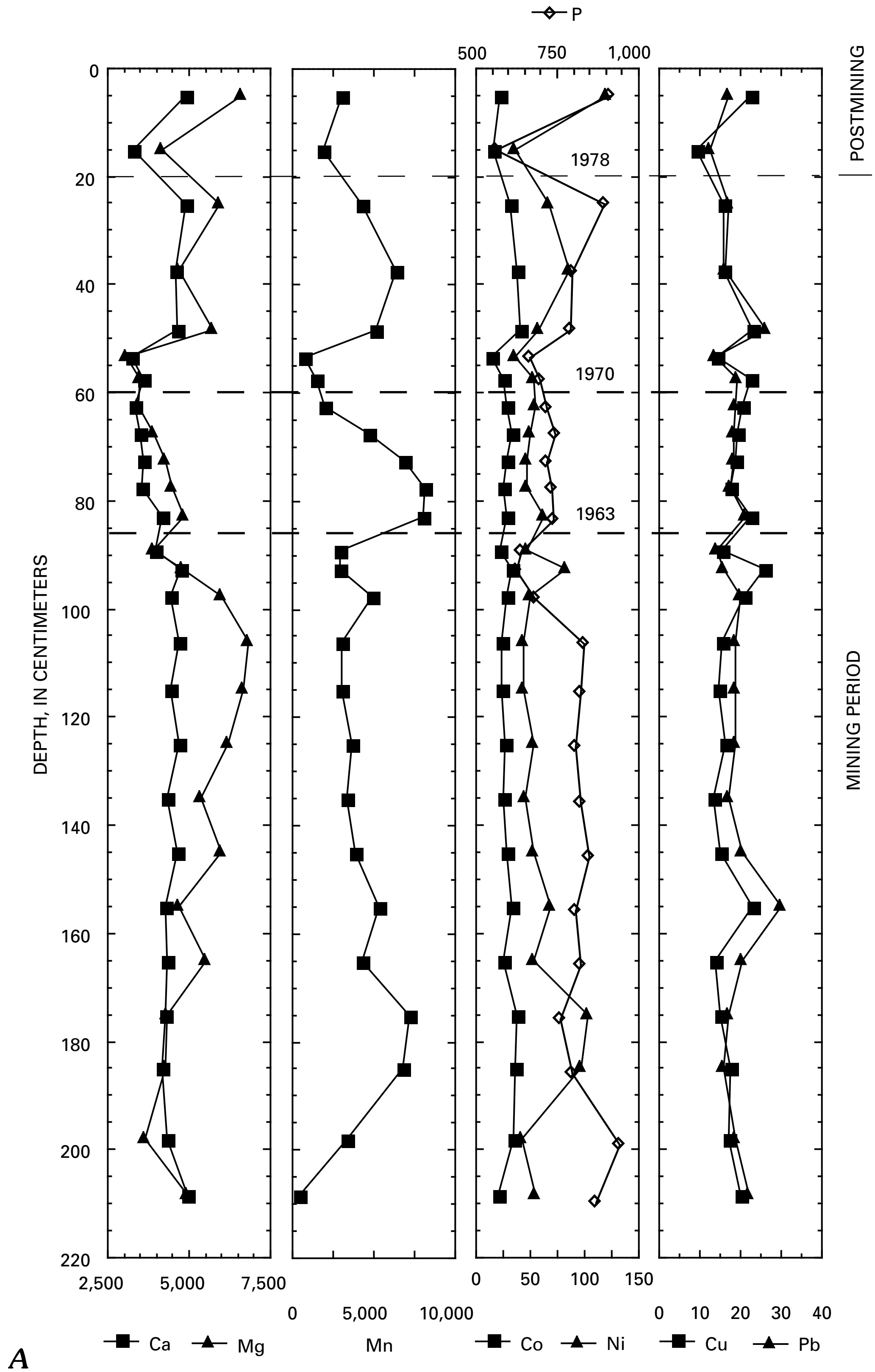


Figure 25. Geochemical plots of *A*, concentrations of calcium (Ca), magnesium (Mg), manganese (Mn), cobalt (Co), nickel (Ni), phosphorus (P, concentrations shown at top of figure), copper (Cu), and lead (Pb) versus depth (in centimeters); and *B*, concentrations of zinc (Zn), uranium (U), in parts per million (ppm or µg/g), and the U/Th value (uranium/thorium) versus depth (in centimeters) for core 06MM02 (figs. 7, 9). The 1963, 1970, and 1978 timelines were determined by comparison with the changes in the geochemical profiles in cores 06MM04 (fig. 24) and 06MM08 (fig. 17). No premining sediment was recovered in this core.

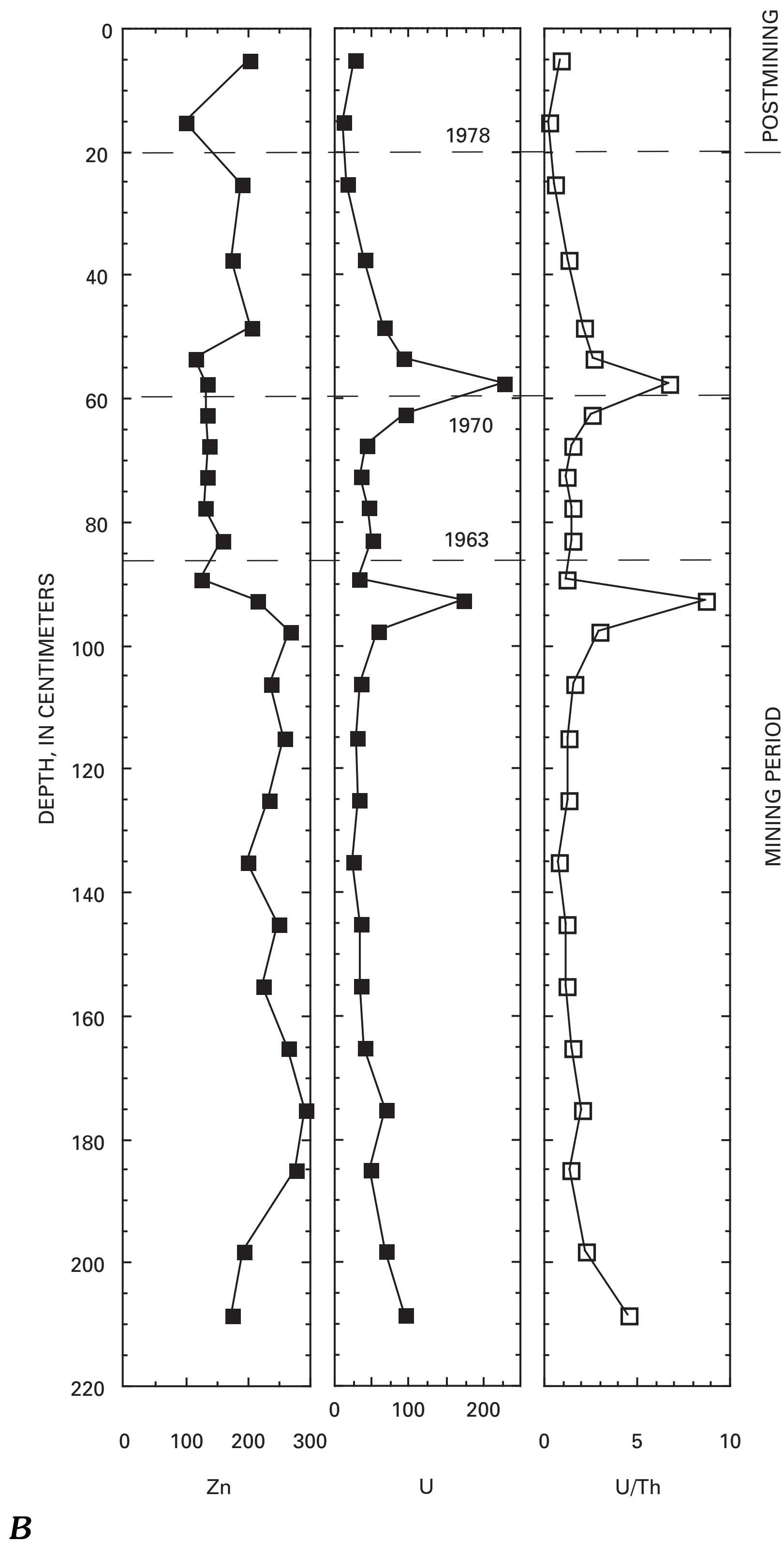


Figure 25—Continued. Geochemical plots of *B*, concentrations of zinc (Zn), uranium (U), in parts per million (ppm or µg/g), and the U/Th value (uranium/thorium) versus depth (in centimeters) for core 06MM02 (figs. 7, 9). The 1963, 1970, and 1978 timelines were determined by comparison with the changes in the geochemical profiles in cores 06MM04 (fig. 24) and 06MM08 (fig. 17). No premining sediment was recovered in this core.

in the beaver pond sediment. Whether this was material eroded from the wetlands site along the Midnite Mine tributary like that at site 06MM08 cannot be determined. The lack of correlation of uranium versus carbon in figure 20 also supports the detrital-transport-of-uranium transport mechanism.

Premining Geochemical Background Upstream of the Midnite Mine

Only three core intervals were obtained from the 22 cm core from site 06MM07 (table A7), the only site not influenced by mining activity at the Midnite Mine. We recognize that a larger suite of samples is required to statistically determine geochemical background upstream of the mine site. Stream-sediment data provide a good medium for estimating geochemical background because they provide a sample that has been derived from and averaged over a large area; thus, they represent a composite sample. Further, the NURE stream-sediment samples were collected using a randomized sampling strategy, sampling sediment from small tributary basins, that was independent of the goals and objectives of the current study and therefore less susceptible to sampling design bias. Samples were collected at a density of approximately 1 sample per square kilometer to delineate the geochemical dispersion pattern of mineralization (Babcock and others, 1981). Stream drainage is very much controlled by lithology and structure in the study area. We reanalyzed the 1979 NURE sediment samples from the Blue Creek basin as well as those from the Sand Creek basin to the north, which is largely underlain by rocks of the Togo Formation (table A17), to provide a more complete data set for determination of geochemical background upstream of the Midnite Mine site. Since the NURE samples were sieved to <100 mesh (<149 µm, Babcock and others, 1981) and were digested using the same EPA-3050 method, the premining geochemical background data from the NURE sediment samples are directly comparable to the geochemical data from the cores and surface sediment from Blue Creek delta collected in this study.

Mining activities in the area sampled for geochemical background have been limited to the Midnite Mine site in the Blue Creek basin. In the Sand Creek basin, the Germania Consolidated mine on Owl Creek (fig. 6), a tributary to Sand Creek, was a tungsten mine consisting of wolframite in quartz veins in the Loon Lake granite porphyry unit (fig. 2). Huntting (1956) reported production of tungsten ore during World War II. The Germania Consolidated mine also has Ag, Au, As, Pb, and U anomalies associated with it. The analytical results from the sample downstream of the mine site (DSOR389S1) do not indicate any geochemical anomalies associated with the mine site. A small prospect, the O-Lo-Lim prospect, is also known near the mouth of Sand Creek. Sample DSOR395S1 (table 21) downstream from this site does not contain elevated base-metal or uranium concentrations.

The geochemical data (table 21) are grouped by underlying bedrock geology into those drainages underlain by metamorphic rocks of the Togo Formation, those underlain by the Loon Lake Granite, and those underlain by both rock types or by subordinate rock types that are a part of the Loon Lake igneous complex (fig. 2). Samples from all sites located immediately downstream of roads in the mine area have been excluded from the data sets. The rationale for excluding these sediment data is that mine-waste rock (Togo Formation) from the Midnite Mine was used as road ballast and fill at stream crossings during the construction of mine and haulage roads. Five of seven stream-sediment samples from sites downstream of roads have elevated uranium concentrations in excess of 22 ppm (Geometric Mean of uranium in the Togo Formation ($GM_{U_{TF}}$) = 1.8 ppm, table 22) and they also have elevated U/Th values of 0.31 to 2.12 ($GM_{U/Th_{TF}}$ = 0.19, table 22). Contamination of sediment in these basins by the road construction practices is readily apparent from the stream-sediment data (table 21). Samples from within the geochemical halo of the Midnite Mine and the Spokane Mountain deposit are indicated in table 21. Statistical summaries of the data from the Loon Lake Granite (*n* = 24), the Togo Formation (*n* = 7), and from basins underlain by both Loon Lake Granite and Togo Formation (*n* = 10) are in table 22. Samples from the Midnite Mine tributary drainage, from Blue Creek, and from the geochemical halos surrounding the Midnite Mine and the Spokane Mountain deposit have been excluded from the statistical analysis.

Differences between the geometric mean concentrations determined for the Loon Lake Granite and the Togo Formation are in table 22. With the exception of Th and U, the GM concentrations for many of the trace elements are higher in the Togo Formation. However, no statistical tests were run on these two populations because the number of sediment samples from small basins underlain by the Togo Formation is too small to provide a robust statistical metric. With respect to crustal abundance values (CA), GM_{As} in the rocks of both the Loon Lake Granite and the Togo Formation exceed CA_{As}, whereas for Ba, Co, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Sr, Ti, Ni, V, and Zn, the GM concentrations for these elements in the Togo Formation is less than CA (table 22). Thorium concentrations in the Loon Lake Granite exceed CA_{Th} somewhat, whereas uranium concentrations in the Loon Lake Granite exceed CA_{U} by a factor of 2 or more.

We recognize from examining the data that, in the suite of samples from small drainage basins containing rocks from both the Loon Lake Granite and the Togo Formation, there is a distinct geochemical relationship between the stream-channel distance from the sediment sampling site and the intrusive contact of the Loon Lake Granite (fig. 28). Near the Loon Lake Granite–Togo Formation contact, base-metal mineralization associated with the intrusion of the Loon Lake Granite (75 Ma, Ludwig and others, 1981) has resulted in elevated concentrations of base metals (As, Cd, Co, Cu, Mo, Ni, Pb, and Zn; fig. 28) with some enrichment of manganese in the contact zone between the two rock units. Concentrations of the base metals will vary depending upon the distance from the igneous contact; however, they are a component of the

Table 20. Selected geochemical data and statistical summary, core 06MM01.

[Complete list of all geochemical data is in table A9; depth reported in centimeters (cm); concentrations reported in parts per million (ppm) or weight percent (wt. percent); Std. Dev., standard deviation; --, no data]

Sample interval	Depth (cm)	As ppm	Ba ppm	Ca ppm	Cd ppm	Co ppm	Cu ppm	Fe ppm	K ppm	Mg ppm	Mn ppm	Mo ppm	Na ppm	Ni ppm	P ppm	Pb ppm	Sr ppm	Th ppm	Ti ppm	U ppm	Zn ppm	U/Th	Total Carbon wt. percent
06MM01.01	0-2.5	6.5	114	4,920	1.0	11.4	16.8	19,300	2,480	5,440	1,020	0.73	174	31	752	18.5	27.1	17.6	851	26.0	217	1.48	--
06MM01.02	2.5-6	5.4	102	4,340	0.88	12.2	15.9	18,000	2,300	5,260	527	0.62	159	44	750	16.9	22.5	16.0	788	11.7	229	0.73	--
06MM01.03	6-8	7.2	134	4,370	1.3	20.6	22.6	21,300	2,560	5,400	601	0.53	166	65	674	18.1	22.4	18.0	911	24.1	291	1.34	1.95
06MM01.04	8-16	6.7	124	4,100	1.4	22.0	19.8	17,800	2,240	4,530	2,320	1.2	146	79	708	15.1	20.4	27.5	701	33.1	214	1.20	--
06MM01.05	16-25	6.9	105	3,590	1.0	18.1	13.3	18,200	2,010	4,270	2,500	2.1	128	70	768	14.4	17.0	53.7	618	29.7	92.0	0.55	--
06MM01.06	25-31.5	7.3	110	3,740	0.94	16.0	12.9	17,000	1,950	3,980	2,520	1.6	135	47	790	12.3	18.6	45.3	598	24.9	90.3	0.55	--
06MM01.07	31.5-34	6.5	92.4	2,640	0.48	22.9	8.1	17,100	1,470	3,360	3,160	1.3	86	33	521	8.9	15.0	39.0	485	12.1	72.0	0.31	--
06MM01.08	34-37.5	11.3	114	4,600	0.73	21.7	24.4	22,300	2,390	4,740	1,560	1.6	149	49	966	20.0	23.5	28.9	750	120	99.6	4.15	--
06MM01.09	37.5-40.5	7.7	216	6,990	4.7	24.9	33.9	16,200	2,000	4,290	715	2.8	139	123	705	22.1	33.7	25.0	665	656	209	26.24	6.79
06MM01.10	40.5-42.5	11.3	209	3,390	1.2	22.4	24.2	21,000	2,580	4,450	1,220	1.8	159	50	632	18.2	23.7	23.0	760	71.5	176	3.11	1.03
06MM01.11	42.5-45	8.5	108	3,900	2.8	31.4	23.8	19,000	2,960	5,240	1,660	1.9	174	97	529	16.4	22.9	20.2	865	142	286	7.03	1.58
06MM01.12	45-54	9.6	162	4,070	1.4	13.8	22.4	24,600	2,920	6,450	4,760	0.80	195	28	825	31.9	26.7	15.3	1,030	38.3	293	2.50	1.04
06MM01.13	54-60	5.1	223	4,500	1.7	5.1	25.0	19,000	2,250	4,820	394	0.56	156	16	611	53.0	28.9	18.0	940	18.8	347	1.04	2.36
06MM01.14	60-69	14.1	238	3,830	0.63	8.0	19.6	25,700	2,190	4,940	513	0.80	151	13	915	31.8	29.0	18.8	803	11.4	235	0.61	--
06MM01.15	69-74	9.1	125	3,830	2.4	8.4	18.5	17,000	2,490	4,430	575	0.67	152	19	523	64.0	24.2	13.3	871	12.4	903	0.93	3.04
06MM01.16	74-79	7.1	152	3,870	2.1	5.2	19.8	18,400	2,880	5,290	208	0.33	173	12	634	90.7	23.3	12.0	976	8.54	697	0.71	2.92
06MM01.17	79-84	4.6	189	3,640	1.6	4.1	19.0	19,300	2,710	4,900	214	0.33	158	13	767	83.9	24.3	11.5	909	9.04	597	0.79	2.93
06MM01.18	84-89	8.5	225	3,760	1.6	4.9	21.9	19,900	2,970	5,090	253	0.37	163	13	644	62.6	26.1	11.2	960	13.2	559	1.18	3.54
06MM01.19	89-94	7.1	200	4,180	0.98	4.8	21.4	20,600	2,870	4,660	272	0.53	165	12	715	32.6	26.9	12.1	923	22.3	315	1.84	4.17
06MM01.20	94-99	8.5	189	4,300	0.65	5.0	23.7	25,400	3,060	5,460	338	0.50	168	16	870	25.3	28.4	13.1	925	14.2	207	1.08	3.66
06MM01.21	99-104.5	10.9	154	5,340	0.55	5.9	28.0	25,300	3,510	5,940	556	0.74	168	15	718	26.9	30.6	13.8	960	5.72	237	0.41	3.58
06MM01.22	104.5-110	16.4	137	5,560	0.33	7.5	28.7	27,900	3,290	6,080	621	0.99	165	18	796	27.4	30.2	14.5	956	4.27	93.5	0.29	3.15
06MM01.23	110-115	20.1	152	4,630	0.16	7.6	23.8	27,700	2,990	6,670	482	0.80	150	14	719	21.4	27.9	15.9	860	4.48	73.9	0.28	1.74
06MM01.24	115-120	25.4	121	4,600	0.10	6.8	20.6	35,700	2,890	7,000	472	0.91	134	17	785	21.3	27.2	14.9	852	5.38	66.6	0.36	1.46
06MM01.25	120-127	9.4	163	5,560	0.11	5.6	24.9	28,100	3,560	7,360	214	1.0	165	16	632	25.2	30.8	18.5	1,130	33.7	85.4	1.82	1.82
Postmining Period (Intervals 01-07, *n* = 7)																							
Minimum		5.4	92	2,640	0.48	11	8.1	17,000	1,470	3,360	527	0.53	86	31	521	8.9	15	16	485	12	72	0.73	--
Maximum		7.3	134	4,920	1.4	23	23	21,300	2,560	5,440	3,160	2.1	174	79	790	19	27	54	911	33	291	0.62	--
Median		6.7	110	4,100	1.0	18	16	18,000	2,240	4,530	2,320	1.2	146	47	750	15	20	28	701	25	214	0.91	--
Geometric Mean		6.6	111	3,893	1.0	17	15	18,336	2,114	4,543	1,471	1.0	139	50	703	14	20	28	693	22	152	0.77	--
Mean		6.6	112	3,957	1.0	18	16	18,386	2,144	4,606	1,807	1.2	142	53	709	15	20	31	707	23	172	0.74	--
Std. Dev.		0.6	14	728	0.30	4.6	4.8	1,496	372	798	1,064	0.57	30	19	91	3.4	4.0	15	152	8.2	86	0.55	--
Premining Period (Intervals 20-25, *n* = 6, pre 1942; Ba, Ti, and U data from interval 25 were excluded)																							
Minimum		8.5	121	4,300	0.1	5.0	21	25,300	2,890	5,460	214	0.5	134	14	632	21	27	13	852	4.3	67	0.33	1.46
Maximum		25	189	5,560	0.7	7.6	29	35,700	3,560	7,360	621	1.0	168	18	870	27	31	19	960	14	237	0.77	3.66
Median		13.7	152	4,985	0.2	6.4	24	27,800	3,175	6,375	477	0.9	165	16	752	25	29	15	925	5.4	89	0.37	2.49
Geometric Mean		13.9	151	4,973	0.2	6.3	25	28,156	3,207	6,385	422	0.8	158	16	750	24	29	15	943	8.1	112	0.54	2.40
Mean		18	137	5,088	0.2	6.9	25	29,850	3,183	6,778	447	0.9	154	16	733	24	29	16	889	4.7	80	0.30	2.04
Std. Dev.		6.7	25	553	0.2	1.1	3.0	3,814	280	714	148	0.2	14	1.6	82	2.6	1.5	1.9	52	4.2	75	2.18	1.00
Premining Period (Intervals 15-19, *n* = 5, beaver pond)																							
Minimum		4.6	125	3,640	1.0	4.1	19	17,000	2,490	4,430	208	0.3	152	12	523	33	23	11	871	8.5	315	0.76	2.92
Maximum		9.1	225	4,180	2.4	8.4	22	20,600	2,970	5,290	575	0.7	173	19	767	91	27	13	976	22.3	903	1.68	4.17
Median		7.1	189	3,830	1.6	4.9	20	19,300	2,870	4,900	253	0.4	163	13	644	64	24	12	923	12.4	597	1.03	3.04
Geometric Mean		7.1	174	3,852	1.7	5.3	20	18,998	2,779	4,864	281	0.4	162	14	651	63	25	12	927	12.3	581	1.03	3.29
Mean		7.3	178	3,856	1.7	5.5	20	19,040	2,784	4,874	304	0.4	162	14	657	67	25	12	928	13.1	614	1.09	3.32
Std. Dev.		1.7	40	201	0.5	1.7	1.5	1,397	189	340	154	0.1	7.9	2.8	92	23	1.5	0.8	42	5.5	214	6.88	0.54
Mining Period (intervals 08-12, *n* = 5)																							
Minimum		7.7	108	3,390	0.73	14	22	16,200	2,000	4,290	715	0.80	139	28	529	16	23	15	665	38	100	2.50	1.03
Maximum		11	216	6,990	4.7	31	34	24,600	2,960	6,450	4,760	2.8	195	123	966	32	34	29	1,030	656	293	22.70	6.79
Median		10	162	4,070	1.4	22	24	21,000	2,580	4,740	1,560	1.8	159	50	705	20	24	23	760	120	209	5.22	1.31
Geometric Mean		10	155	4,442	1.7	22	25	20,415	2,544	4,978	1,608	1.7	162	61	716	21	26	22	805	125	198	5.69	1.84
Mean		10	162	4,590	2.2	23	26	20,620	2,570	5,034	1,983	1.8	163	69	731	22	26	22	814	206	213	9.14	2.61
Std. Dev.		1.6	51	1,409	1.6	6.3	4.6	3,200	397	870	1,596	0.72	22	39	170	6.1	4.5	5.1	140	255	81	49.88	2.80

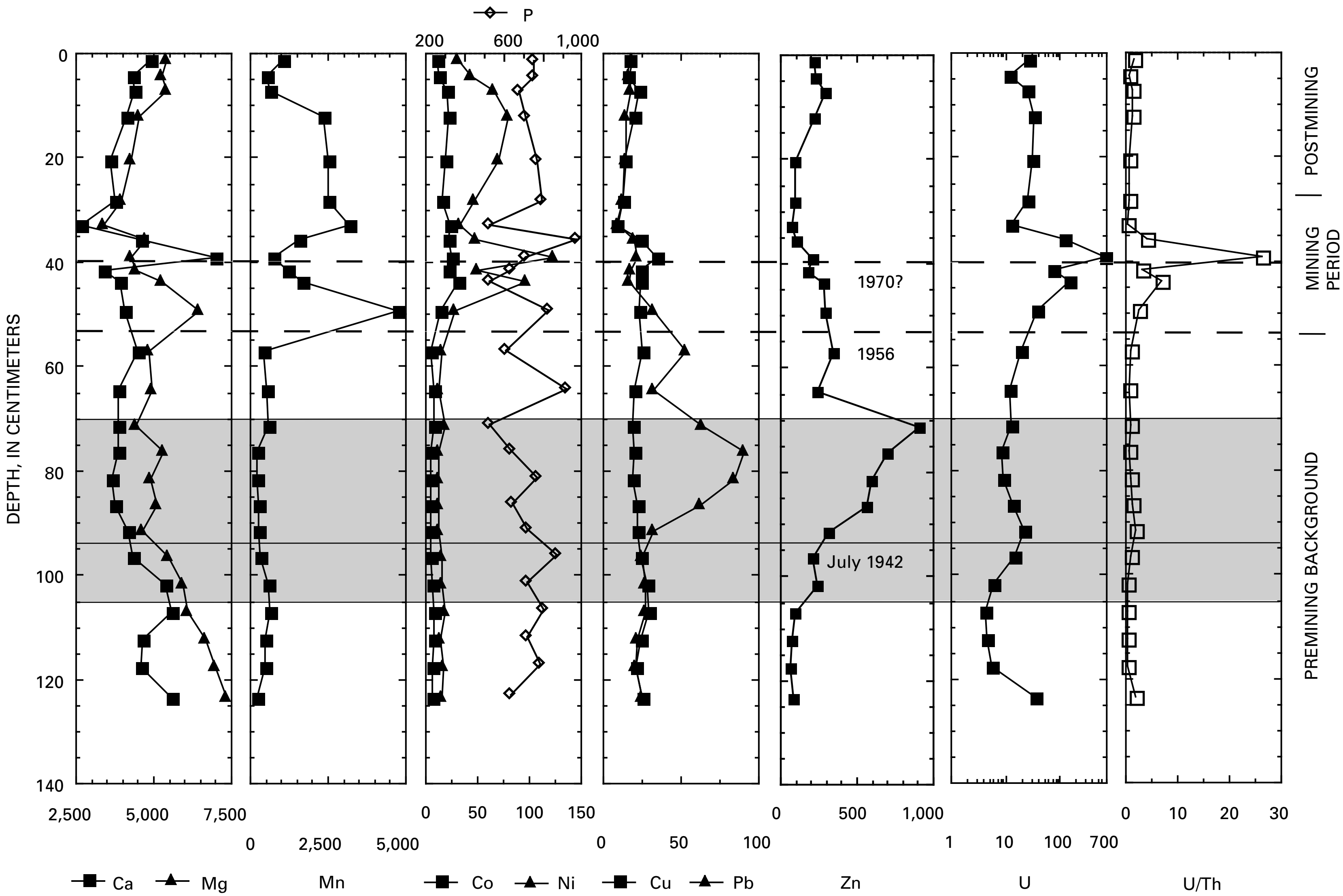


Figure 26. Geochemical plots of the concentrations of calcium (Ca), magnesium (Mg), manganese (Mn), cobalt (Co), nickel (Ni), phosphorus (P, concentrations shown at top of figure), copper (Cu), lead (Pb), zinc (Zn), uranium (U), in parts per million (ppm or µg/g), and the U/Th value (uranium/thorium) versus depth (in centimeters) for core 06MM01. The 1956 and the 1970 timelines were determined by comparison with the changes in the geochemical profiles in cores 06MM04 (fig. 24) and 06MM02 (fig. 25). The sedimentary record is discontinuous; sediment from the mining period following 1970 is not present. Postmining sediment (that is, above 34 cm, table A1) has no time constraints; that is, it could have been deposited any time from the period 1981 to present. The beaver pond (shaded area) was established prior to July 1942 (fig. 16) and then abandoned following flooding by Lake Roosevelt. Premining sediment from Blue Creek as well as sediment from the Coeur d'Alene mining district accumulated in this sediment catchment.

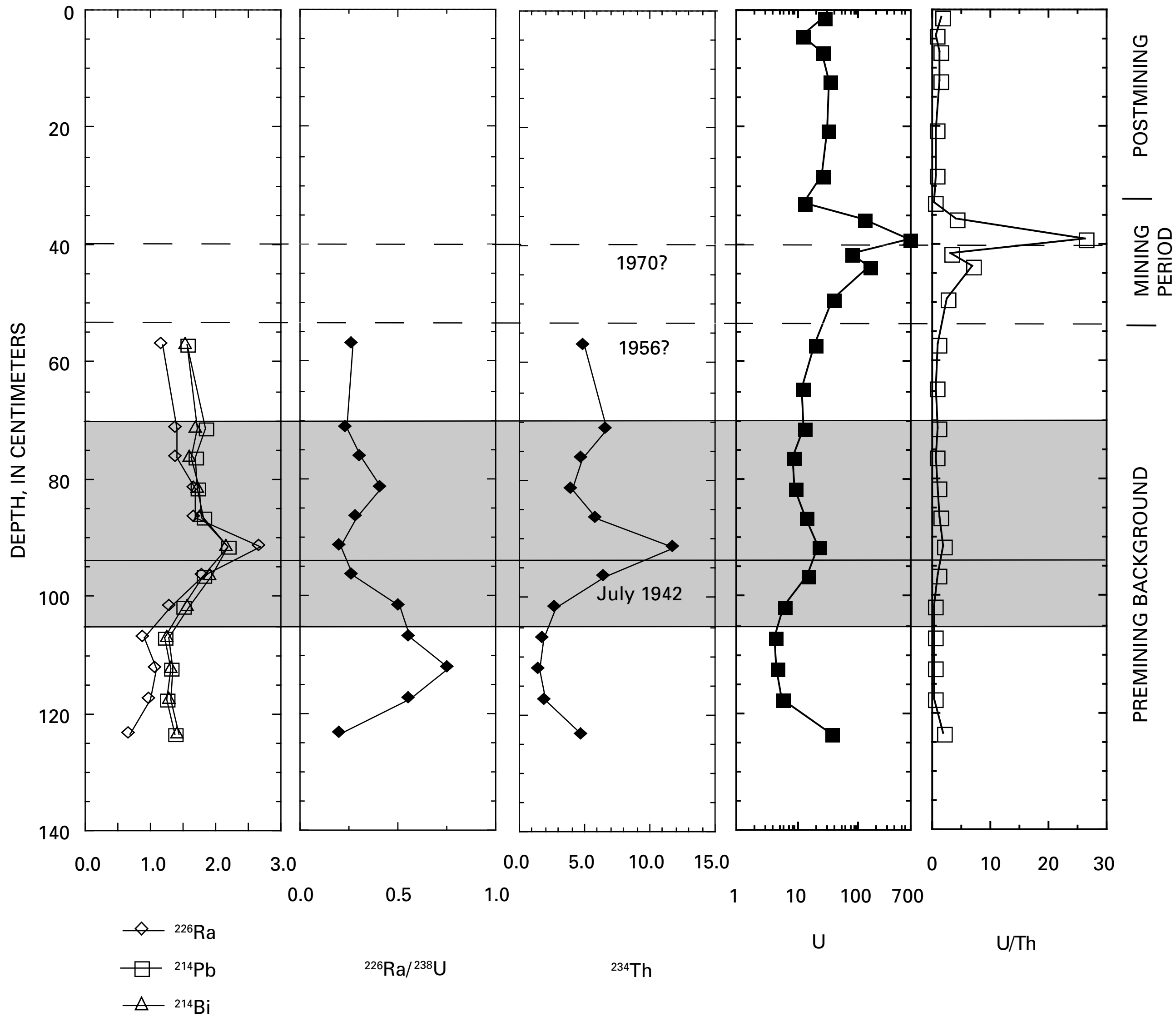


Figure 27. Radionuclide activity (pCi/g) measured in core 06MM01 for ^{226}Ra, ^{214}Pb, ^{214}Bi, and ^{234}Th, activity ratios for $^{226}Ra/^{238}U$, concentrations of uranium (log scale), and the U/Th value versus depth (in centimeters). As there are large counting errors associated with the direct measurement of the ^{226}Ra activity, the $^{226}Ra/^{238}U$ value is calculated from the activities of ^{214}Pb and ^{214}Bi. Because of the long half-life of ^{230}Th (fig. 18), the activity of ^{234}Th is used as a proxy for the ^{238}U activity. This ratio is used to demonstrate that the activity of the two isotopes ($^{226}Ra/^{238}U$) is out of equilibrium. This disequilibrium is caused by aqueous transport of ^{238}U and subsequent deposition at another site. Timelines and shaded area of beaver pond sedimentation are from figure 26.

pre-uranium-mineralization geochemical background. Erosion of Togo Formation rocks from the mine site contributed base metals to the premining geochemical background. The entire spread of the geochemical data from unmineralized sediment samples (fig. 28), with some exceptions for arsenic, cadmium, and molybdenum, is generally within a factor of 2 of the GM concentration in rocks from the Togo Formation (table 22). In contrast with the base-metal associations at the igneous contact, samples from within the geochemical halos of the uranium deposits show a marked increase in uranium concentration and the U/Th value (fig. 28). The enrichment of uranium, as shown by the increase in U/Th (fig. 28), resulted from the Eocene hydrothermal event (Ludwig and others, 1981), whereas the earlier base-metal enrichment at the contact is related to the 75 Ma intrusive event. Multiple episodes of mineralization are common along igneous contacts with older rocks as they constitute zones of structural weakness in the Earth's crust. The mineralogical observations (Barrington and Kerr, 1961) that late-stage marcasite was precipitated on pitchblende, as well as petrographic observations (Nash, 1977) that previously existing chalcopyrite was corroded and sphalerite was late in the paragenetic sequence, indicate that the base-metal sulfide minerals present in the Midnite Mine deposit were remobilized during the 51±0.5 Ma hydrothermal event that formed the Midnite Mine uranium deposit.

Stream-sediment samples from Blue Creek upstream of the Midnite Mine tributary confluence, from Oyachen Creek, and from Sand Creek where they were not influenced by historical mining were pooled to calculate the premining geochemical background (table 23 and tables A20 and A21). Collectively, these sites constitute a geochemical background reference area (U.S. EPA, 2002). The only stream-sediment data excluded from the calculation of geochemical background for case I (table A20, case I, $n = 59$) are those samples directly affected by mining at the Midnite Mine site. Those samples from within the geochemical halo of the Midnite Mine deposit and the Spokane Mountain deposit have not been excluded, nor should they be. The geochemical halo surrounding the Midnite Mine site and certainly the geochemical anomaly associated with the Spokane Mountain uranium deposit constitute a legitimate component of the premining geochemical background for this study. The statistical results from case I (59 samples) are summarized in table 23, and the graphical results from log-transformed data are included in table A20 in Appendix A.

Stream-sediment data from the geochemical halo of the Midnite Mine and Spokane Mountain uranium deposits were excluded from the data set for the calculation of geochemical background in Case II (table 23). The geochemical data from the Midnite Mine and Spokane Mountain deposits have a minimal effect on the statistics for most elements (case II, table 23; table A21, $n = 49$). The effect of using the geochemical data set from case II as an estimate of geochemical background would result in reducing the geometric mean and the 95 percent confidence interval determined in case I ($n = 59$) by 7 percent or less for the majority of the elements. Only molybdenum and U/Th changed by more than 9 percent.

The 95 percent confidence interval on the GM concentrations brackets the uncertainty about the GM concentration for a given element. The exceptions to this generalization are: GM_{Ba} was reduced by 7 percent, GM_{Mo} by 9 percent (two large outliers have been excluded from the Mo data set), GM_{U} by 5.5 percent and U/Th by 8.5 percent. The 95 percent confidence interval about the GM was reduced by more than 10 percent for Mo and U/Th, and increased by more than 10 percent for Ca, Mg, P, Th, Ti, and V. Thus, the data in table 23, case II constitute a more conservative data set to use for geochemical background. The U/Th value is the most discriminating measure of uranium mineralization. Comparison of the geochemical background data from this study with the geochemical background data used in the Ecological Risk Assessment (Lockheed Martin, 2005) shows that the two data sets are fundamentally different because the U.S. EPA used bulk sediment samples rather than sieved sediment samples. Therefore, for comparisons of the geochemical data determined in this study from sites in Blue Creek downstream from the Midnite Mine and in the Blue Creek delta, we use the new premining geochemical background data (case II, table 23).

Comparison of the 1975 USGS Sediment Geochemical Data with Geochemical Data from the 1970s Sample Intervals in 2006 Cores

The stream-sediment data collected by Otton (1976), and to a much lesser extent, the 1979 NURE sediment data (Babcock and others, 1981) provided a series of samples collected at a specific time during the mining period against which we can compare the results from our core study. Stream-sediment geochemistry changes dramatically downstream with distance because of dilution with sediment derived from unmineralized areas. Those changes are shown in the idealized geochemical dispersion model for sediment transport downstream from a mineralized site (fig. 29). In this geochemical dispersion model, zone 1 represents the mineralized area where some trace-elements are concentrated and would be analogous to the Midnite Mine site. The premining geochemical concentration of any trace element elevated at a mineralized site is represented as zone 1. In zone 2, downstream of the mineralized site, analogous to the reach of Blue Creek downstream of the Midnite Mine tributary, mixing and dilution by sediment from unmineralized areas would occur. The reduction in metal concentrations would be proportional to the area of the drainage basin, the erodability of the rock present, and the geochemistry of the rocks in other parts of the basin. This mixing process is a complex, nonlinear function of at least three variables: area, erodability, and stream distance. Downstream, the concentration of any given metal will become asymptotic to the regional premining background concentration (zone 3, analogous to the Blue Creek delta), but will never reach premining geochemical background concentrations. Distances on the *x*-axis are relative and the length of mixing zone (zone 2) will vary

Table 21. Selected NURE stream-sediment geochemical data from samples grouped on the basis of underlying geology.

[Complete list of all analytical data is in table A17; concentrations are reported in parts per million (ppm); distance from contact in kilometers (km); samples indicated by S1* are the mean value of duplicate analyses. Highlighted samples from downstream of historical mines]

Sample No.	Al	As	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sr	Th	Ti	U	V	Zn	U/Th	Distance from contact[3]
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm		km
Blue Creek sediment:																									
DSOR136S1	10,200	4.3	69	4,200	0.57	10.1	17.1	8.6	27,800	1,710	2,810	885	1.60	158	24.6	770	14.1	23.6	121	802	45.6	58.7	80.6	0.38	
RZAH028S1	13,700	15.6	71	2,900	2.8	19.7	13.8	18.7	18,100	2,610	2,920	4,060	4.30	170	79.9	368	14.2	18.4	42.9	599	102	29.3	174	2.38	
Midnite Mine tributary:																									
DSOR137S1	13,400	16.3	92	3,820	6.4	98	13.7	35.2	19,500	1,980	2,580	14,000	4.00	195	295	448	14.2	24.3	94.9	704	166	38.0	392	1.75	
DSOR313S1*	29,500	24.0	159	4,835	0.20	13.3	26.2	28.5	28,350	4,575	5,335	864	3.90	226	24.0	554	19.4	37.2	27.5	1,075	195	44.7	73.9	7.12	
DSOR314S1	23,300	6.2	190	3,590	0.16	9.1	18.3	17.9	19,700	3,730	3,300	592	2.60	148	15.0	451	12.6	33.4	12.0	1,230	8.7	33.4	51.4	0.72	
DSOR460S1	21,200	15.6	127	3,540	0.49	13.3	15.4	22.8	21,000	3,420	3,660	828	3.90	206	29.0	448	17.5	27.7	26.2	753	127	30.0	78.7	4.85	
Sites downstream of road crossings:																									
DSOR102S1	26,200	3.5	194	4,660	0.17	6.7	18.1	16.6	20,000	2,910	3,100	548	0.33	274	12.5	627	14.1	44.6	18.0	1,090	25.4	30.9	58.2	1.41	
DSOR129S1*	13,250	7.5	96	14,400	0.15	5.8	11.4	16.3	16,250	2,325	3,760	659	1.55	264	8.5	501	12.3	32.5	42.0	692	45.1	32.8	43.4	1.07	
DSOR131S1	25,700	4.0	134	4,150	0.19	5.1	12.1	16.4	19,200	3,320	3,580	480	0.64	428	9.7	357	16.8	32.9	10.5	1,140	22.3	24.3	68.5	2.12	
DSOR424S1	27,400	8.5	358	9,360	0.36	11.0	18.7	22.6	26,600	4,790	5,010	1,710	1.50	222	18.6	870	22.4	56.0	45.2	1,620	23.9	41.3	95.6	0.53	
DSOR441S1	23,000	8.5	164	4,970	0.30	7.2	13.5	15.1	20,500	3,460	3,800	960	0.98	248	12.7	587	14.7	30.1	26.4	999	22.6	28.5	70.0	0.86	
DSOR442S1	19,500	3.7	414	27,400	0.33	6.5	15.4	23.3	14,700	5,580	5,660	716	0.91	395	11.5	1,520	17.6	102	7.6	966	8.8	21.5	108	1.16	
DSOR448S1	47,000	76.3	226	4,610	0.52	41.1	33.0	61.9	49,500	6,310	7,730	1,170	2.50	168	52.2	1,130	18.6	43.6	13.0	1,780	4.0	59.2	118	0.31	
Togo Formation:																									
DSOR315S1	27,200	11.6	169	3,320	0.16	10.4	23.1	29.2	23,200	4,270	3,890	560	0.90	206	18.7	470	12.4	29.4	10.3	1,340	3.1	39.1	49.6	0.30	
DSOR378S1	25,100	21.5	127	3,520	0.09	9.0	23.4	38.8	24,100	4,120	4,970	483	0.36	201	18.2	388	16.0	30.0	10.2	1,530	2.4	44.5	51.1	0.24	
DSOR379S1	26,200	17.3	330	5,030	0.26	9.4	18.5	38.8	20,900	3,540	6,770	522	0.42	384	16.0	567	20.4	24.6	6.6	1,480	1.0	33.4	49.8	0.15	
DSOR387S1	32,900	41.3	223	2,870	0.24	16.2	44.0	39.3	35,400	10,900	8,920	684	4.4	154	33.2	481	13.7	26.8	13.8	2,060	2.68	53.9	72.9	0.194	
DSOR395S1	17,400	8.1	146	2,340	0.08	7.0	18.4	18.4	20,400	4,340	4,560	313	0.40	132	15.8	459	11.6	21.3	10.5	1,050	1.4	28.8	51.6	0.13	
DSOR418S1[1]	32,200	18.3	290	5,320	0.32	9.9	14.0	26.2	20,800	1,900	2,390	596	0.84	512	20.4	1,330	18.3	53.8	6.1	1,320	1.9	28.7	75.2	0.32	
DSOR455S1*	16,650	21.4	109	1,925	0.08	7.3	14.6	19.8	19,350	4,350	3,450	295	0.43	184	13.9	425	7.7	21.9	9.6	1,075	1.5	25.3	32.8	0.15	
RZAH021S1*	20,600	39.8	111	3,675	0.08	14.9	21.1	32.4	25,850	3,225	4,205	619	0.54	141	18.0	422	14.4	24.9	11.7	1,420	1.8	46.5	38.1	0.15	
Loon Lake granite:																									
06MM07.01	17,200	3.3	130	5,630	0.65	6.4	15.3	12.0	17,700	2,190	2,510	554	0.83	156	12.1	1,100	17.7	42.4	63.3	507	21.2	25.7	56.4	0.33	
06MM07.02	19,800	2.9	119	4,930	0.21	5.7	12.8	12.6	20,500	2,340	2,760	501	0.73	141	10.0	1,180	17.7	37.1	59.5	598	20.2	30.0	57.3	0.34	
06MM07.03	24,800	3.8	152	5,380	0.44	4.8	47.4	22.9	19,700	2,300	2,830	291	2.50	172	35.2	910	22.4	42.6	44.9	755	30.5	44.6	63.1	0.68	
DSOR100S1*	18,200	3.6	154	2,780	0.31	7.3	14.6	13.0	17,600	3,165	3,285	683	0.48	174	12.5	480	18.1	26.1	14.0	1,195	1.5	31.1	61.9	0.11	
DSOR101S1	18,500	3.0	190	3,470	0.14	8.7	15.7	15.0	18,300	3,670	3,380	747	0.50	170	14.3	475	13.4	30.0	13.2	1,170	1.5	31.6	56.6	0.11	
DSOR118S1	15,700	7.9	133	2,660	0.16	6.8	17.1	16.6	19,800	4,250	4,360	391	1.20	150	14.2	480	14.6	23.6	10.9	1,040	2.3	30.7	58.6	0.21	
DSOR119S1	16,700	3.0	132	3,360	0.11	5.9	10.2	11.4	14,500	2,700	2,920	559	0.43	352	8.8	458	12.2	33.2	11.5	855	5.0	22.0	49.4	0.44	
DSOR120S1	21,900	4.0	116	4,430	0.19	5.2	11.0	12.3	19,400	2,590	3,430	331	0.26	295	9.4	674	22.2	34.8	26.2	822	11.9	27.6	80.4	0.45	
DSOR121S1	14,600	8.5	111	3,100	0.33	6.8	14.3	15.7	19,200	3,840	5,060	641	0.53	152	12.1	498	22.1	23.3	16.8	962	2.7	27.7	90.2	0.16	
DSOR126S1	25,400	3.9	194	3,280	0.26	5.0	10.1	21.7	15,000	3,230	2,360	639	0.44	511	9.2	679	14.4	33.1	6.0	1,120	1.9	22.2	73.0	0.32	
DSOR127S1	15,500	4.6	167	4,840	0.35	6.5	12.6	12.4	17,700	3,790	3,910	903	0.76	203	10.7	611	21.2	40.4	17.5	956	2.3	27.8	82.8	0.13	
DSOR128S1	27,300	4.8	198	7,610	0.25	6.0	16.9	16.1	21,200	3,180	3,680	652	0.47	301	12.9	617	16.9	44.6	31.6	1,080	13.9	29.9	62.1	0.44	
DSOR133S1	14,400	5.2	90	3,380	0.14	4.9	12.1	14.6	16,400	2,890	3,230	420	0.76	263	9.0	444	12.3	27.3	21.4	835	3.4	26.7	58.1	0.16	
DSOR134S1*	17,400	5.3	105	3,260	0.23	4.8	12.1	13.8	19,400	3,020	3,985	433	0.31	180	9.2	463	17.2	26.4	23.9	970	9.4	28.7	98.1	0.40	
DSOR403S1	14,900	2.4	109	3,800	0.24	5.0	7.2	8.3	15,800	3,690	3,220	958	1.20	269	5.6	565	22.9	33.8	49.4	959	20.9	24.6	72.2	0.42	
DSOR404S1	14,700	2.3	170	2,520	0.19	2.9	7.4	8.3	12,400	2,190	2,160	529	0.44	388	5.7	623	12.7	26.0	14.9	940	1.6	20.0	115	0.11	
DSOR419S1	11,900	1.7	135	2,000	0.10	5.8	13.5	9.3	13,000	2,130	2,370	583	0.30	119	11.1	263	7.2	21.1	13.2	1,160	2.0	27.9	37.9	0.15	
DSOR420S1	22,600	2.4	151	2,480	0.10	6.4	12.4	11.7	20,700	3,980	4,030	707	0.30	154	10.8	503	9.8	25.9	32.6	1,430	4.9	33.2	71.6	0.15	
DSOR421S1	21,800	5.0	153	2,490	0.15	5.2	12.5	13.8	20,600	2,910	4,280	515	0.56	151	10.1	603	16.8	25.5	20.4	1,130	6.1	32.4	70.2	0.30	
DSOR422S1	25,600	2.2	167	4,370	0.26	4.8	11.4	14.7	15,300	2,670	2,630	503	0.31	629	9.8	402	12.8	48.8	14.0	1,130	4.5	23.6	55.7	0.32	
DSOR423S1	23,800	2.7	201	3,720	0.23	7.2	14.1	14.9	18,400	4,060	3,800	726	0.63	258	10.4	722	12.1	37.9	22.5	1,250	9.5	29.8	61.3	0.42	
DSOR425S1	23,500	3.4	218	3,550	0.44	7.5	15.3	15.4	18,500	3,400	3,380	596	0.65	220	11.8	640	13.4	39.8	10.5	1,250	2.0	29.4	62.2	0.19	
DSOR426S1	20,400	1.7	183	2,680	0.17	5.7	13.4	10.8	16,900	3,190	3,740	725	0.36	270	11.6	357	10.0	35.1	29.2	1,280	4.8	27.9	53.9	0.16	
RZAH027S1	16,600	2.7	102	2,930	0.04	4.9	11.2	9.5	16,500	2,270	2,890	456	0.25	214	8.2	538	9.9	29.8	58.5	929	11.8	25.5	41.6	0.20	

Table 21. Selected NURE stream-sediment geochemical data from samples grouped on the basis of underlying geology.--Continued.

Sample No.	Al ppm	As ppm	Ba ppm	Ca ppm	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe ppm	K ppm	Mg ppm	Mn ppm	Mo ppm	Na ppm	Ni ppm	P ppm	Pb ppm	Sr ppm	Th ppm	Ti ppm	U ppm	V ppm	Zn ppm	U/Th	Distance from contact[3] km
Loon Lake granite porphyry:																									
DSOR135S1	13,000	21.2	102	12,200	0.27	7.4	16.4	18.4	21,700	2,720	8,500	482	0.49	150	13.5	711	18.8	28.4	13.4	888	2.8	27.6	67.4	0.21	<5
DSOR388S1	21,400	4.3	152	3,740	0.07	7.8	14.1	13.4	21,000	2,620	3,700	532	0.77	200	10.8	562	12.1	38.3	10.6	1,270	2.0	40.5	43.2	0.19	>5
DSOR389S1	16,100	14.0	159	3,360	0.22	6.7	10.9	18.9	19,000	2,690	2,930	591	3.50	252	9.2	558	24.4	23.5	17.8	1,110	3.2	36.3	49.0	0.18	-1.93
DSRO395S1	17,400	8.1	146	2,340	0.08	7.0	18.4	18.4	20,400	4,340	4,560	313	0.40	132	15.8	459	11.6	21.3	10.5	1,050	1.4	28.8	51.6	0.134	
DSOR398S1	39,100	42.9	266	4,070	0.16	17.6	36.4	39.4	41,600	11,000	7,110	716	1.70	181	32.5	809	12.1	40.5	14.9	1,850	2.2	44.5	85.2	0.15	-1.93
DSOR399S1	30,000	7.6	344	5,230	0.28	11.4	22.1	24.2	25,100	4,230	3,890	887	0.85	249	19.8	751	17.1	56.7	9.6	1,700	2.1	39.1	74.9	0.22	-1.16
Togo Formation, calc-silicate unit:																									
DSOR438S1[2]	33,900	44.4	144	9,620	0.22	17.5	28.8	43.2	37,400	4,230	6,010	829	1.50	210	33.1	754	16.1	38.7	12.9	1,220	3.5	42.4	72.9	0.27	0.16
DSOR443S1	19,800	3.9	202	5,630	0.33	7.4	18.4	16.5	17,200	3,490	3,740	515	0.40	197	13.1	574	18.3	41.9	7.6	1,190	2.7	30.2	56.3	0.35	0.16
Loon Lake granite and Togo Formation:																									
DSOR414S1[1]	16,600	2.9	157	2,960	0.14	6.6	12.4	12.6	14,700	2,050	2,530	700	0.69	193	10.4	508	14.3	32.7	13.7	856	36.6	24.9	44.0	2.67	-0.32
DSOR415S1[1]	25,100	2.8	342	4,290	0.25	6.3	12.9	12.9	17,300	2,280	2,910	1,150	0.52	327	12.4	1,050	18.7	38.7	10.4	1,180	4.1	26.5	85.1	0.39	-0.43
DSOR416S1[1]	21,200	14.8	109	2,730	0.10	10.4	17.1	18.2	20,500	2,390	2,870	491	0.87	236	15.7	455	17.2	24.7	24.7	1,090	18.9	33.8	38.1	0.77	-0.03
DSOR417S1[1]	44,100	4.0	432	3,490	0.20	7.8	18.6	27.8	23,800	2,410	3,710	656	0.36	684	22.6	843	14.9	44.6	9.4	1,680	7.2	35.2	79.6	0.77	-1.29
DSOR447S1[1]	32,700	10.1	296	4,620	0.59	14.4	26.6	34.7	28,700	3,830	4,200	708	1.20	288	33.3	1,070	16.9	43.7	11.0	1,450	11.2	44.4	126	1.02	0.40
DSOR449S1[1]	17,400	2.1	192	3,030	0.22	7.1	9.8	9.0	17,800	3,910	3,760	1,230	0.48	158	9.8	500	16.3	31.0	31.5	1,240	5.4	27.6	57.9	0.17	-0.23
DSOR439S1[2]	20,900	37.3	257	4,680	0.29	6.4	14.5	23.9	22,100	2,770	2,560	510	2.90	159	13.9	921	19.9	37.1	9.3	904	2.3	33.8	41.9	0.24	0.16
DSOR440S1[2]	30,500	182	324	4,090	0.65	20.4	19.6	46.9	31,800	2,710	3,260	735	3.10	123	43.4	773	24.6	36.1	12.5	1,190	13.7	39.6	68.0	1.10	0.16
DSOR376S1	23,400	22.8	149	2,800	0.15	9.4	25.6	24.5	23,300	4,760	5,160	356	0.39	243	22.4	588	8.6	24.7	10.8	1,300	2.0	34.6	44.8	0.19	1.53
DSOR400S1	24,200	28.8	233	4,750	0.33	11.2	23.6	34.0	22,300	4,360	3,820	769	0.84	282	20.1	808	25.5	41.0	10.2	1,470	2.7	35.6	70.7	0.26	0.64
DSOR445S1	28,100	7.7	172	2,890	0.23	10.4	19.9	21.2	23,200	6,540	6,340	463	0.51	268	20.4	608	8.6	27.9	15.4	1,620	2.6	27.9	54.4	0.17	0.72
DSOR446S1	31,100	7.0	343	2,930	0.19	10.6	24.6	23.5	25,700	4,900	4,540	571	0.43	353	20.7	1,120	10.8	29.9	9.8	1,800	1.2	37.8	73.3	0.12	1.09
DSOR450S1	38,200	80.6	207	4,650	0.14	19.6	41.0	40.2	39,800	10,200	8,370	784	0.63	155	34.2	1,200	11.3	39.0	11.5	1,750	1.5	59.1	61.2	0.13	>5
DSOR451S1*	27,950	24.1	192	4,000	0.19	11.3	24.5	25.4	25,550	5,710	5,625	564	0.49	254	22.6	618	13.5	33.3	11.2	1,465	4.5	34.2	52.1	0.40	1.61
DSOR452S1	33,900	62.7	357	5,160	0.61	18.6	27.0	42.1	34,600	6,860	5,750	1,060	0.69	273	30.8	1,320	30.1	51.5	8.6	1,910	1.3	59.8	91.8	0.15	1.00
DSOR456S1	21,100	79.2	143	3,300	0.14	10.7	20.8	27.4	25,500	4,960	4,930	440	0.54	160	18.9	575	12.8	27.8	13.6	1,190	3.0	33.6	49.6	0.22	3.54
DSOR457S1*	14,300	12.9	36	889	0.11	7.5	15.9	56.8	25,200	4,125	2,690	93	0.89	35	10.8	196	4.8	8.4	14.0	655	3.8	22.5	16.5	0.27	0.90
DSOR458S1*	25,100	98.4	199	3,190	0.22	21.7	21.3	39.7	33,250	3,885	3,870	778	8.90	87	35.0	584	15.2	32.0	19.3	1,095	8.0	40.8	53.1	0.42	0.32
Sites draining older glacial deposits:																									
DSOR340S1	14,100	20.2	137	19,400	0.23	9.8	19.6	22.8	24,900	2,880	9,170	540	0.50	159	17.3	760	20.3	41.0	11.7	953	1.9	34.4	69.1	0.16	
DSOR341S1	11,700	20.0	98	15,000	0.18	7.1	15.6	18.5	20,400	2,570	8,560	453	0.42	131	12.8	717	16.8	32.0	9.4	792	1.0	26.4	58.0	0.11	
RZAH037S1	19,000	3.9	124	3,590	0.09	5.2	13.0	15.2	17,500	2,230	2,670	493	0.32	287	11.3	500	13.8	35.4	60.8	846	24.1	30.2	43.6	0.40	

[1] Indicates sediment site from within the geochemical anomaly of the Spokane Mountain uranium deposit (Robbins, 1978).

[2] Indicates sediment site from within the geochemical anomaly of the Midnite Mine uranium deposit. [3]Blank, not applicable.

Table 22. Summary and comparison of statistical data for stream sediment from drainage basins underlain by Loon Lake Granite, Togo Formation, and a combination of Loon Lake Granite and Togo Formation rocks.

[Concentrations reported in parts per million (ppm); crustal abundance data from Fortescue (1992); *n*, number of observations; Std. Dev., Standard Deviation; CV, Coefficient of Variation; n.d. not determined]

	Statistical parameter	Al	As	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sr	Th	Ti	U	V	Zn	U/Th
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	
	Crustal Abundance	*83,600*	*1.8*	*390*	*46,600*	*0.16*	*29.0*	*122*	*68.0*	*62,200*	*18,400*	*27,600*	*1,060*	*1.20*	*22,700*	*99.0*	*1,120*	*13.0*	*384.0*	*8.1*	*6,320*	*2.3*	*136.0*	*76.0*	*0.284*
Loon Lake Granite:																									
n = 24	Minimum	11,900	1.7	89.7	2,000	0.04	2.9	7.2	8.3	12,400	2,130	2,160	291	0.25	119	5.6	263	7.2	21.1	6.0	507	1.5	20.0	37.9	0.11
	25th percentile	15,650	2.6	118	2,755	0.15	5.0	11.4	11.6	16,250	2,528	2,813	490	0.35	156	9.2	472	12.3	26.0	13.8	911	2.2	25.7	56.6	0.16
	50th percentile	18,350	3.4	152	3,370	0.22	5.8	12.5	13.4	18,000	3,093	3,333	571	0.49	209	10.6	552	14.5	33.2	20.9	1,005	4.8	27.9	62.0	0.25
	75th percentile	22,825	4.7	173	4,385	0.27	6.6	14.4	15.1	19,475	3,675	3,828	689	0.74	276	12.1	649	17.8	38.4	31.9	1,163	11.8	30.2	72.4	0.40
	Maximum	27,300	8.5	218	7,610	0.65	8.7	17.1	22.9	21,200	4,250	5,060	958	2.5	629	35.2	1,180	22.9	48.8	63.3	1,430	30.5	44.6	115	0.68
	Mean	19,300	3.8	149	3,694	0.24	5.8	12.8	13.6	17,688	3,069	3,342	585	0.63	245	11.4	595	15.4	32.9	26.1	1,013	8.2	28.4	66.2	0.28
	Std. Dev.	4,309	1.7	35.9	1,276	0.13	1.2	2.6	3.6	2,434	660	725	164	0.48	123	5.5	214	4.5	7.6	16.9	218	8.0	4.8	17.4	0.15
	CV (in percent)	22	46	24	35	57	21	21	26	14	22	22	28	75	50	48	36	29	23	65	21	98	17	26	53
	Geometric Mean	**18,840**	**3.4**	**145**	**3,515**	**0.20**	**5.7**	**12.5**	**13.2**	**17,516**	**3,000**	**3,267**	**563**	**0.53**	**223**	**10.7**	**563**	**14.8**	**32.0**	**21.6**	**988**	**5.3**	**28.0**	**64.2**	**0.24**
	Skewness	0.25	1.42	0.20	1.42	1.40	0.10	-0.25	0.92	-0.58	0.16	0.37	0.39	2.90	1.78	3.67	1.40	0.21	0.35	1.11	-0.47	1.42	1.36	1.08	0.81
	Kurtosis	-1.09	2.06	-0.98	2.52	2.71	0.90	0.07	1.42	-0.38	-1.16	-0.18	0.15	10.31	3.38	16.25	2.22	-0.88	-0.85	0.09	0.25	1.37	4.70	1.62	0.36
Togo Formation[1]:																									
n = 7	Minimum	16,650	8.1	109	1,925	0.08	7.0	14.0	18.4	19,350	1,900	2,390	295	0.36	132	13.9	388	7.7	21.3	6.1	1,050	1.0	25.3	32.8	0.13
	25th percentile	19,000	14.5	119	2,830	0.08	8.1	16.5	23.0	20,600	3,383	3,670	398	0.41	163	15.9	423	12.0	23.3	8.1	1,198	1.4	28.8	43.9	0.15
	50th percentile	25,100	18.3	146	3,520	0.09	9.4	18.5	29.2	20,900	4,120	4,205	522	0.43	201	18.0	459	14.4	24.9	10.2	1,340	1.8	33.4	49.8	0.15
	75th percentile	26,700	21.4	230	4,353	0.21	10.2	22.1	35.6	23,650	4,305	4,765	578	0.69	295	18.5	519	17.2	29.7	10.4	1,450	2.2	41.8	51.4	0.27
	Maximum	32,200	39.8	330	5,320	0.32	14.9	23.4	38.8	25,850	4,350	6,770	619	0.90	512	20.4	1,330	20.4	53.8	11.7	1,530	3.1	46.5	75.2	0.32
	Mean	23,621	19.7	183	3,590	0.15	9.7	19.0	29.1	22,086	3,678	4,319	484	0.56	251	17.3	580	14.4	29.4	9.3	1,316	1.9	35.2	49.7	0.21
	Std. Dev.	5,652	10.1	90	1,257	0.10	2.6	3.8	8.3	2,340	896	1,364	131	0.22	142	2	336	4.3	11.3	2.1	188	0.7	8.3	13.4	0.08
	CV (in percent)	24	51	49	35	65	27	20	28	11	24	32	27	40	57	13	58	30	38	23	14	37	24	27	38
	Geometric Mean	**23,031**	**17.7**	**167**	**3,393**	**0.13**	**9.4**	**18.7**	**28.0**	**21,982**	**3,557**	**4,136**	**466**	**0.52**	**224**	**17.2**	**527**	**13.8**	**28.0**	**9.0**	**1,304**	**1.8**	**34.3**	**48.3**	**0.19**
	Skewness	0.12	1.34	1.09	0.18	1.07	1.38	-0.22	-0.07	0.62	-1.56	0.65	-0.77	1.02	1.34	-0.22	2.49	-0.15	2.18	-0.87	-0.62	0.71	0.32	0.97	0.70
	Kurtosis	-1.02	2.75	-0.64	-1.03	-0.57	2.66	-1.54	-1.53	-0.92	2.25	1.44	-1.19	-0.96	0.68	-0.41	6.35	-0.40	5.11	-0.86	-1.20	0.29	-1.76	2.15	-1.70
Loon Lake Granite and Togo Formation[2]:																									
n = 10	Minimum	14,300	2.8	36.0	889	0.11	6.3	12.4	12.9	17,300	2,280	2,690	93.3	0.39	34.6	10.8	196	4.8	8.4	8.6	655	1.33	22.5	16.5	0.13
	25th percentile	21,675	15.4	155	2,965	0.14	9.7	16.6	24.7	23,225	4,184	3,833	446	0.51	156	19.2	585	9.3	27.8	10.5	1,183	2.16	29.3	50.2	0.17
	50th percentile	25,100	26.5	195	3,650	0.20	11.0	21.1	30.7	25,350	4,860	5,045	667	0.59	248	21.4	613	13.2	32.6	11.3	1,383	2.85	34.4	53.7	0.24
	75th percentile	32,413	75.1	227	4,560	0.25	16.8	25.3	40.1	31,325	6,333	5,719	782	0.80	272	28.8	990	17.8	38.9	13.9	1,583	3.99	39.5	68.3	0.36
	Maximum	44,100	98.4	357	5,160	0.61	21.7	41.0	56.8	39,800	10,200	8,370	1,150	8.90	327	35.0	1,320	30.1	51.5	19.3	1,910	8.02	59.8	91.8	0.42
	Mean	26,975	42.0	203	3,592	0.24	12.7	22.0	32.4	27,000	5,368	4,947	646	1.44	208	22.8	755	14.9	32.4	12.5	1,363	3.34	37.5	57.9	0.26
	Std. Dev.	9,374	34.8	94.0	1,258	0.15	5.3	8.4	12.7	6,771	2,158	1,715	325	2.63	95	8.3	342	7.9	11.6	3.1	362	1.95	12.7	21.3	0.11
	CV (in percent)	35	83	46	35	62	42	38	39	25	40	35	50	183	45	37	45	53	36	25	27	58	34	37	42
	Geometric Mean	**25,535**	**26.5**	**177**	**3,289**	**0.21**	**11.7**	**20.7**	**30.1**	**26,274**	**5,003**	**4,681**	**542**	**0.77**	**178**	**21.3**	**674**	**13.1**	**29.7**	**12.2**	**1,313**	**2.92**	**35.7**	**53.3**	**0.24**
	Skewness	0.57	0.52	0.22	-0.95	2.12	0.75	1.22	0.44	0.74	1.13	0.58	-0.01	3.14	-0.75	0.23	0.35	0.90	-0.58	1.15	-0.43	1.61	1.06	-0.19	0.46
	Kurtosis	-0.30	-1.49	0.52	1.19	5.09	-0.91	2.24	0.17	-0.03	2.22	0.40	-0.45	9.90	-0.51	-0.88	-0.33	0.18	1.55	1.29	0.45	3.35	0.21	0.81	-1.46

[1] Sediment samples from within the geochemical anomaly of the Midnite Mine uranium deposit excluded from statistical calculations.

[2] Sediment samples from within the geochemical anomaly of the Spokane Mountain uranium deposit excluded from statistical calculations.

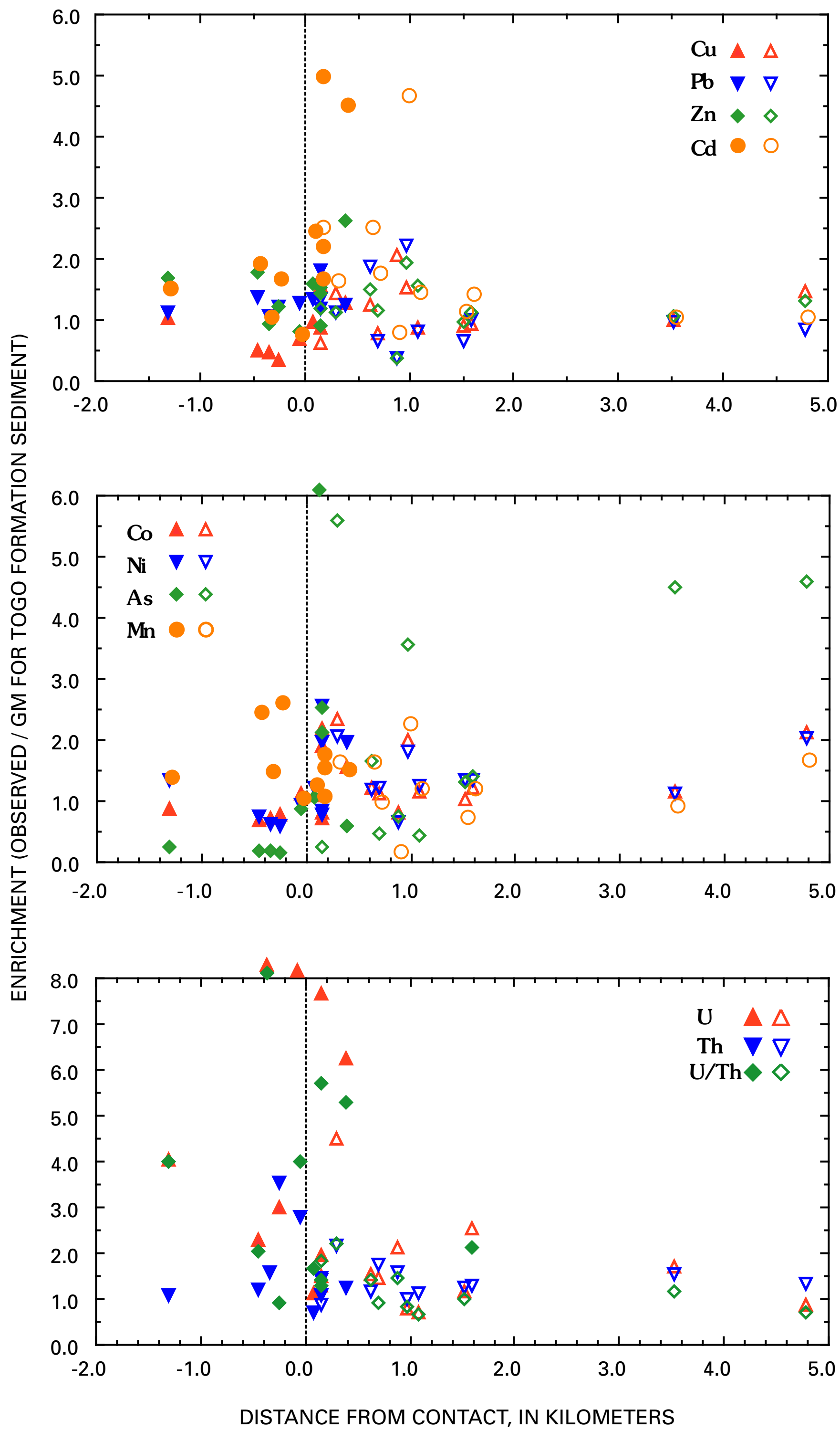


Figure 28. Plot of the geochemical data from mixed lithologies (table 21; selected NURE sediment samples) versus distance from the contact of the Loon Lake Granite with rocks of the Togo Formation. Contact is the closest distance, measured in kilometers; 0.0 km would indicate sediment sampling site is at the contact. Negative values indicate contact is upstream (that is, the sample site is in the Loon Lake Granite); positive values indicate that the site is in the Togo Formation. Geochemical data are plotted as normalized values (observed concentration in mixed lithology basin/geometric mean (GM) value of the Togo Formation). Samples from within the geochemical halo of the Midnite Mine or the Spokane Mountain deposit are indicated by the solid symbols, whereas those from outside the uranium mineralized areas are indicated by the open symbols.

based on the relative areas of the mineralized and barren rock, the enrichment factor for the trace element in the mineralized zone, and the gradient of the stream. In the example shown (fig. 29), during mining a given contaminant might have twice the concentration released prior to mining. The dispersion pattern for that contaminant will be steeper and will not generally reach premining geochemical background concentrations downstream unless the distance between zones 1 and 3 is great. Postmining, the disturbance at the mine site will result in an elevated concentration of the contaminant at the mined site and an elevated metal concentration in sediment downstream in zones 2 and 3.

Geochemical data collected from Blue Creek and the Midnite Mine tributary in 1975 (Otton, 1976) show how mining at the Midnite Mine site affected the geochemistry of sediment in Blue Creek. Enrichment of uranium at the Midnite Mine site is well shown by the uranium aero-radiometric map (fig. 30) from the NURE program (Carson Helicopters, 1982). Plots of the changes in metal concentrations downstream of the mine site are shown by the 1975 data (fig. 31). Two NURE sites (1979) also sampled sediment in Blue Creek: one site just downstream of the Midnite Mine tributary confluence (R028, fig. 30) and another just downstream of the Oyachen Creek confluence (D136, fig. 30) are also included on the geochemical profile plots. Sediment geochemical data from Oyachen Creek and from Blue Creek upstream of the Midnite Mine tributary confluence are very comparable to the geochemical background concentrations (case II, table 23) and are representative of the 1975 geochemical background in the Blue Creek basin. Samples from the Midnite Mine tributary (east branch of the Midnite Mine tributary on the mine site, fig. 30) clearly show the effects of mining on the geochemistry of sediment in Blue Creek (fig. 31). In the Midnite Mine tributary, concentrations of uranium increase rapidly downstream of the uraniferous spring (site 99103, fig. 6). Concentrations of Mn, Co, Ni, and Zn also show small increases downstream of this spring (fig. 31). This is direct evidence that uranium was being mobilized and carried away from the mine site by ground water during the mining period. Downstream of the confluence with the Midnite Mine tributary, concentrations of many elements (fig. 31) show an increase in sediment from Blue Creek and remain elevated to the mouth of the creek (site 98111 and 06MM05, figs. 6, 7) before it enters Blue Creek cove about 6 km downstream (fig. 31).

Comparison of the sediment geochemical background determined from this study with the data from the USGS 1975 stream-sediment geochemical data provides additional insight into the changes that occurred in Blue Creek and the Midnite Mine tributary as a result of mining at the Midnite Mine site (fig. 32). Sediment background concentrations (case II, table 23) agree well with sediment data from upstream sites sampled in the USGS 1975 geochemical survey (fig. 32) with the exception of lead and arsenic, both of which were limited by higher analytical blanks in the 1975 data set. Data from the 1970s mining intervals from core 06MM08 from the Midnite Mine tributary are in good agreement with the USGS 1975 geochemical background data for U, Mn, Co, Ni, and As, but are somewhat low in the core intervals for Cu and Zn (fig. 32). Trace-element concentrations in the premining sediment from core 06MM08 are strongly elevated for uranium, and show relatively minor enrichments for other major and trace elements (table 13) relative to the geochemical background (case II, table 23). A comparison of the geochemical background data from upstream of the Midnite Mine site with the GM concentrations determined in sediment from the mining period from the Midnite Mine tributary (core 06MM08, table 13) shows that concentrations of As, Ba, Ca, Cd, Co, Cu, Mg, Mn, Mo, Ni, Pb, Th, U, and Zn exceed the 95 percent confidence interval of the background (table 23, case II) whereas the concentrations of K, Na, P, Sr, and Ti were less than the 95 percent confidence interval of the background population. No statistical tests were run, however, because *n* for the entire mining interval from core 06MM08 (table 13) was only 11 samples. In other words, if there had been a uranium exploration geochemical survey in the early 1950s in the Blue Creek basin, the geochemical anomaly on the Midnite Mine tributary (site 06MM08) would have been very evident and the geochemical halo around the deposit well defined (fig. 30). These trace elements constitute the group of metals that are possible contaminants released by mining at the Midnite Mine that must be evaluated in Blue Creek downstream of the confluence with the Midnite Mine tributary and in sediment in the Blue Creek delta. Elevated concentrations of Ca and Mg in sediment from the mining period (core 06MM08, intervals 4–14, table 13) reflect the fact that large amounts of calc-silicate rock are present at the mine site and were disturbed during the mining period. Premining data from core 06MM06 (fig. 6) are diluted by unmineralized sediment relative to the data from core 06MM08 and show a downstream pattern like that expected from the dispersion model in zone 2 (fig. 29). In the Blue Creek delta, comparison of the 1970s mining interval data from the cores 06MM05, from the mouth of Blue Creek, and 06MM04, the most complete core from the Blue Creek delta, shows good agreement with the 1975 USGS surface-sediment study for the site downstream from the Oyachen Creek confluence (site 98110, fig. 6). Data from the 1975 USGS study from the site at the mouth of Blue Creek (98111, fig. 6) have concentrations that are elevated above those found in core 06MM05 for U, Co, Zn, and Cu (fig. 32). The wide range of geochemical data, particularly for uranium (fig. 32), shows simply that the trace elements in the sediment of Blue Creek delta were affected by mining.

Geochemical Data from the Blue Creek Delta

Geochemical Contamination from the Spokane River in Lake Roosevelt

Grosbois and others (2002) have documented the extent of metal contamination from mining in the Coeur d'Alene mining district downstream of Lake Coeur d'Alene. Large amounts of metal, transported as suspended sediment, have been released by decades of dredging in the Coeur d'Alene

Table 23. Statistical summary of stream-sediment geochemical data from sites not impacted by mining, Blue Creek and Sand Creek basins.

[Concentrations reported in parts per million (ppm); crustal abundance data from Fortescue (1992); *n*, number of observations; Std. Dev., Standard Deviation; CV, Coefficient of Variation; upper and lower 95th percent confidence limit of the geometric mean; UCL_{95}, 95th upper confidence limit of the mean calculated from log-transformed data; n.d., not determined]

Statistical parameter	Al	As	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sr	Th	Ti	U	V	Zn	U/Th
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	
Crustal Abundance	*83,600*	*1.8*	*390*	*46,600*	*0.16*	*29.0*	*122*	*68.0*	*62,200*	*18,400*	*27,600*	*1,060*	*1.20*	*22,700*	*99.0*	*1,120*	*13.0*	*384.0*	*8.1*	*6,320*	*2.3*	*136.0*	*76.0*	*0.284*
Case I:																								
n =	59	56	59	59	59	59	59	59	59	59	59	59	57	59	59	59	59	59	59	59	57	59	59	57
Minimum	11,700	1.7	36.0	889	0.04	2.9	7.2	8.3	12,400	1,900	2,160	93.3	0.25	34.6	5.6	196	4.8	8.4	6.0	507	1.0	20.0	16.5	0.11
25th percentile	16,675	3.2	129	2,945	0.14	6.0	12.7	13.2	17,700	2,645	2,915	487	0.42	157	10.6	480	12.3	26.2	10.5	955	2.0	27.6	49.7	0.15
50th percentile	21,200	5.3	157	3,550	0.21	7.3	15.6	18.4	20,500	3,230	3,740	564	0.52	203	13.1	588	15.2	33.1	13.2	1,160	2.8	30.2	58.1	0.22
75th percentile	25,900	18.7	202	4,715	0.27	10.4	20.9	26.8	23,950	4,178	4,550	712	0.83	272	20.0	757	18.3	39.4	20.9	1,330	6.1	36.0	72.6	0.35
Maximum	44,100	79	432	19,400	0.65	21.7	47.4	56.8	41,600	11,000	9,170	1,230	3.1	684	43.4	1,330	30.1	56.7	63.3	1,910	31	59.8	126.0	1.10
Mean	22,415	13.0	182	4,408	0.23	8.8	17.7	21.7	21,695	3,673	4,129	602	0.73	236	16.4	657	15.7	33.5	18.7	1,173	5.9	32.7	62.1	0.28
Std. Dev.	7,158	15.8	80.6	3,006	0.14	4.3	7.6	11.2	6,157	1,685	1,661	206	0.59	120	8.5	253	5.0	9.0	14.3	312	6.7	8.2	19.3	0.19
CV (in percent)	32	121	44	68	60	49	43	52	28	46	40	34	80	51	52	38	32	27	76	27	114	25	31	66
Skewness	0.86	2.31	1.16	3.32	1.56	1.54	1.79	1.10	1.46	2.59	1.50	0.71	2.74	1.81	1.38	1.02	0.41	0.22	1.99	0.38	2.00	1.31	0.85	2.18
Kurtosis	0.51	5.98	0.96	12.76	2.55	1.81	4.27	0.58	2.33	8.60	1.86	1.46	7.93	4.14	1.29	0.66	0.28	0.47	3.23	-0.08	3.46	2.25	1.80	6.12
Shapiro-Wilks' statistic	0.945	0.703	0.889	0.621	0.851	0.820	0.852	0.887	0.875	0.743	0.843	0.958	0.659	0.837	0.841	0.910	0.986	0.978	0.711	0.979	0.696	0.902	0.954	0.776
p =	0.0098	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0385	<0.0001	<0.0001	<0.0001	0.0003	0.7397	0.3648	<0.0001	0.4098	<0.0001	0.0002	0.0268	<0.0001
Log-transformed data:																								
Geometric Mean	**21,375**	**7.5**	**166**	**3,858**	**0.20**	**7.9**	**16.4**	**19.3**	**20,963**	**3,413**	**3,865**	**564**	**0.60**	**212**	**14.6**	**614**	**14.9**	**32.2**	**15.4**	**1,131**	**3.7**	**31.8**	**59.2**	**0.24**
Upper 95 percent confidence limit of GM	23,156	9.9	186	4,372	0.23	8.9	18.1	21.9	22,404	3,752	4,239	625	0.70	240	16.5	677	16.2	34.8	17.9	1,216	4.7	33.8	64.4	0.28
Lower 95 percent confidence limit of GM	19,712	5.7	149	3,405	0.17	7.1	14.9	17.0	19,614	3,106	3,526	510	0.52	187	13.0	557	13.6	29.7	13.2	1,053	2.9	30.0	54.4	0.21
UCL_{95}	22,860	9.4	183	4,280	0.22	8.7	17.8	21.4	22,160	3,690	4,180	615	0.96	235	16.2	640	16.0	34.3	17.5	1,200	4.6	33.5	63.5	0.36
Shapiro-Wilks' statistic	0.986	0.933	0.951	0.900	0.982	0.944	0.978	0.968	0.960	0.931	0.947	0.892	0.921	0.942	0.954	0.968	0.973	0.9065	0.905	0.981	0.922	0.969	0.951	0.949
p =	0.7456	0.0040	0.1850	0.0001	0.5056	0.0090	0.3444	0.1196	0.0520	0.0023	0.0117	<0.0001	0.0120	0.0073	0.0258	0.1228	0.2041	0.0003	0.0002	0.4836	0.0013	0.1431	0.0191	0.0185
Case II:																								
n =	49	47	49	49	49	49	49	49	49	49	49	49	47	49	49	49	49	49	49	49	49	49	49	49
Minimum	11,700	1.7	36.0	889	0.04	2.9	7.2	8.3	12,400	2,130	2,160	93.3	0.25	34.6	5.6	196	4.8	8.4	6.0	507	1.0	20.0	16.5	0.11
25th Percentile	16,600	3.4	124	2,930	0.14	5.7	12.6	13.4	17,700	2,700	3,220	463	0.41	155	10.4	475	12.1	26.0	10.5	953	1.9	27.6	49.8	0.15
50th Percentile	20,600	5.2	152	3,520	0.19	7.2	15.6	16.6	20,400	3,490	3,820	554	0.50	201	12.8	575	14.4	32.0	13.6	1,130	2.7	30.2	58.0	0.20
75th Percentile	25,100	18.7	194	4,750	0.26	9.8	21.1	24.5	23,300	4,250	4,930	683	0.75	269	18.7	711	18.1	39.0	21.4	1,340	5.0	35.6	70.7	0.33
Maximum	39,100	79.2	357	19,400	0.65	21.7	47.4	56.8	41,600	11,000	9,170	1,060	2.5	629	35.2	1,320	30.1	56.7	63.3	1,910	30.5	59.8	115	0.68
Mean	21,386	12.6	167	4,393	0.22	8.4	17.8	20.9	21,329	3,841	4,274	570	0.62	226	15.3	624	15.3	32.5	19.7	1,165	5.7	32.5	60.7	0.25
Std. Dev.	6,423	16.0	67.6	3,189	0.13	4.1	7.9	10.8	5,959	1,769	1,727	183	0.4	104	7.5	236	5.2	8.9	15.2	326	6.8	8.5	17.6	0.13
CV (in percent)	30	127	40	73	58	49	44	52	28	46	40	32	64	46	49	38	34	27	77	28	120	26	29	51
Skewness	0.80	2.55	1.31	3.31	1.58	1.74	1.85	1.30	1.66	2.50	1.40	0.29	2.95	1.64	1.41	1.25	0.56	0.29	1.85	0.42	2.13	1.44	0.59	1.14
Kurtosis	0.50	7.32	1.93	12.22	3.31	2.91	4.40	1.35	3.52	7.60	1.44	0.76	11.25	4.31	1.45	1.66	0.25	0.67	2.46	-0.14	3.98	2.58	1.40	1.22
Shapiro-Wilks' statistic	0.947	0.670	0.877	0.603	0.872	0.810	0.838	0.866	0.855	0.742	0.850	0.981	0.704	0.875	0.839	0.888	0.975	0.973	0.717	0.976	0.667	0.885	0.966	0.872
p =	0.0270	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.5880	<0.0001	<0.0001	<0.0001	0.0002	0.3672	0.3075	<0.0001	0.4028	<0.0001	0.0002	0.1671	<0.0001
Log-transformed data:																								
Geometric Mean	**20,500**	**7.3**	**155**	**3,794**	**0.18**	**7.6**	**16.4**	**18.7**	**20,645**	**3,567**	**3,995**	**536**	**0.54**	**205**	**13.9**	**585**	**14.4**	**31.2**	**16.0**	**1,120**	**3.5**	**31.6**	**58.1**	**0.22**
Upper 95 percent confidence limit of GM	22,292	9.8	174	4,381	0.22	8.6	18.4	21.4	22,181	3,960	4,429	599	0.63	234	15.8	649	15.9	34.1	19.0	1,217	4.58	33.8	63.6	0.25
Lower 95 percent confidence limit of GM	18,845	5.4	138	3,288	0.16	6.8	14.7	16.3	19,206	3,213	3,605	479	0.47	179	12.3	527	13.0	28.5	13.5	1,031	2.72	29.5	53.1	0.19
UCL_{95}	22,000	9.3	171	4,280	0.21	8.4	18.0	20.9	21,900	3,890	4,360	588	0.6	229	15.4	638	15.7	33.6	18.5	1,200	4.4	33.4	62.7	0.25
Shapiro-Wilks' statistic	0.983	0.933	0.934	0.892	0.986	0.946	0.972	0.965	0.952	0.923	0.951	0.868	0.945	0.931	0.955	0.959	0.980	0.900	0.902	0.982	0.907	0.962	0.927	0.942
p =	0.7093	0.0096	0.0086	0.0003	0.8104	0.0243	0.2982	0.1541	0.0457	0.0033	0.0418	<0.0001	0.0281	0.0065	0.0578	0.0823	0.5531	0.0005	0.0007	0.6611	0.001	0.1165	0.0047	0.0179

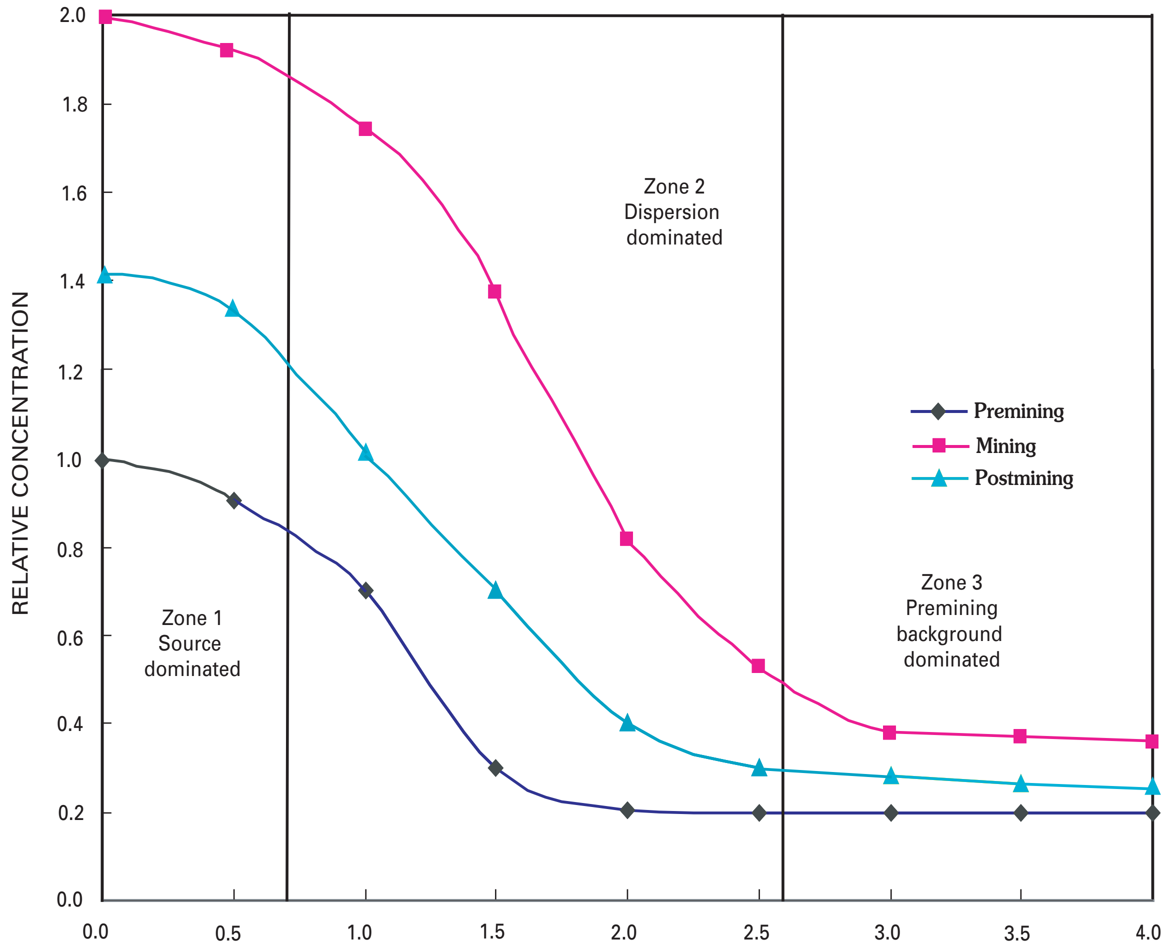


Figure 29. Idealized geochemical dispersion model showing the dilution of geochemical signatures from mineralized areas (zone 1) by sediment from unmineralized areas as the distance away from the source increases downstream. In the study area, the Midnite Mine site would represent zone 1, the downstream area along Blue Creek zone 2, and the Blue Creek delta zone 3.

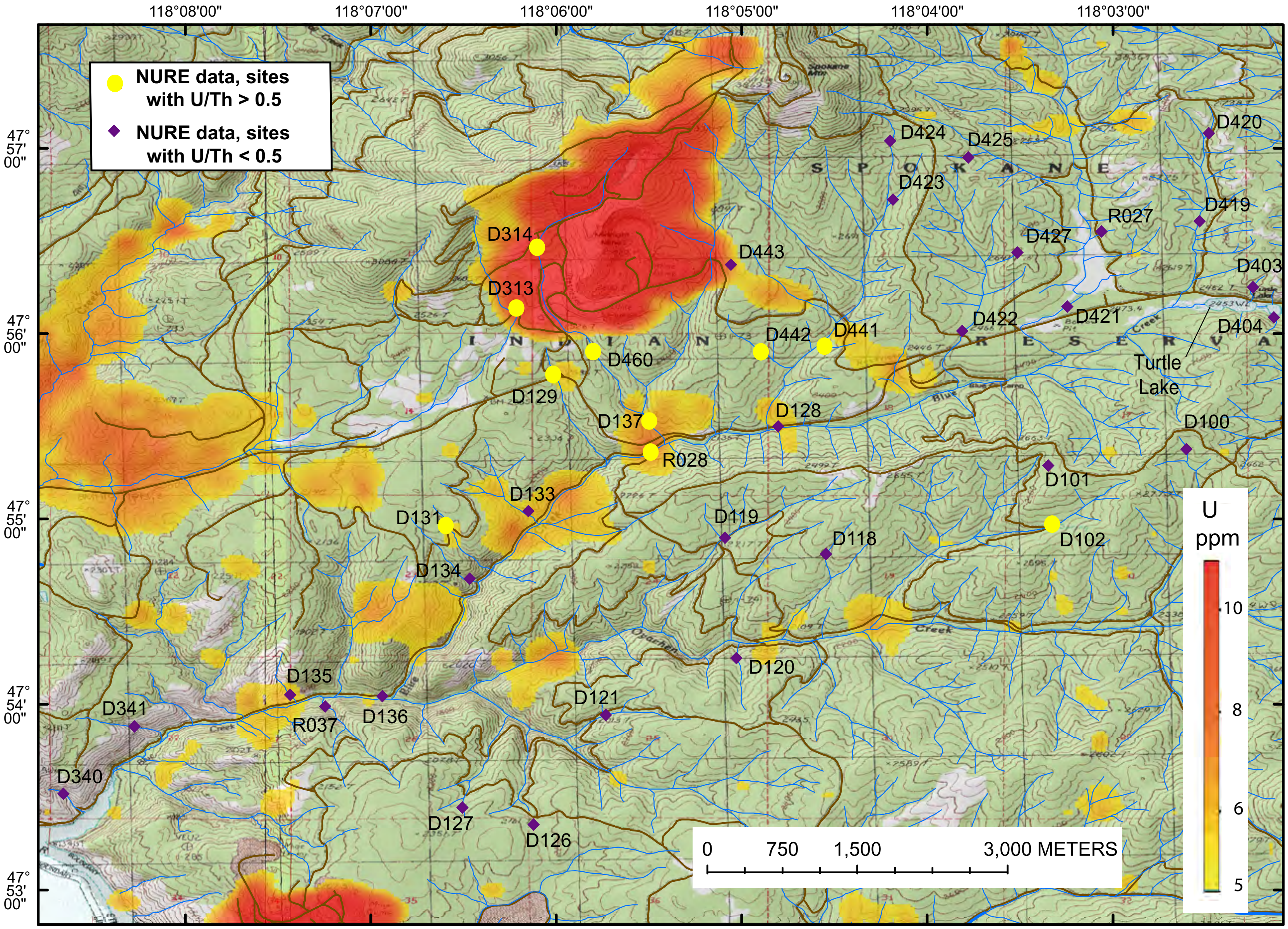


Figure 30. Values of uranium measured in the Blue Creek basin by aero-radiometric mapping survey flown during the NURE program (Carson Helicopters, 1982; International Exploration, 1982). Minimum cutoff value of 5 ppm was selected to show the areas where uranium concentration exceeded 5 ppm. Highest value determined was about 55 ppm over the Midnite Mine site. NURE sediment samples within the Blue Creek basin that have a U/Th value greater than 0.5 are enriched in uranium and are generally from the Midnite Mine site. Those samples that have U/Th less than 0.5 are geochemical background samples for the Blue Creek basin. Turtle Lake, near site D403 on the east portion of Blue Creek upstream from the Midnite Mine site, is used as a reference point for downstream geochemical plots of the data (figs. 31, 32).

River. According to Long (2001), dredging of the Coeur d'Alene River began in July 1932 and continued through 1968. This dredging has resulted in large-scale As, Cd, Pb, and Zn contamination downstream caused by the resuspension of the mill tailings deposited in the Coeur d'Alene River from many decades of earlier mining. Although the extent of contamination from mining in the Coeur d'Alene district decreases with distance downstream from Lake Coeur d'Alene (table 24), metal concentrations are elevated in suspended sediment and reached Lake Roosevelt (fig. 33). Geochemical comparisons of the data from these extraneous sources are compared in the boxplot in figure 34 with the geochemical signature diagnostic of mining activity at the Midnite Mine on Blue Creek. The geochemical data from silt-rich layers in the cores have concentrations and enrichment factors (table 24) very similar to those in Long Lake (Grosbois and others, 2002), the lake on the Spokane River nearest to Lake Roosevelt and farthest downstream from the Coeur d'Alene mining district (fig. 35). The geochemical data from sediment from core CSA-8 (fig. 35; table 4) from the Spokane Arm, Lake Roosevelt (Cox and others, 2004) showed similar although somewhat more enrichment in cadmium, lead, and zinc concentrations. This contamination is also present in metal-rich layers of fine silt (fig. 33) at the top of core 06MM03 (intervals 1–5, table 17) and in the beaver pond sediment in core 06MM01 (intervals 19–15, table 20). Concentrations of cadmium, lead, and zinc in the Spokane Arm sediment (CSA-8) and in the beaver pond in core 06MM01 (fig. 34) compare well and are indicative of a common source from the Coeur d'Alene River sediment. In contrast, elevated concentrations of manganese, cobalt, and nickel (fig. 34) are clearly related to the mining activity at the Midnite Mine and not to the base-metal contamination associated with historical mining in the Coeur d'Alene district. Elevated concentrations of cadmium, lead, and zinc in intervals 19–15, core 06MM01 (table 20) represent deposition of suspended sediment derived from the Coeur d'Alene mining district from 1942 to 1957 rather than from Blue Creek. Mining at the Midnite Mine did not commence until 1957.

Premining Geochemical Background Data, Blue Creek Delta

A comparison of the regional premining geochemical background data (table 23, case II) with premining data determined from sediment from the Blue Creek delta (table 25 and fig. 34) shows how the geochemistry of sediment in the Blue Creek delta (zone 3, fig. 29) was affected by erosion at the mine site prior to mining. The geochemical data from the Blue Creek delta that are between the 25th and the 75th percentiles for these elements (fig. 34) are comparable. However, the outliers for arsenic, lead, zinc, and cadmium overlap the range of values for these elements in the Coeur d'Alene district and are attributed to the thin lenses of fine sediment present in the delta cores (fig. 33). A comparison of all the other geochemical data shows a relatively good comparison for the elements aluminum, barium, cobalt, potassium, molybdenum, and vanadium (GM within ±12 percent) and a poorer fit for the elements iron and sodium (GM within ±15 percent). Manganese and thorium are diluted in the premining delta sediment (39 and 26 percent, respectively) and calcium, magnesium, uranium, chromium, copper, and nickel are enriched by 18 to 45 percent in the premining delta sediment. These elements are more abundant in the metamorphic calc-silicate host rock at the Midnite Mine site and reflect the erosion of the uranium mineralization in the calc-silicate rocks exposed at the mine site prior to mining.

Data from Surface-Sediment Sites, Blue Creek Delta

In May 2005, the Trustees and AESE, Inc., personnel collected surface-sediment samples from the Blue Creek delta area to evaluate how mining has changed the elemental composition of surface sediment in zone 3 (fig. 29), the Blue Creek delta. Surface sediment in the thalweg of the delta, which is typically submerged when Lake Roosevelt is maintained at summer water elevations (fig. 16), was exposed down to an elevation of 1,253.2 ft. Samples were collected from the Blue Creek delta along the thalweg out to about 500 m from the mouth of Blue Creek. A second set of data was collected along the shoreline of Lake Roosevelt in Blue Creek cove. In addition, surface-sediment samples were collected from exposed beaches along the shore in Lake Roosevelt a considerable distance downstream of the Blue Creek confluence to evaluate the possible transport of mining-affected sediment downstream to these sites. These three sites, Porcupine Bay, A-Frame, and China Bar (fig. 35 and table 26), are areas where recreational use on the shores of Lake Roosevelt is high. They are 2.1, 9.3, and 22 km downstream from the Blue Creek delta. Geochemical data from the surface samples collected in the 2006 USGS sediment cores (that is, the upper 5–10 cm of cores 06MM01–06MM05) are also included in the Blue Creek delta surface-sediment data set (table 26). Statistical summaries of these two data sets (table 26) show distinctly different trace-element patterns: the lake shore data from the Blue Creek cove show the effects of contamination by the suspended sediment derived from upstream from the Coeur d'Alene mining district, whereas the surface sediment from the thalweg area of Blue Creek delta contains elevated concentrations of cobalt, nickel, uranium, and radionuclides indicative of contamination derived from mining upstream at the Midnite Mine site (table 26).

Dispersion of contaminants from Blue Creek to recreational sites downstream on the shores of Lake Roosevelt (fig. 35) can readily be evaluated by comparing the ratio of the uranium concentration of the samples from those downstream sites to the geochemical data from surface samples from the thalweg area of Blue Creek delta (samples LR-014 through LR-023 and the surface samples from the 06MM core data, table 26). Uranium concentrations at all three downstream recreational sites are low, ranging from 1.1 to 3.3 ppm uranium. Crustal abundance for uranium is 2.3 ppm. The premining concentration of uranium in Blue Creek delta sediment was 4.7 ppm (table 25). Surface-sediment concentration of uranium in the Blue Creek delta area is 28 ppm (table 26). There

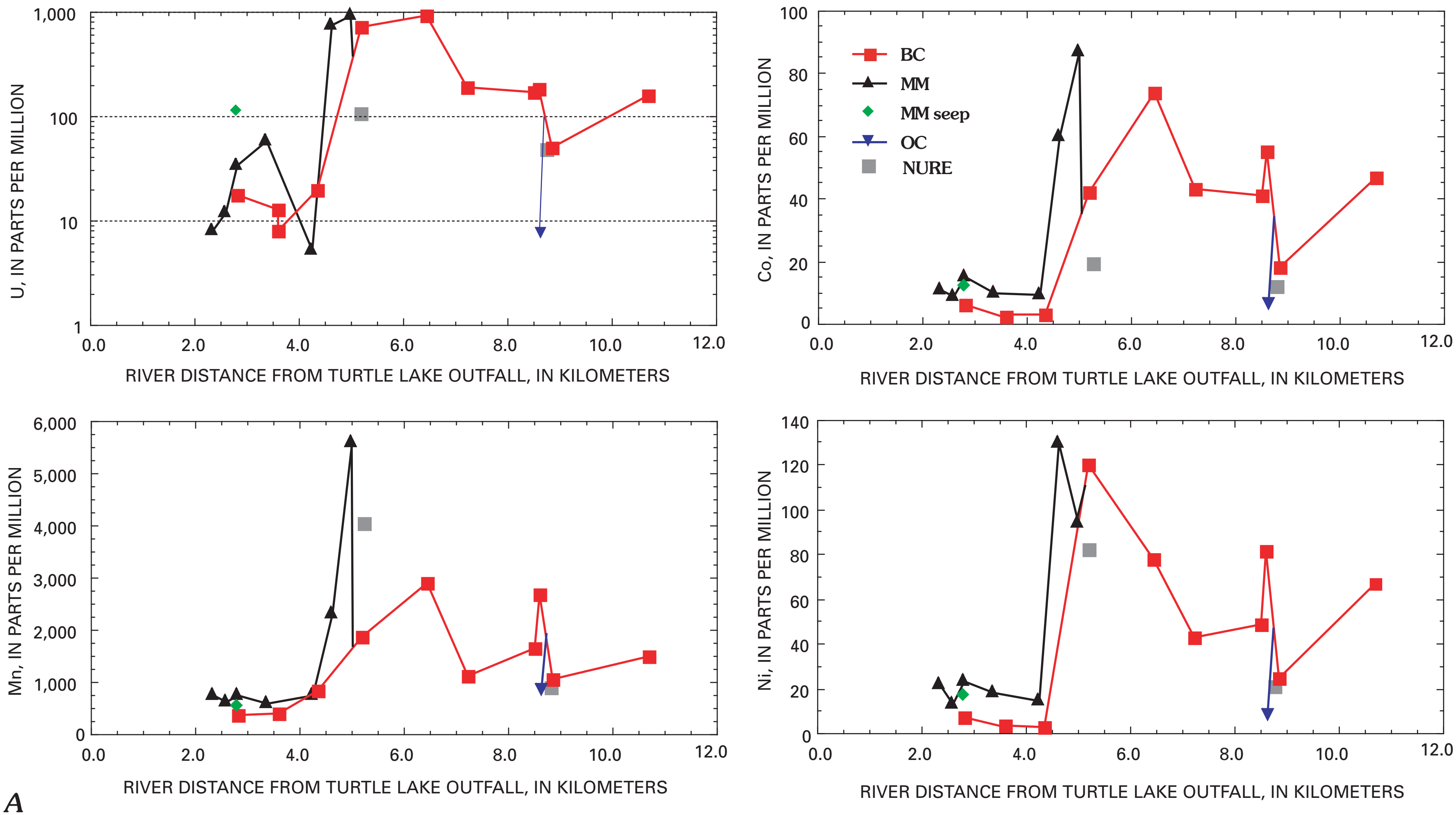


Figure 31. Downstream plots of geochemical data determined in the 1975 USGS stream-sediment study (Otton, 1976) and the 1979 NURE study (Babcock and others, 1981) of Blue Creek. *A*, concentrations of uranium (U), manganese (Mn), cobalt (Co), and nickel (Ni), in parts per million (ppm), and *B*, concentrations of zinc (Zn), lead (Pb), copper (Cu), and arsenic (As) in parts per million (ppm) are plotted against river distance (in kilometers) measured from the outfall of the dam at Turtle Lake. Downstream flow progresses from left to right, measured from the outfall of Turtle Lake (fig. 30). Sediment data from different stream reaches are projected down their tributaries to the confluence and are color coded: Blue Creek (BC, red), Midnite Mine tributary (MM, black), spring in the upper part of the east branch of the Midnite Mine tributary (MM seep, green), and Oyachen Creek (OC, blue). Two samples from the 1979 NURE study (in gray) are also shown.

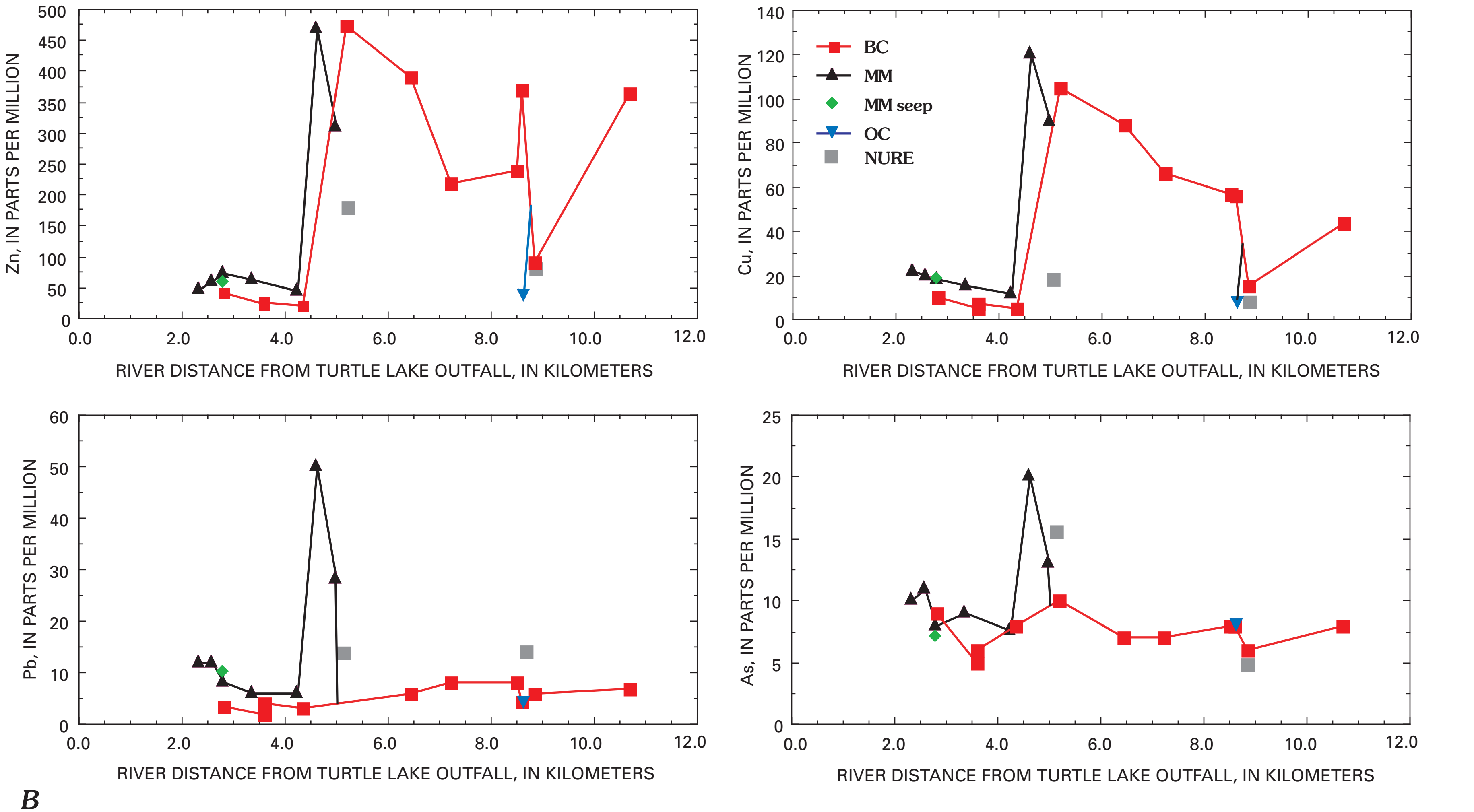


Figure 31—Continued. Downstream plots of geochemical data determined in the 1975 USGS stream-sediment study (Otton, 1976) and the 1979 NURE study (Babcock and others, 1981) of Blue Creek. *B*, concentrations of zinc (Zn), lead (Pb), copper (Cu), and arsenic (As) in parts per million (ppm) are plotted against river distance (in kilometers) measured from the outfall of the dam at Turtle Lake. Downstream flow progresses from left to right, measured from the outfall of Turtle Lake (fig. 30). Sediment data from different stream reaches are projected down their tributaries to the confluence and are color coded: Blue Creek (BC, red), Midnite Mine tributary (MM, black), spring in the upper part of the east branch of the Midnite Mine tributary (MM seep, green), and Oyachen Creek (OC, blue). Two samples from the 1979 NURE study (in gray) are also shown.

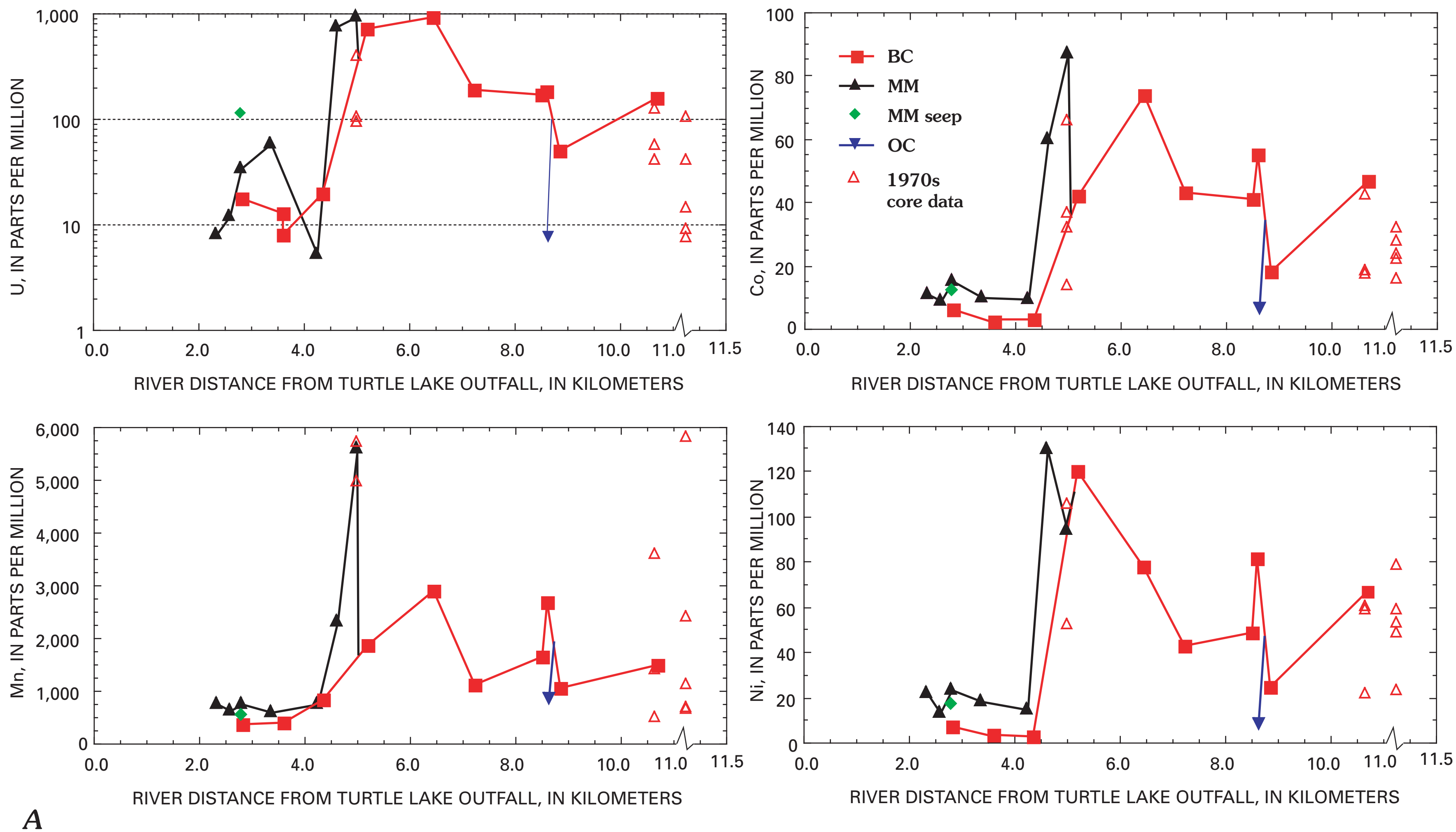


Figure 32. Comparison of the geochemical data determined in the 1975 USGS stream-sediment study (Otton, 1976) of Blue Creek with geochemical data determined from premining geochemical background (blue) and mining period from 1970 to 1980 (red) sediment from the 2006 core study. *A*, concentrations of uranium (U), manganese (Mn), cobalt (Co), and nickel (Ni), in parts per million (ppm); *B*, concentrations of zinc (Zn), lead (Pb), copper (Cu), and arsenic (As), in parts per million (ppm), plotted against river distance (in kilometers) measured from the outfall of the dam at Turtle Lake (fig. 30). Sediment data from different stream reaches are solid symbols that are color coded: Blue Creek (BC, red), Midnite Mine tributary (MM, black), spring in the upper part of the east Midnite Mine tributary (MM seep, green), and Oyachen Creek (OC, blue). Note that the scale at the downstream reach in the Blue Creek delta has been expanded to allow discernment of data from cores 06MM01–06MM05 (open triangle).

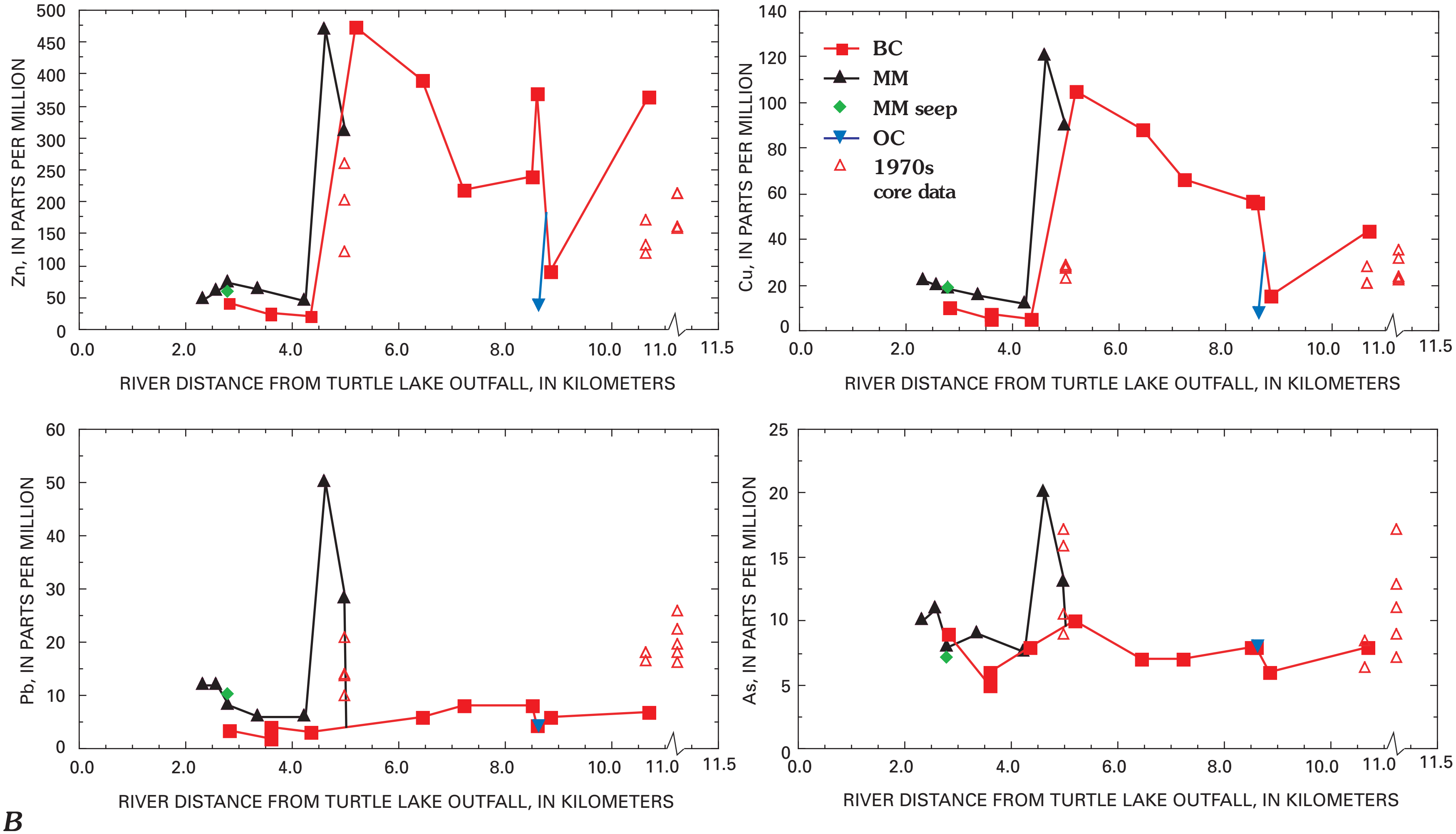


Figure 32—Continued. Comparison of the geochemical data determined in the 1975 USGS stream-sediment study (Otton, 1976) of Blue Creek with geochemical data determined from premining geochemical background (blue) and mining period from 1970 to 1980 (red) sediment from the 2006 core study. *B*, concentrations of zinc (Zn), lead (Pb), copper (Cu), and arsenic (As), in parts per million (ppm), plotted against river distance (in kilometers) measured from the outfall of the dam at Turtle Lake (fig. 30). Sediment data from different stream reaches are solid symbols that are color coded: Blue Creek (BC, red), Midnite Mine tributary (MM, black), spring in the upper part of the east Midnite Mine tributary (MM seep, green), and Oyachen Creek (OC, blue). Note that the scale at the downstream reach in the Blue Creek delta has been expanded to allow discernment of data from cores 06MM01–06MM05 (open triangle).

Table 24. Trace-element concentrations and enrichment factors in sediment, Blue Creek delta.

[Concentration data reported in parts per million (ppm); crustal abundance value of 0.08 ppm used to calculate enrichment for Ag (Fortescue, 1992)]

Site	*n* =	Ag ppm	As ppm	Cd ppm	Co ppm	Cu ppm	Mn ppm	Ni ppm	Pb ppm	Zn ppm
Geochemical data:										
Lake Coeur d'Alene surface sediment [1]	17	6	151	62	23	72	6,700	21	1,900	3,600
Upper Spokane River[2]	43	2.2	33	18	16	48	2,300	30	950	3,200
Nine-Mile Reservoir[2]	3	0.9	12	5.9	14	27	790	20	65	710
Long Lake[2]	20	0.8	13	8.2	12	29	660	23	120	940
Core CSA-8, Lake Roosevelt[3]	18	<3	16	10	14	38	823	23	102	1,189
Core 06MM01, intervals 15-19	5	<1	7	2	5.3	20	281	14	63	614
Enrichment relative to premining background:										
Lake Coeur d'Alene surface sediment		75	32	22	1.9	2.9	13	1.3	79	33
Upper Spokane River		28	7.0	6.4	1.3	1.9	4.6	1.9	40	29
Nine-Mile Reservoir		11	2.6	2.1	1.2	1.1	1.6	1.3	2.7	6.5
Long Lake		10	2.8	2.9	1.0	1.2	1.3	1.4	5.0	8.5
Core CSA-8, Lake Roosevelt		--	3.4	3.7	1.2	1.5	1.6	1.4	4.3	11
Core 06MM01, intervals 15-19		--	1.5	0.6	0.4	0.8	0.6	0.9	2.6	5.6
Lake Coeur d'Alene background concentrations [1]		<1	4.7	2.8	12	25	500	16	24	110
Spokane River background concentrations [2]	43	<0.5	5.6	0.2	8	21	480	15	34	85

[1]Horowitz and others (1993).
[2]Grosbois and others (2002).
[3]Cox and others (2004).

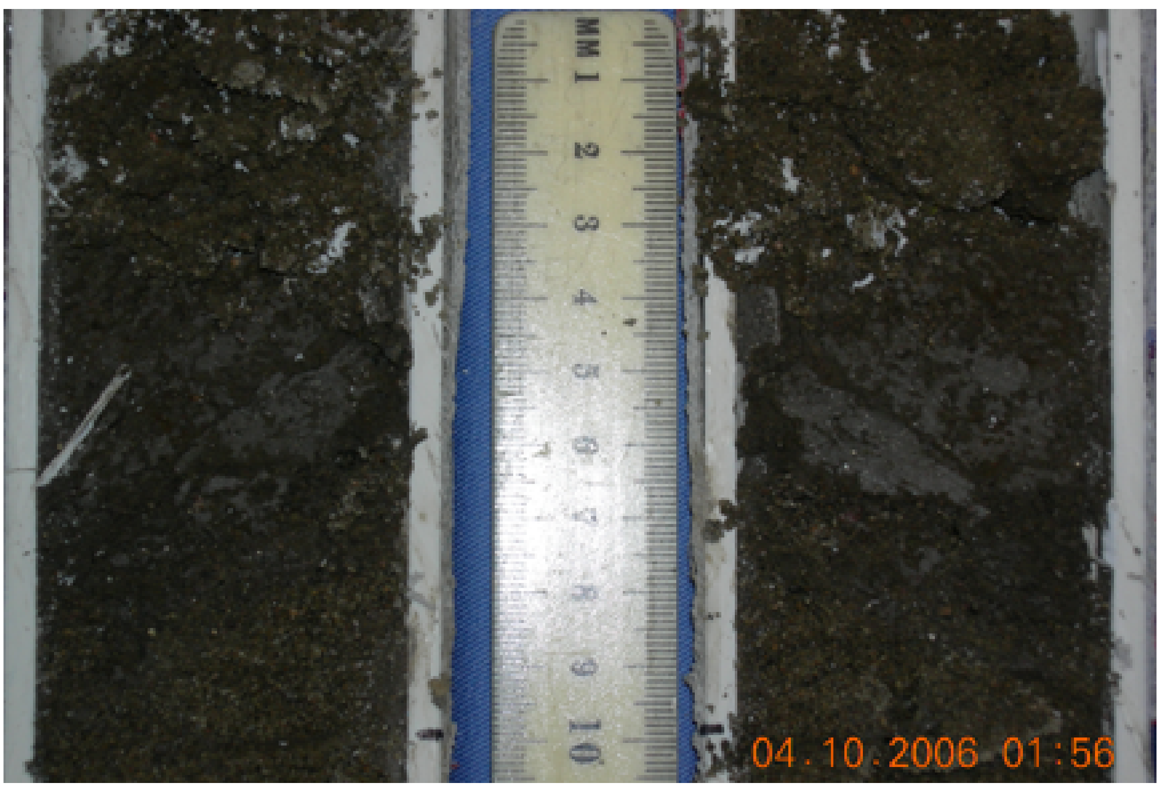


Figure 33. Photograph of core 06MM03, 1–10 centimeter depth interval, showing wisps of silt that are interpreted as suspended sediment from the Coeur d’Alene mining district.

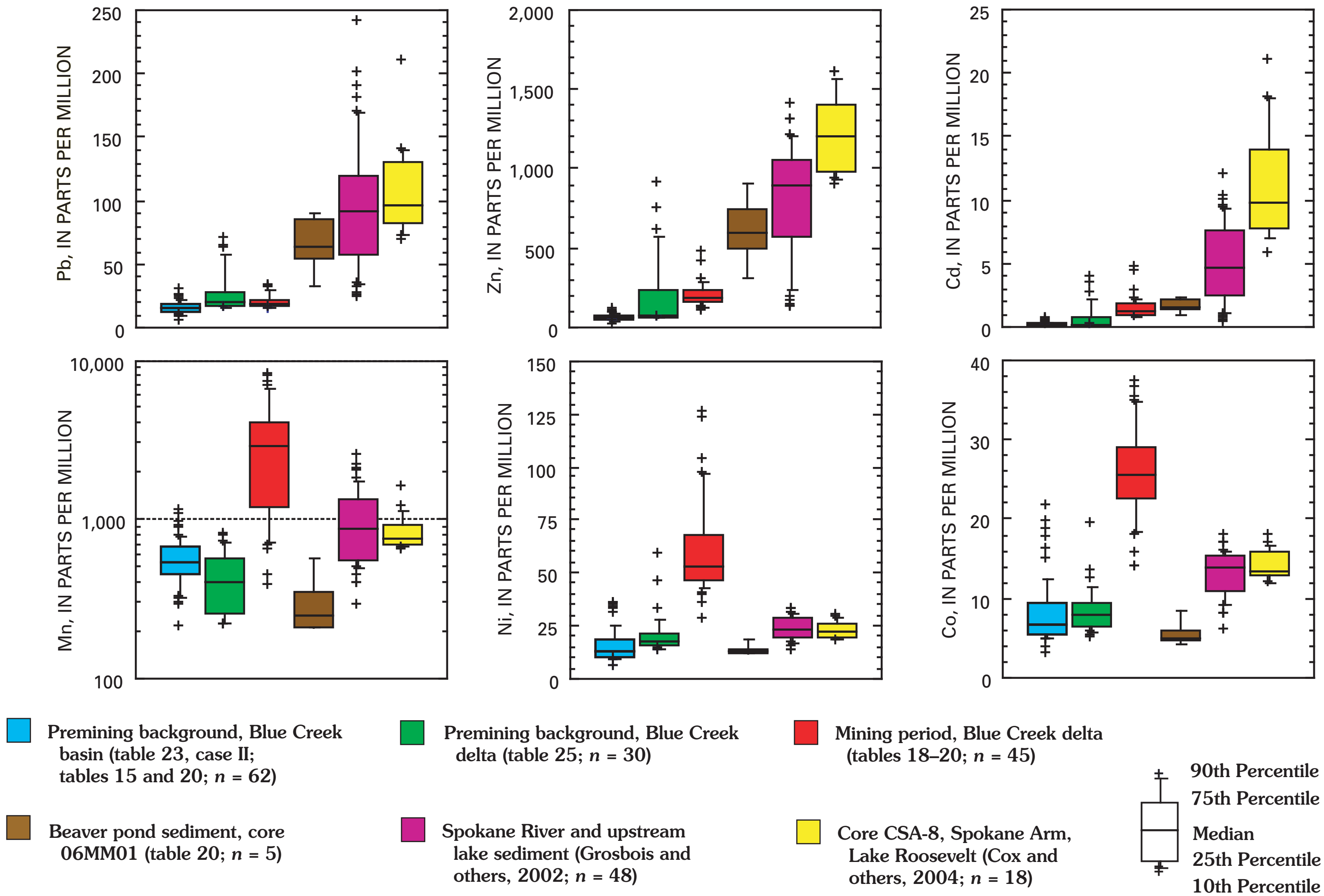


Figure 34. Box plot comparing geochemical data for lead (Pb), zinc (Zn), cadmium (Cd), manganese (Mn), nickel (Ni), and cobalt (Co), all in parts per million (ppm) from the premining- and mining-period sediment from the Blue Creek delta deposited in Lake Roosevelt with geochemical background data from Blue Creek (zone 1) and geochemical background from the Blue Creek delta (zone 3) with data from core CSA-8, Spokane Arm, Lake Roosevelt (Cox and others, 2004) and with the data from contaminated sediment from an upstream lake, Long Lake, and the lower Spokane River (*n* = 48; Grosbois and others, 2002). Pluses, outliers beyond 10th and 90th percentiles of each distribution.

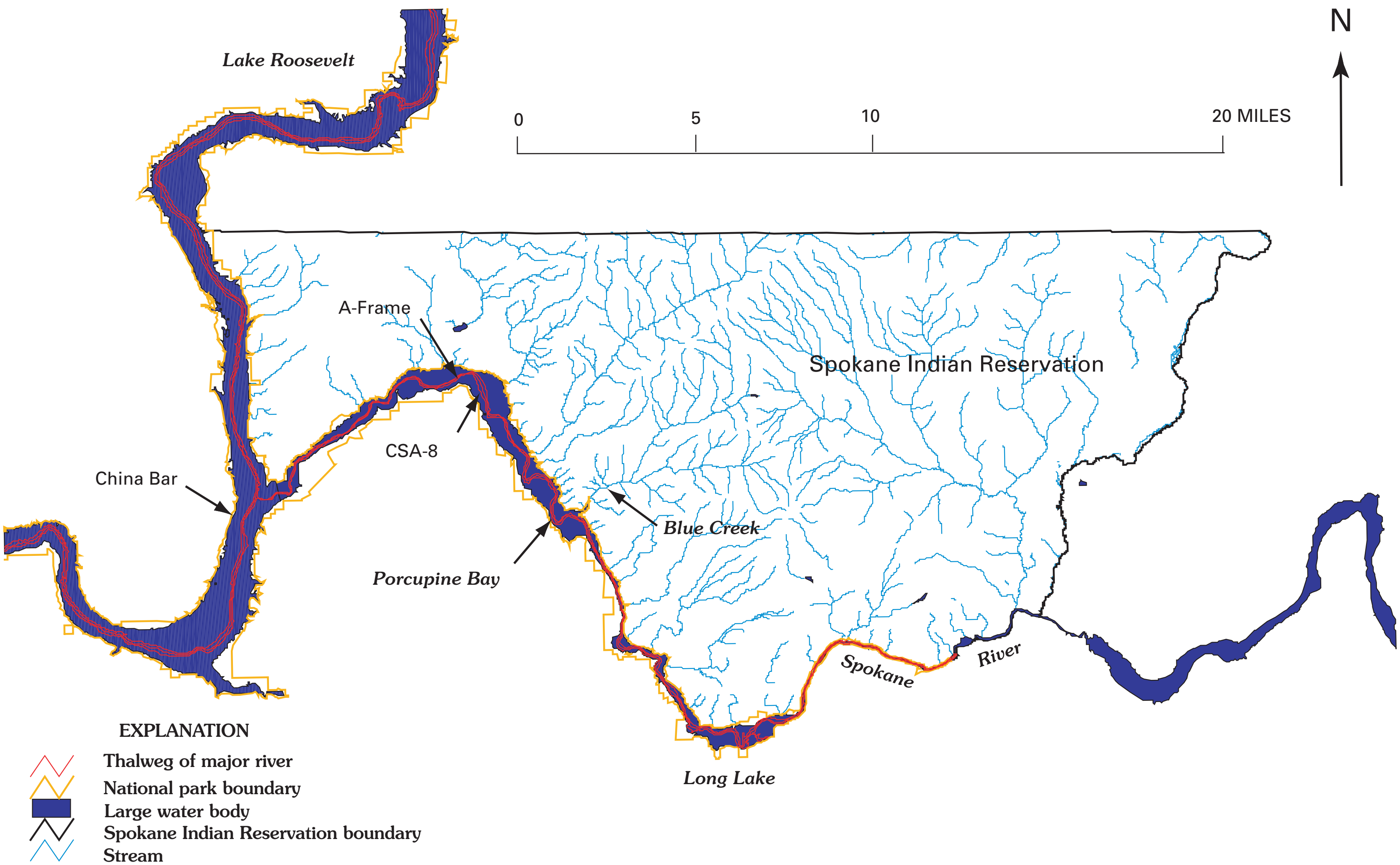


Figure 35. Map of the Spokane Indian Reservation showing localities of samples from outlying downstream sites discussed in text. Reservation boundary follows Spokane River or 1,290-ft elevation along shore of Lake Roosevelt where not otherwise discernible.

is, therefore, no geochemical evidence that contamination from mining at the Midnite Mine site can be traced to these downstream recreational sites on the shores of Lake Roosevelt.

Comparison of the geochemical data in contaminated surface sediment in Blue Creek delta with premining data from the delta for the 10 possible contaminants from the Midnite Mine site (As, Cd, Co, Cu, Mn, Mo, Ni, Pb, U, and Zn) is in table 27. Comparison of the postmining surface-sediment data in the thalweg area (table 26) with premining data both from Blue Creek (table 23, case II) and from the Blue Creek delta (table 25) shows that the surface sediment has clearly been contaminated for the elements Co, Ni, Mn, and U by mining activity at the Midnite Mine. Maximum concentrations of As, Cd, Ni, Pb, U, and Zn in surface-sediment samples from Blue Creek delta are elevated with respect to premining geochemical background sediment concentrations determined in Blue Creek basin (table 23, case II). Whereas maximum concentrations of Co, Cu, Mn, and Ni in surface sediment of the Blue Creek delta do not exceed crustal abundance concentrations, a comparison of the concentrations of these contaminants in surface sediment from the Blue Creek delta shows that they are significantly different from the premining concentrations determined from core samples if one uses the UCL_{95} approach recommended by U.S. EPA (2002), that is, the postmining surface sediment has been contaminated by the mining at the Midnite Mine site. Large increases of the geometric mean concentrations of cobalt (1.6), nickel (1.7 to 2.2) and uranium (4.7 to 6.3; table 27) indicate that the GM concentrations for these three elements are significantly greater than the maximum expected value of the GM concentrations for either the premining geochemical background data set from Blue Creek (table 23, case II) or the premining geochemical background data set from Blue Creek delta (core 06MM03, table 25).

Using the approach described above, currently, the documented extent of surficial contamination extends to approximately 500 meters from the mouth of Blue Creek as represented by the 1,290-ft elevation. The surficial sediment sampling conducted by AESE, Inc., was biased to investigate exposure to humans in near-shore conditions—it was not designed to (1) delineate anomalies located offshore near the submerged thalweg of Blue Creek, (2) delineate the historical nature and extent of contamination, or (3) track changes in the surficial distribution of contaminants from the Midnite Mine. Since the littoral zone of the Blue Creek embayment is prone to erosion and since contaminants are still being released from the mine site, the extent of the contamination downstream along the Blue Creek thalweg into Lake Roosevelt remains open.

Factor analysis is a statistical method that uses the variance-covariance matrix of a data set to group variables into a smaller subset of correlated variables, that is, to interpret the structure of the data set (Davis, 1973). In other words, it is a statistical tool to facilitate the interpretation of a large multivariant data set. In the use of factor analysis of the different subsets of the data (tables 16–20, 23, case I, tables 25 and 26), lithologic factors and mining factors from both the Coeur d'Alene mining district and the Midnite Mine site were always discriminated as discrete populations. Plots of element concentrations versus different element ratios show these different element associations (figs. 36–38). In figure 36, the plot of uranium concentration versus U/Th clearly shows how the data from the two background populations overlap (zone 1 in blue and zone 3 in green) and plot at lower uranium concentrations relative to postmining delta sediment data. Sediment samples from core 06MM01 from the beaver pond show some increase in uranium and U/Th, probably as the result of sorption by organic matter in the sediment, as mentioned previously. Sediment in the Blue Creek delta cores from the period of operation of the Midnite Mine (1956–1981) show the greatest uranium concentrations and the highest uranium enrichment (that is, increases in the U/Th) in sediment. Postmining sediment has lower uranium concentrations and U/Th values, and the few surface sediment samples that have reported thorium concentrations plot within the postmining sediment field.

The plot of uranium versus zinc concentrations, however, discriminates different populations within the sediment data from the Blue Creek delta (fig. 36*B*). The two background populations largely overlap, but some of the sediment background data from Blue Creek delta show higher zinc concentrations, indicating that mixing of the contaminated sediment from the Coeur d'Alene mining district affects this data set. Sediment data from the buried beaver pond (core 06MM01, intervals 19–15, table 20) clearly show how the geochemical signature of the contaminated sediment from the Coeur d'Alene mining district can be used to distinguish this population from sediment derived from the Midnite Mine. The sediment from the mining period also shows effects of mixing of sediment from the Coeur d'Alene mining district, whereas the surface-sediment data from Blue Creek delta show less of an effect from the Coeur d'Alene mining district contaminant. Lake-shore sediment data from the Blue Creek delta (LR-001 to LR-013, table 26), however, have elevated concentrations of the metals diagnostic of this contaminant: arsenic, cadmium, lead, and zinc.

Elevated concentrations of arsenic, cadmium, lead, and zinc in surface sediment of the Blue Creek delta have been shown herein to be the result of metal contamination from the Coeur d'Alene mining district (table 23 and fig. 34). Elevated concentrations of these elements in core 06MM08 from the Midnite Mine tributary showed that mining at the Midnite Mine resulted in release of somewhat elevated concentrations of these elements (table 13, intervals 14–4). The concentrations of these metals in the surface sediment of the Blue Creek delta beyond 500 meters from the mouth of Blue Creek are not defined by the current data set (table 26). Certainly one would expect that contaminated sediment from Blue Creek would continue down the thalweg for some distance. Sediment in the thalweg will be largely submerged throughout most of the year; the elevation of Lake Roosevelt has dropped below 1,250 ft only seven times in the last two decades during the winter months prior to spring runoff (fig. 14). Further, there is no evidence of contamination by sediment from Blue Creek in core CSA-8 (fig. 35) from deep in Lake Roosevelt.

Table 25. Premining geochemical background data from cores sampled in 2006 from the Blue Creek delta.

[Analytical data from tables 14, 17, 18, and 20; concentrations reported in parts per million (ppm); radionuclide activities reported in picocuries per gram (pCi/g); --, no data; Std. Dev., Standard Deviation; CV, Coefficient of Variation, in percent; *n* , number of samples; UCL95, Upper 95th Confidence Limit (USEPA, 2001). ^{238}U concentration based on ^{234}Th activity data]

Sample interval	Al ppm	As ppm	Ba ppm	Ca ppm	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe ppm	K ppm	Mg ppm	Mn ppm	Mo ppm	Na ppm	Ni ppm	Pb ppm	Th ppm	U ppm	V ppm	Zn ppm	U/Th	^{210}Pb pCi/g	^{226}Ra pCi/g	^{238}U pCi/g
06MM01.13	17,900	5.1	223	4,500	1.7	5.1	16.0	25.0	19,000	2,250	4,820	394	0.56	156	16	53.0	18.0	18.8	30.0	347	1.04	9.48	8.21	14.98
06MM01.14	14,800	14.1	238	3,830	0.63	8.0	15.6	19.6	25,700	2,190	4,940	513	0.80	151	13	31.8	18.8	11.4	30.6	235	0.61	--	--	--
06MM01.15	16,300	9.1	125	3,830	2.4	8.4	14.2	18.5	17,000	2,490	4,430	575	0.67	152	19	64.0	13.3	12.4	24.5	903	0.93	10.14	10.27	20.31
06MM01.16	17,000	7.1	152	3,870	2.1	5.2	15.4	19.8	18,400	2,880	5,290	208	0.33	173	12	90.7	12.0	8.54	27.5	697	0.71	11.95	9.31	14.70
06MM01.17	16,000	4.6	189	3,640	1.6	4.1	16.0	19.0	19,300	2,710	4,900	214	0.33	158	13	83.9	11.5	9.04	26.1	597	0.79	9.61	10.19	12.27
06MM01.18	18,000	8.5	225	3,760	1.6	4.9	16.7	21.9	19,900	2,970	5,090	253	0.37	163	13	62.6	11.2	13.2	28.4	559	1.18	11.64	11.40	18.01
06MM01.19	19,700	7.1	200	4,180	0.98	4.8	15.9	21.4	20,600	2,870	4,660	272	0.53	165	12.2	32.6	12.1	22.3	29.5	315	1.84	13.60	19.10	35.75
06MM01.20	18,600	8.5	189	4,300	0.65	5.0	19.0	23.7	25,400	3,060	5,460	338	0.50	168	15.5	25.3	13.1	14.2	30.2	207	1.08	10.98	12.03	19.89
06MM01.21	18,200	10.9	154	5,340	0.55	5.9	16.7	28.0	25,300	3,510	5,940	556	0.74	168	14.9	26.9	13.8	5.72	30.4	237	0.41	9.53	7.72	8.27
06MM01.22	17,500	16.4	137	5,560	0.33	7.5	19.8	28.7	27,900	3,290	6,080	621	0.99	165	18.1	27.4	14.5	4.27	33.8	93.5	0.29	8.38	4.73	5.68
06MM01.23	17,200	20.1	152	4,630	0.16	7.6	16.9	23.8	27,700	2,990	6,670	482	0.80	150	13.5	21.4	15.9	4.48	34.2	73.9	0.28	7.35	6.38	4.75
06MM01.24	18,400	25.4	121	4,600	0.10	6.8	22.3	20.6	35,700	2,890	7,000	472	0.91	134	16.9	21.3	14.9	5.38	37.0	66.6	0.36	6.95	5.63	5.98
06MM03.01	18,400	8.0	129	5,780	1.8	10.8	20.8	22.0	24,500	2,820	7,720	528	0.45	269	19.6	41.3	10.5	4.52	31.6	546	0.43	--	--	--
06MM03.02	25,400	10.8	155	5,230	3.9	13.4	36.8	29.7	29,900	3,620	8,430	358	0.53	249	32.8	62.4	11.8	7.40	38.1	905	0.63	--	--	--
06MM03.03	19,800	8.3	116	4,620	2.6	8.8	21.5	26.1	23,600	3,150	7,340	240	0.39	208	17.6	51.6	14.2	5.03	32.4	750	0.35	--	--	--
06MM03.04	21,300	12.1	134	4,700	3.4	9.5	20.9	27.1	25,500	3,390	6,880	256	0.46	195	16.9	63.2	12.9	6.52	34.4	605	0.51	--	--	--
06MM03.05	20,500	7.7	127	4,880	1.8	8.0	22.0	36.1	23,200	3,940	8,320	217	0.36	274	17.6	70.4	9.79	4.37	32.1	388	0.45	--	--	--
06MM03.06	17,800	9.9	116	4,340	0.25	6.5	18.8	28.5	21,900	3,870	8,440	219	0.30	255	15.5	15.8	9.15	2.29	29.1	83.1	0.25	--	--	--
06MM03.07	17,900	14.4	117	4,490	0.19	6.2	25.2	27.5	23,400	3,870	8,800	236	0.39	206	19.9	15.9	9.02	2.21	30.4	78.8	0.25	--	--	--
06MM03.08	20,800	14.9	133	4,380	0.17	6.8	30.3	27.5	26,800	4,180	9,080	264	0.53	200	22.6	17.5	12.0	2.59	35.6	82.5	0.22	--	--	--
06MM03.09	18,400	13.7	125	4,210	0.15	6.0	25.2	24.7	24,200	3,830	8,210	240	0.48	159	18.3	17.2	10.2	3.00	33.5	75.8	0.29	--	--	--
06MM03.10	18,600	15.1	130	3,790	0.12	5.9	21.7	24.7	25,000	3,840	8,210	280	0.36	146	15.6	15.3	10.6	1.89	33.8	73.8	0.18	--	--	--
06MM03.11	19,100	15.9	129	3,940	0.08	6.5	28.0	23.3	25,800	3,600	8,170	336	0.50	141	20.2	15.1	12.8	2.02	33.6	68.2	0.16	--	--	--
06MM03.12	18,900	16.7	128	4,410	0.09	7.3	31.9	22.0	26,600	3,560	8,740	418	0.58	149	23.1	16.1	14.3	3.61	34.8	69.2	0.25	--	--	--
06MM03.13	18,300	15.0	121	4,600	0.08	7.8	19.4	19.4	26,200	3,460	9,230	493	0.36	159	14.1	16.1	14.1	1.99	32.8	64.3	0.14	--	--	--
06MM03.14	18,400	15.5	126	4,670	0.10	8.3	32.3	19.4	25,800	3,470	9,360	577	0.48	171	23.1	17.0	13.3	1.91	31.4	65.0	0.14	--	--	--
06MM03.15	18,800	16.6	133	4,920	0.12	9.1	20.4	19.7	26,800	3,440	9,740	668	0.39	187	14.8	18.2	12.9	1.80	32.9	67.6	0.14	--	--	--
06MM03.16	19,700	18.8	135	5,150	0.12	10.5	20.8	21.2	28,500	3,420	10,400	789	0.40	200	16.4	21.2	15.6	3.18	35.0	70.9	0.20	--	--	--
06MM03.17	16,600	17.2	118	4,740	0.12	9.3	19.0	19.3	24,900	2,910	9,150	694	0.37	163	14.6	18.0	13.3	1.94	31.0	63.9	0.15	--	--	--
06MM03.18	18,000	18.2	124	4,980	0.14	10.0	21.4	20.2	27,000	3,150	10,100	701	0.46	180	16.0	18.4	14.8	2.38	33.4	67.8	0.16	--	--	--
06MM03.19	17,900	17.2	125	4,700	0.11	10.2	29.5	18.8	26,700	3,130	10,400	730	0.48	183	21.8	17.6	14.2	1.70	32.6	66.0	0.12	--	--	--
06MM03.20	16,800	16.8	131	4,670	0.17	9.3	29.2	18.2	25,200	3,110	10,100	796	0.52	201	22.0	17.4	12.6	2.98	30.6	66.5	0.24	--	--	--
06MM04.21	16,800	4.5	90.8	5,440	1.4	19.5	18.1	21.6	18,700	2,490	5,640	228	0.61	183	45.6	17.5	13.8	13.8	26.2	168	1.00	--	--	--
06MM04.22	17,000	10.4	109	8,100	0.73	12.3	58.3	89.2	23,900	2,990	8,580	289	1.3	198	58.8	24.5	8.52	8.52	32.1	265	1.00	--	--	--
n =	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	11	11	11
Minimum	14,800	4.5	91	3,640	0.08	4.1	14.2	18.2	17,000	2,190	4,430	208	0.30	134	12.2	15.1	8.5	1.7	24.5	63.9	0.12	7.0	4.7	4.7
Maximum	25,400	25.4	238	8,100	3.9	19.5	58.3	89.2	35,700	4,180	10,400	796	1.3	274	58.8	90.7	18.8	22.3	38.1	905	1.84	13.6	19.1	35.8
Median	18,250	13.9	130	4,610	0.29	7.7	20.8	22.0	25,250	3,150	8,190	376	0.48	170	16.9	21.4	13.0	4.4	32.1	88.3	0.32	9.6	9.3	14.7
Mean	18,376	12.8	143	4,670	0.90	8.1	22.8	25.2	24,588	3,216	7,539	425	0.54	182	19.5	33.2	12.9	6.3	31.8	265	0.49	10.0	9.5	14.6
Std. Dev.	1,851	4.97	35.2	812	1.04	3.0	8.44	12.0	3,737	491	1,886	190	0.22	35.7	9.43	22.2	2.34	5.26	3.05	266	0.40	2.00	3.94	9.03
CV (in percent)	10	39	25	17	117	37	37	48	15	15	25	45	40	20	48	67	18	83	10	100	82	20	41	62
Log-transformed data:																								
Geometric Mean	**18,293**	**11.7**	**139**	**4,612**	**0.42**	**7.7**	**21.7**	**23.8**	**24,308**	**3,178**	**7,293**	**386**	**0.50**	**179**	**18.2**	**27.7**	**12.7**	**4.7**	**31.6**	**165**	**0.37**	**9.8**	**8.9**	**12.3**
Upper 95 percent confidence limit of GM	18,913	13.7	150	4,868	0.66	8.6	24.1	26.4	25,660	3,358	8,007	451	0.57	190	20.5	33.9	13.6	6.2	32.7	232	0.48	--	--	--
Lower 95 percent confidence limit of GM	17,693	10.1	134	4,370	0.27	6.8	19.6	21.6	23,027	3,008	6,642	330	0.45	168	16.1	22.6	11.9	3.6	30.5	118	0.28	--	--	--
UCL95	18,800	13.3	148	4,820	0.61	8.4	23.7	25.9	25,400	3,330	7,880	439	0.56	188	20.1	32.8	13.4	5.9	32.5	219	0.46			
Shapiro-Wilks' statistic	0.931	0.937	0.869	0.902	0.881	0.978	0.911	0.702	0.936	0.965	0.910	0.913	0.936	0.925	0.834	0.844	0.976	0.933	0.968	0.820	0.946	--	--	--
p =	0.0325	0.0484	0.0007	0.0052	0.0015	0.7191	0.0088	<0.0001	0.0461	0.3328	0.0086	0.0092	0.0464	0.0233	0.0001	0.0002	0.6533	0.0385	0.4097	<0.0001	0.0938	--	--	--

Table 26. Surface-sediment data collected from Blue Creek delta and from sites in the Spokane Arm, Lake Roosevelt, May 2005.

[Analytical data determined by ICP-MS from EPA-3050 method; concentrations reported in parts per million (ppm); radionuclide activities in picocuries per gram (pCi/g); ACE Laboratories; Ag, Hg, Se and Ta were measured, but few if any values were detected; --, no data. Std. Dev., Standard Deviation; CV, Coefficient of Variation expressed in percent]

Sample No.	Location or depth in core (cm)	Al ppm	As ppm	Ba ppm	Ca ppm	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe ppm	K ppm	Mg ppm	Mn ppm	Na ppm	Ni ppm	Pb ppm	U ppm	V ppm	Zn ppm	^{210}Pb pCi/g	^{226}Ra pCi/g	^{238}U pCi/g
LR05092005-001	Blue Creek cove, lake shore	19,400	9.7	123	9,300	1.41	8	19	28	27,100	2,930	8,960	522	260	15	32.6	2.54	41.6	390	1.2	2.1	1.04
LR05092005-002	Blue Creek cove, lake shore	25,100	14.2	199	5,330	2.94	13	24	27	30,600	3,540	8,110	1,090	280	19	55.0	4.30	45.2	630	1.7	2.8	1.49
LR05092005-003	Blue Creek cove, lake shore	28,500	9.2	187	4,810	3.29	12	26	29	31,700	3,870	7,940	746	280	21	60.7	5.66	47.2	771	2.1	2.5	2.3
LR05092005-004	Blue Creek cove, lake shore	28,400	17.3	188	5,590	4.13	14	26	28	34,100	3,990	8,420	1,240	280	21	81.3	6.05	46.1	916	4.4	2.4	2.43
LR05092005-005	Blue Creek cove, lake shore	22,800	14.7	156	6,220	2.18	10	23	25	30,300	3,570	8,350	813	260	18	45.0	3.78	43.5	491	2.1	2.8	1.40
LR05092005-006	Blue Creek cove, lake shore	25,800	13.3	158	6,230	3.22	13	24	26	31,600	3,790	8,170	949	290	21	59.6	5.03	42.4	772	4.5	3.3	1.39
LR05092005-007	Blue Creek cove, lake shore	26,500	11.5	166	6,980	2.65	15	24	26	31,100	3,870	7,940	847	300	27	54.6	9.63	42.6	749	--	3.6	3.78
LR05092005-008	Blue Creek cove, lake shore	26,000	11.8	162	6,350	2.71	14	23	26	31,000	3,810	7,830	768	300	24	55.5	7.98	41.0	715	1.8	3.4	3.34
LR05092005-009	Blue Creek cove, lake shore	28,000	11.8	164	7,000	3.13	15	24	28	32,100	3,970	7,910	887	300	29	56.4	9.38	43.0	746	4.1	3.0	3.51
LR05092005-010	Blue Creek cove, lake shore	24,200	19.4	177	4,950	2.16	13	24	25	34,900	3,840	8,070	979	270	19	50.0	4.18	41.1	637	3.9	2.5	1.78
LR05092005-011	Blue Creek cove, lake shore	23,100	22.6	177	6,550	2.76	10	23	28	39,500	4,070	8,280	403	260	17	48.0	3.47	42.0	593	3.8	2.4	1.56
LR05092005-012	Blue Creek cove, lake shore	22,300	20.6	179	5,720	2.38	10	23	26	39,100	3,910	8,060	355	270	17	45.1	2.85	41.0	551	--	2.4	1.31
LR05092005-013	Blue Creek cove, lake shore	22,800	21.2	184	5,360	2.48	11	24	29	40,200	3,960	8,190	340	280	18	47.3	2.99	41.4	614	2.5	2.3	1.16
LR05092005-014	Blue Creek delta	22,300	8.7	130	4,730	2.07	28	16	24	21,900	2,970	5,210	835	230	65	17.4	81.6	33.5	245	7.3	8.0	26.6
LR05092005-015	Blue Creek delta	23,800	9.3	153	5,760	1.10	11	18	20	23,700	2,740	5,190	1,160	250	37	19.0	51.1	35.1	130	1.7	5.7	53.4
LR05092005-016	Blue Creek delta	21,700	11.1	142	8,040	0.92	11	16	23	24,400	2,710	5,850	293	240	30	21.3	30.3	36.8	132	2.6	5.7	50.5
LR05092005-017	Blue Creek delta	23,700	17.4	144	5,540	1.13	13	16	29	24,400	2,960	5,210	448	220	27	21.2	161	34.4	149	7.7	10	11.3
LR05092005-018	Blue Creek delta	24,900	17.2	169	5,420	1.48	16	17	32	25,400	3,210	5,770	593	230	33	26.7	176	38.6	237	6.7	11	16.4
LR05092005-019	Blue Creek delta	23,900	15.2	161	10,900	2.05	14	19	24	29,600	3,430	7,010	416	260	30	26.8	21.2	36.5	357	1.3	4.5	8.05
LR05092005-020	Blue Creek delta	25,500	11.3	101	9,530	2.01	13	18	24	27,700	3,340	6,580	734	270	31	22.7	25.1	37.7	258	4.8	5.0	8.24
LR05092005-021	Blue Creek delta	17,700	9.9	133	9,990	1.19	10	17	21	23,200	2,830	6,420	177	220	24	20.7	18.8	34.1	192	0.92	4.7	5.97
LR05092005-022	Blue Creek delta	17,800	17.6	147	8,830	1.23	11	19	24	30,800	3,020	6,830	233	250	21	19.9	9.47	37.6	223	3.2	4.4	4.54
LR05092005-023	Blue Creek delta	21,500	11.1	131	6,180	1.36	15	17	30	22,900	3,200	5,970	323	920	31	19.9	62.4	33.7	191	9.5	8.1	23.5
06MM01.01	Blue Creek delta, depth 0-2.5	17,200	6.5	114	4,920	1.0	11.4	15.5	16.8	19,300	2,480	5,440	1,020	174	31	18.5	26.0	26.1	217	--	--	--
06MM01.02	Blue Creek delta, depth 2.5-6	14,600	5.4	102	4,340	0.88	12.2	38.8	15.9	18,000	2,300	5,260	527	159	44	16.9	11.7	24.6	229	--	--	--
06MM02.01	Blue Creek delta, depth 0-10	15,500	8.4	155	4,890	1.2	22.2	123	22.7	22,600	2,880	6,630	3,060	185	120	17.2	26.7	30.3	201	--	--	--
06MM03.01	Blue Creek delta, depth 0-3	18,400	8.0	129	5,780	1.8	10.8	20.8	22.0	24,500	2,820	7,720	528	269	20	41.3	4.52	31.6	546	--	--	--
06MM03.02	Blue Creek delta, depth 3-7	25,400	10.8	155	5,230	3.9	13.4	36.8	29.7	29,900	3,620	8,430	358	249	33	62.4	7.40	38.1	905	--	--	--
06MM04.01	Blue Creek delta, depth 0-5	21,300	11.9	178	5,030	1.8	14.9	21.5	25.0	27,200	3,230	7,310	1,360	187	39	33.0	18.2	32.9	382	--	--	--
06MM05.01	Blue Creek delta, depth 0-11	15,100	6.3	93.0	6,300	0.74	10.1	25.8	15.4	19,000	1,970	4,460	999	171	35	14.2	29.6	32.9	79.5	--	--	--
LR05092005-024	Porcupine Bay, lake shore	21,700	13.5	169	4,810	1.58	12	23	23	32,600	3,950	7,740	308	300	17	29.9	1.94	37.9	648	--	2.0	1.0
LR05092005-025	Porcupine Bay, lake shore	23,900	14.3	185	6,970	2.23	14	26	37	32,500	3,930	8,350	554	310	20	46.3	2.15	41.7	911	2.6	2.0	1.1
LR05092005-026	Porcupine Bay, lake shore	18,900	30.2	232	34,000	0.35	19	22	37	32,900	2,590	11,500	1,050	250	21	35.4	1.28	41.0	103	1.4	2.7	0.6
LR05092005-027	Porcupine Bay, lake shore	17,900	14.3	141	6,340	1.19	12	22	23	26,300	3,050	9,350	746	210	18	29.2	1.20	34.7	407	3.3	1.7	0.73
LR05092005-028	A-Frame, lake shore	24,900	15.1	197	7,210	2.63	13	26	34	30,200	3,810	8,960	851	270	21	59.5	2.29	42.1	635	3.9	2.1	1.15
LR05092005-029	A-Frame, lake shore	24,400	9.7	181	5,590	2.50	13	31	23	28,000	3,250	6,860	1,110	300	20	62.0	2.67	43.4	875	1.0	1.8	1.42
LR05112005-030	A-Frame, lake shore	26,300	9.9	195	5,980	1.99	13	33	23	29,100	3,300	6,950	1,070	320	20	64.3	3.28	47.1	769	3.0	2.4	1.07
LR05112005-031	A-Frame, lake shore	24,000	10.0	176	5,360	2.02	13	30	23	28,100	3,150	6,690	1,000	290	20	62.9	2.86	43.3	856	1.2	1.7	1.43
LR05112005-032	China Bar, lake shore	19,600	4.7	158	4,580	1.43	10	25	24	22,000	2,340	4,850	228	330	19	31.4	1.10	40.5	240	--	1.6	0.82
LR05112005-033	China Bar, lake shore	19,200	5.1	169	4,410	1.26	11	27	27	23,800	2,460	5,400	323	330	22	33.0	1.19	43.8	229	0.31	2.0	0.5
LR05112005-034	China Bar, lake shore	21,300	7.8	240	4,720	7.02	12	28	34	25,500	2,820	5,670	450	310	23	172	2.04	44.3	568	--	2.6	0.88
Blue Creek cove, lake shore:																						
Minimum		19,400	9	123	4,810	1.4	8.0	19	25	27,100	2,930	7,830	340	260	15	33	2.5	41	390	1.2	2.1	1.0
Maximum		28,500	23	199	9,300	4.1	15	26	29	40,200	4,070	8,960	1,240	300	29	81	10	47	916	4.5	3.6	3.8
Median		25,100	14	177	6,220	2.7	13	24	27	31,700	3,870	8,110	813	280	19	55	4.3	42	637	2.5	2.5	1.6
Mean		24,838	15	171	6,180	2.7	12	24	27	33,300	3,780	8,170	765	279	20	53	5.2	43	660	2.9	2.7	2.0
Std. Dev.		2,723	4.6	19	1,180	0.7	2.2	1.7	1.4	4,030	297	295	285	15	4.1	11	2.4	2.0	138	1.2	0.5	1.0
Geometric Mean		**24,696**	**15**	**170**	**6,090**	**2.6**	**12**	**24**	**27**	**33,100**	**3,770**	**8,170**	**708**	**279**	**20**	**52**	**4.8**	**43**	**645**	**2.7**	**2.7**	**1.9**
CV (in percent)		11	30	11	19	24	18	7	5	12	8	4	37	5	20	21	46	5	21	42	17	47
n =		13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	11	13	13
Blue Creek delta:																						
Minimum		14,600	5.4	93	4,340	0.7	10	16	15	18,000	1,970	4,460	177	159	20	14	4.5	25	80	0.9	4.4	4.5
Maximum		25,500	18	178	10,900	3.9	28	123	32	30,800	3,620	8,430	3,060	920	120	62	176	39	905	10	11	53
Median		21,500	11	142	5,760	1.2	13	18	24	24,400	2,960	5,970	528	230	31	21	26	34	223	4.0	5.7	14
Mean		20,600	11	137	6,550	1.5	14	27	23	24,400	2,920	6,190	768	264	38	25	45	34	275	4.6	6.7	21
Std. Dev.		3,760	3.9	24	2,070	0.7	4.7	26	4.8	3,770	417	1,050	684	173	23	12	51	4.0	196	3.1	2.4	18
Geometric Mean		**20,300**	**10**	**135**	**6,290**	**1.4**	**13**	**22**	**23**	**24,100**	**2,890**	**6,110**	**591**	**239**	**34**	**23**	**28**	**34**	**232**	**3.5**	**6.4**	**15**
CV (in percent)		18	35	18	32	49	34	96	21	15	14	17	89	66	61	48	113	12	71	67	36	86
n =		17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	10	10	10

Elevated concentrations of uranium and associated radionuclides from the radioactive decay of ^{238}U in the surface sediment of Blue Creek delta are caused by mining at the Midnite Mine site. Using the UCL_{95} concentration for the premining geochemical background sediment from the Blue Creek delta (table 25), the extent of uranium contamination in surface sediment extends to at least 500 meters from the mouth of Blue Creek (table 26 and fig. 37). (The 1,290-ft elevation marks the boundary between land administered by the National Park Service and the Spokane Indian Reservation.) As we do not have radionuclide data on the premining surface sediment, the radionuclide data are normalized to the geometric mean concentration of the surface sediment data from the delta. This approach shows that elevated concentrations of radionuclides associated with the decay of ^{238}U at the Midnite Mine site are restricted to the surface sediment in the Blue Creek delta and do not accumulate in the lake-shore sediment of the Blue Creek delta (fig. 37). Normalization of the radionuclide data relative to the GM concentrations (table 28) shows that only three sites have elevated ^{210}Pb concentrations (that is >1.0) beyond the 500-m distance from the 1,290-ft national park boundary. Downstream from this boundary (between sites LR-014 and LR-007, fig. 7), the measured uranium concentrations are also much lower, generally less than the UCL_{95} concentration in the premining geochemical background sediment from Blue Creek delta (table 25).

Concentrations of the elements arsenic, cadmium, lead, and zinc in surface sediment also change dramatically with distance from the 1,290-ft elevation in Blue Creek delta (table 26). We have shown that two viable sources exist for these metals, the suspended sediment from the Coeur d'Alene mining district and the sediment from the Midnite Mine site. Through the use of factor analysis, both suites of metals are discriminated. Element-concentration versus element-ratio plots were developed to show these two populations and the mixing relationships between them in the surface sediment of the Blue Creek delta. Three element ratios are shown in figure 38 plotted against the concentrations of zinc. All three plots show that the background sediment populations from both the Blue Creek delta (table 25) and from upper Blue Creek (table 23, case II) have low zinc concentrations and relatively constant Cd/Pb, Ni/Zn, and Co/Zn values. These ratios did not change during mining, but the concentration of zinc did increase as a result of mining and release of contaminants at the Midnite Mine site. Samples of suspended sediment from the Coeur d'Alene mining district (fig. 34) have distinctive Cd/Pb, Ni/Pb, and Co/Zn values, indicating that no appreciable cobalt or nickel contamination in surface sediment from the Midnite Mine in Blue Creek delta sediment can be attributed to suspended sediment from the Coeur d'Alene mining district. There is also a gradient in zinc concentration in the surface-sediment data (table 26). Zinc concentrations increase in the surface sediment with distance from the 1,290-ft elevation boundary (fig. 6). Therefore, a portion of the zinc (and As, Cd, and Pb) in surface sediment that exceeds the GM_{Zn} concentration during the mining period (197 ppm, table 18, core 06MM04) can be attributed to the Coeur d'Alene mining district. The portion of zinc and associated metals (As, Cd, and Pb) increases with distance away from the 1,290-ft elevation boundary. This gradient is simply a function of mixing and dilution of sediment from these two dominant sources. As a result, there is an increasingly large component of metal from the Coeur d'Alene mining district and a correspondingly lower contribution of zinc and associated metals (U, Co, Mn, and Ni) from the Midnite Mine as a function of distance from the 1,290-ft elevation boundary. All of the Co, Mn, and Ni in surface sediment above the background concentration are attributed to mining at the Midnite Mine.

Summary of Geochemical Data

The geochemical results from the study are summarized for nine elements in table 29. The data have been subdivided into two groups: Co, Cu, Ni, Mn, and U, which we have shown are diagnostic of contamination by mining at the Midnite Mine site, and As, Cd, Pb, and Zn, which in the Blue Creek delta setting, contain contaminants from both the Midnite Mine and the Coeur d'Alene mining district. Geochemical data from core 06MM08, from the Midnite Mine tributary, summarize the changes immediately downstream from the source (zone 3, fig. 29). Relative to the premining GM concentrations in sediment from core 06MM08, all trace elements show a substantial increase in core 06MM08 during the period of mining activity ranging from 0.9 for lead and manganese to 4 to 7 for cobalt, nickel, and cadmium. Uranium concentrations increased to 1.7 times the premining geochemical background concentration and are highly variable. Following mining, the concentrations of several of the trace elements decreased: As, Cu, Mn, Pb, and U enrichments decreased to near one, whereas the enrichment of the base metals Cd, Co, Ni, and Zn remain elevated at 3.7 to 26 times premining background values. Core 06MM06 provides no substantive data for zone 2 concentrations except for the premining data, which have been discussed previously.

Downstream at the Blue Creek delta (zone 3, fig. 29), core 06MM01 has the largest number of premining, pre-Lake-Roosevelt-flooding samples. Comparison of these trace-element data with the premining geochemical data from core 06MM03 shows that the range of enrichment ranges from 0.8 to 1.6 for the base metals and a high enrichment value of 3.5 for uranium. During the mining period, enrichment of the base metals copper, lead, and zinc in sediment from Blue Creek delta in cores 06MM01, 06MM02, and 06MM04 ranged from less than 1 to 2.8 for zinc, between 3 and 4 for cobalt, nickel, and manganese, more than 10 for cadmium, and from 16 to 55 for uranium relative to the premining geochemical background data from core 06MM03. Postmining geochemical data from Blue Creek delta (core 06MM01 and 06MM05) have copper and lead enrichments near 1; enrichments of arsenic, cobalt, nickel, manganese, and zinc range between 1.4 and 3.3; cadmium enrichment is 7.7; and uranium enrichment ranges between 9.6 and 18.7. These geochemical enrichments compare very well with the independently collected data from surface sediment from Blue Creek delta.

Table 27. Enrichment of possible contaminants from the Midnite Mine in surface sediment, Blue Creek delta.

[Concentration data reported in parts per million (ppm); Std. Dev., Standard Deviation; crustal abundance data (in ppm) from Fortescue (1992). Values greater than 1 are shaded for emphasis]

	As ppm	Cd ppm	Co ppm	Cu ppm	Mn ppm	Ni ppm	Pb ppm	U ppm	Zn ppm
Crustal Abundance	*1.8*	*0.16*	*29.0*	*68.0*	*1,060*	*99.0*	*13.0*	*2.3*	*76.0*
Data ratioed to Crustal Abundance:									
Maximum	9.8	24.4	1.0	0.47	2.9	1.2	4.8	76.5	11.9
Median	6.0	7.7	0.45	0.35	0.50	0.32	1.6	11.3	2.9
Minimum	3.0	4.6	0.34	0.23	0.17	0.20	1.1	2.0	1.0
Mean	6.1	9.5	0.48	0.34	0.72	0.39	1.9	19.5	3.6
Geometric Mean	5.7	8.7	0.46	0.34	0.56	0.35	1.8	12.0	3.1
Data ratioed to GM of the premining background data from Blue Creek delta (table 26):									
Maximum	1.5	9.3	3.6	1.3	7.9	6.6	2.3	37.4	5.5
Median	0.9	2.9	1.7	1.0	1.4	1.7	0.7	5.5	1.4
Minimum	0.5	1.8	1.3	0.6	0.5	1.1	0.5	1.0	0.5
Mean	0.9	3.6	1.8	1.0	2.0	2.1	0.9	9.5	1.7
Geometric Mean	0.9	3.3	1.7	1.0	1.5	1.9	0.8	5.9	1.4
Data ratioed to GM, Blue Creek watershed data (table 23, Case II):									
Maximum	2.4	21.7	3.7	1.7	5.7	8.6	4.3	50.1	15.5
Median	1.5	6.8	1.7	1.3	1.0	2.2	1.4	7.4	3.8
Minimum	0.7	4.1	1.3	0.8	0.3	1.4	1.0	1.3	1.4
Mean	1.5	8.5	1.8	1.3	1.4	2.8	1.7	12.8	4.7
Geometric Mean	1.4	7.7	1.8	1.2	1.1	2.5	1.6	7.9	4.0
Data ratioed to the UCL_{95}, geochemical background, Blue Creek watershed (table 23, case II):									
Maximum	1.9	18.6	3.3	1.5	5.2	7.8	4.0	40.0	14.4
Median	1.2	5.9	1.5	1.1	0.9	2.0	1.3	5.9	3.6
Minimum	0.6	3.5	1.2	0.7	0.3	1.3	0.9	1.0	1.3
Mean	1.2	7.2	1.7	1.1	1.3	2.5	1.6	10.2	4.4
Geometric Mean	1.1	6.6	1.6	1.1	1.0	2.2	1.5	6.3	3.7
Data ratioed to the UCL_{95}, premining geochemical background, Blue Creek delta (table 26):									
Maximum	1.3	14.4	3.3	1.2	7.0	6.0	1.9	29.8	4.1
Median	0.8	4.6	1.5	0.9	1.2	1.6	0.6	4.4	1.0
Minimum	0.4	2.7	1.2	0.6	0.4	1.0	0.4	0.8	0.4
Mean	0.8	5.6	1.7	0.9	1.8	1.9	0.8	7.6	1.3
Geometric Mean	0.8	5.2	1.6	0.9	1.3	1.7	0.7	4.7	1.1

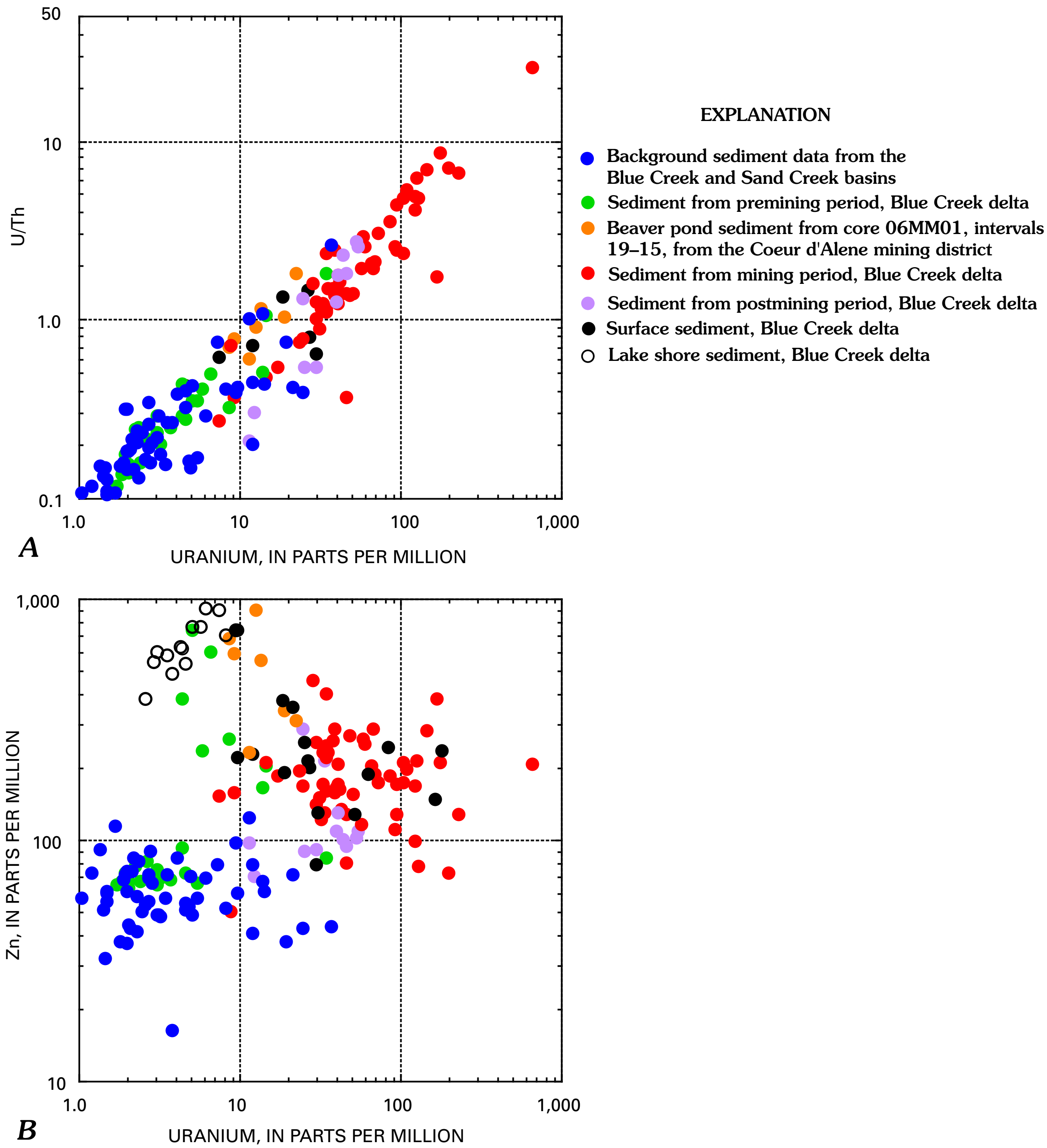


Figure 36. Plots of *A*, uranium versus U/Th, and *B*, uranium versus zinc showing changes as a function of time and mining activity in the Blue Creek basin.

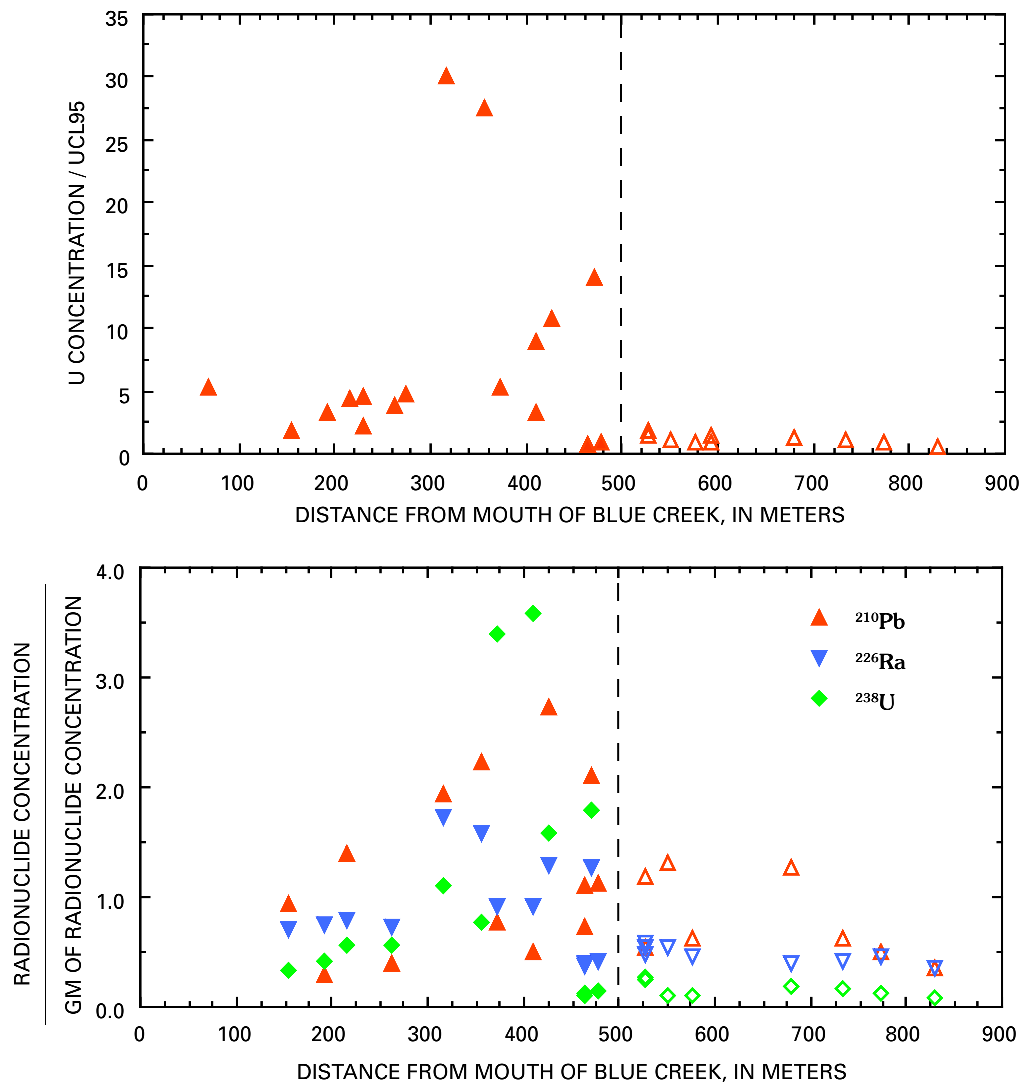


Figure 37. Graph showing relationship of uranium and radionuclides in surface sediment, Blue Creek delta, versus distance downstream in meters. The 1,290-ft elevation is used as the starting distance from the mouth of Blue Creek. Concentrations observed in surface sediment samples from Blue Creek delta (in parts per million) are divided by the 95th upper confidence limit (UCL_{95}) in sediment from the premining geochemical background population, Blue Creek delta (table 25). Dashed line at 500 m represents break between two different sample types discussed in text. Closed symbols are concentration data from samples that were collected from the Blue Creek delta along the thalweg out to about 500 m from the mouth of Blue Creek. Open symbols are concentration data from samples that were collected along the shoreline of Lake Roosevelt in Blue Creek cove.

Table 28. Enrichment of U and radionuclides in surface sediment from Blue Creek delta.

[^{238}U concentration based on ^{234}Th activity; --, no data. Values exceeding 1 are shown in bold type]

Sample No.	Distance from mouth of Blue Creek[1] (meters)	U / UCL_{95}[2]	Observed Concentration / GM[3]			
			U	^{210}Pb	^{226}Ra	^{238}U
06MM05.01	70	**5.0**	**6.2**	--	--	--
LR05092005-022	157	**1.6**	**2.0**	0.91	0.69	0.30
LR05092005-021	194	**3.2**	**3.9**	0.26	0.73	0.40
LR05092005-020	219	**4.3**	**5.2**	**1.37**	0.78	0.55
06MM01.01	233	**4.4**	**5.4**	--	--	--
06MM01.02	233	**2.0**	**2.4**	--	--	--
LR05092005-019	266	**3.6**	**4.4**	0.37	0.70	0.54
06MM02.01	277	**4.5**	**5.6**	--	--	--
LR05092005-018	319	**30**	**37**	**1.91**	**1.72**	**1.09**
LR05092005-017	358	**27**	**34**	**2.20**	**1.56**	0.75
LR05092005-016	376	**5.1**	**6.3**	0.74	0.89	**3.37**
06MM04.01	412	**3.1**	**3.8**	--	--	--
LR05092005-015	412	**8.7**	**11**	0.49	0.89	3.56
LR05092005-023	430	**11**	**13**	**2.71**	**1.27**	**1.57**
LR05092005-011	466	0.6	0.7	**1.09**	0.38	0.10
LR05092005-012	466	0.5	0.6		0.38	0.09
LR05092005-013	466	0.5	0.6	0.71	0.36	0.08
LR05092005-014	474	**14**	**17**	**2.09**	**1.25**	**1.77**
LR05092005-010	481	0.7	0.9	**1.11**	0.39	0.12
LR05092005-007	530	**1.6**	**2.0**		0.56	0.25
LR05092005-008	530	**1.4**	**1.7**	0.51	0.53	0.22
LR05092005-009	530	**1.6**	**2.0**	**1.17**	0.47	0.23
LR05092005-006	554	0.9	1.0	**1.29**	0.52	0.09
LR05092005-005	580	0.6	0.8	0.60	0.44	0.09
06MM03.01	596	0.8	0.9	--	--	--
06MM03.02	596	**1.3**	**1.5**	--	--	--
LR05092005-004	683	1.0	**1.3**	**1.26**	0.38	0.16
LR05092005-003	737	1.0	**1.2**	0.60	0.39	0.15
LR05092005-002	776	0.7	0.9	0.49	0.44	0.10
LR05092005-001	832	0.4	0.5	0.34	0.33	0.07

[1]Distance measured from the 1,290-ft elevation.

[2]Blue Creek delta, premining sediment (table 25).

[3]Geometric mean of the data from the Blue Creek delta sediment (table 26).

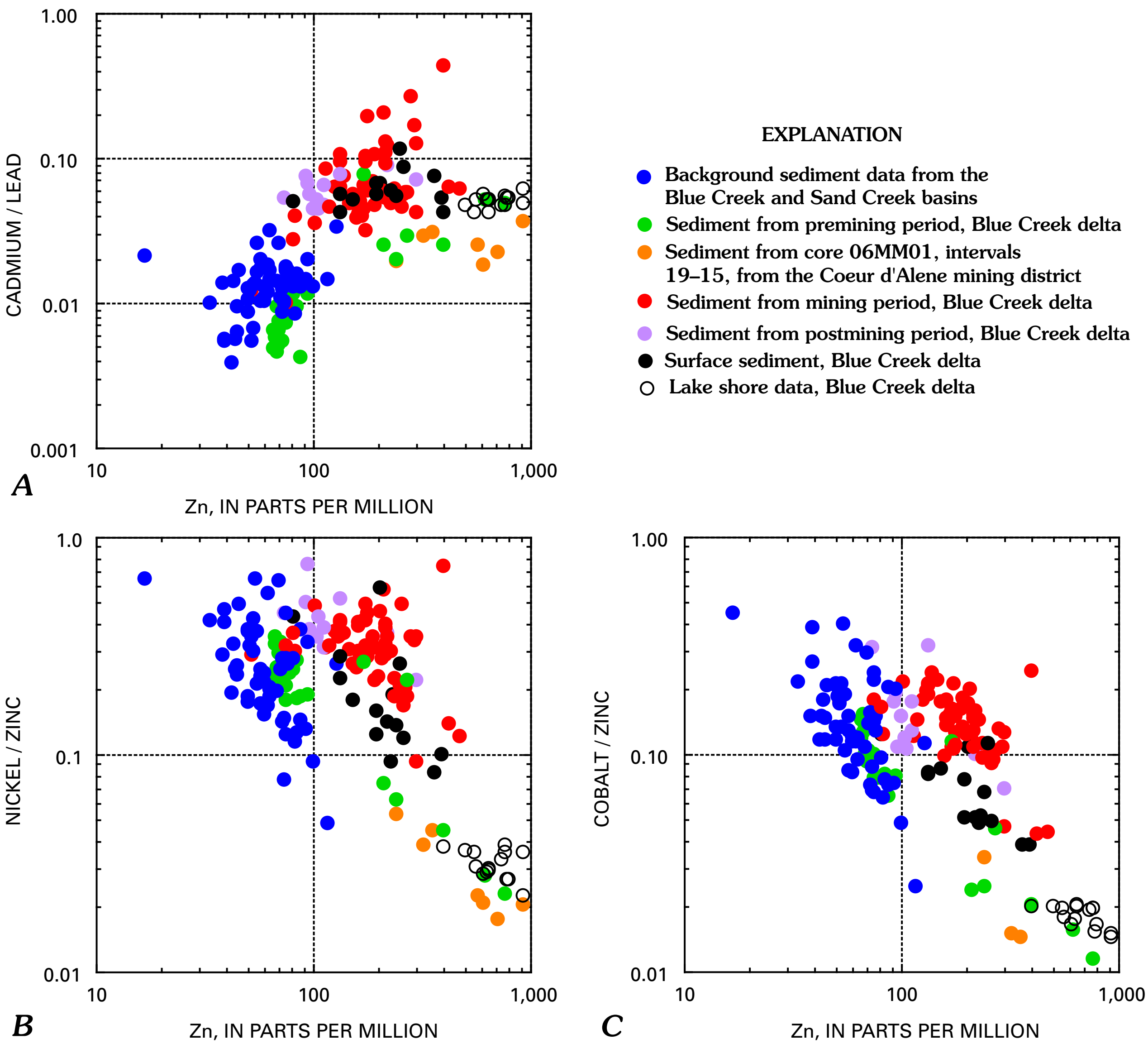


Figure 38. Relationship of *A*, Cd/Pb, *B*, Ni/Zn, and *C*, Co/Zn relative to zinc concentration in sediment, Blue Creek delta.

Table 29. Summary of geochemical data from core study.
[Concentrations in parts per million, ppm; --, no data. Where *n* is small, the mean value is used. Data from the beaver pond sediment in core 06MM01 are not included in this table; see discussion in previous section]

Period of time	Core							
	06MM08 (table 13)	06MM06 (table 15)	06MM05 (table 16)	06MM04 (table 18)	06MM02 (table 19)	06MM01 (table 20)	06MM03 (pre-1942, table 17)	Surface sediment, Blue Creek delta (table 26)
Premining Period:								
Co Range	6 - 12	4 - 10	--	12 - 20	--	5 - 8	5.9 - 11	--
GMCo	9.0	6.5	--	16	--	6.0	7.8	--
Cu Range	17 - 21	20 - 23	--	22 - 89	--	21 - 29	18 - 29	--
GMCu	19	21	--	55	--	25	22	--
Ni Range	33 - 44	12 - 21	--	46 - 59	--	14 - 18	14 - 23	--
GMNi	38	17	--	52	--	16	18	--
Mn Range	20,600 - 26,000	323 - 710	--	228 - 289	--	214 - 621	219 - 796	--
GMMn	22,900	520	--	259	--	422	446	--
U Range	92 - 117	69 - 72	--	8.5 - 14	--	4.3 - 14	1.7 - 3.6	--
GMU	106	70	--	11	--	8.1	2.3	--
As Range	5 - 15	4.0 - 7.7	--	4.5 - 10	--	8.5 - 25	10 - 19	--
GMAs	9.1	5.5	--	7.5	--	14	16	--
Cd Range	0.4 - 0.7	0.07 - 0.17	--	0.7 - 1.4	--	0.1 - 0.7	0.08 - 0.12	--
GMCd	0.5	0.1	--	1.1	--	0.2	0.1	--
Pb Range	16 - 19	17 - 24	--	18 - 25	--	21 - 27	15 - 21	--
GMPb	18	20	--	21	--	24	17	--
Zn Range	75 - 92	57 - 65	--	168 - 265	--	67 - 237	64 - 83	--
GMZn	83	61	--	217	--	112	71	--
Mining Period:								
Co Range	13 - 94	--	--	16 - 35	14 - 41	14 - 31	--	--
GMCo	43	--	--	25	28	22	--	--
Cu Range	21 - 80	--	--	19 - 182	13 - 26	22 - 34	--	--
GMCu	35	--	--	28	18	25	--	--
Ni Range	64 - 1,750	--	--	40 - 126	35 - 103	28 - 123	--	--
GMNi	172	--	--	60	56	61	--	--
Mn Range	14,100 - 27,900	--	--	381 - 5,280	448 - 8,150	715 - 4,960	--	--
GMMn	21,300	--	--	1,530	3,580	1,610	--	--
U Range	93 - 391	--	--	7.4 - 125	17 - 227	38 - 656	--	--
GMU	174	--	--	36	50	125	--	--
As Range	9 - 26	--	--	5 - 17	5.1 - 22	7.7 - 11	--	--
GMAs	15	--	--	9.4	10	10	--	--
Cd Range	1.2 - 20	--	--	0.7 - 2.2	0.7 - 4.3	0.7 - 4.7	--	--
GMCd	3.4	--	--	1.3	1.4	1.7	--	--
Pb Range	9.7 - 24	--	--	16 - 32	14 - 30	16 - 32	--	--
GMPb	17	--	--	21	19	21	--	--
Zn Range	119 - 1,640	--	--	143 - 466	112 - 292	100 - 293	--	--
GMZn	280	--	--	197	187	198	--	--
Postmining Period:								
Co Range	31 - 35	--	10 - 20	--	15 - 22	11 - 23	--	10 - 28
GMCo	33	--	13	--	18	17	--	13
Cu Range	21 - 23	--	15 - 23	--	10 - 23	8 - 23	--	32 - 23
GMCu	22	--	20	--	--	15	--	23
Ni Range	218 - 246	--	35 - 45	--	36 - 126	31 - 79	--	20 - 120
GMNi	233	--	38	--	--	50	--	34
Mn Range	34,000 - 44,000	--	315 - 2,380	--	1,900 - 3,060	527 - 3,160	--	177 - 3,060
GMMn	37,600	--	1,160	--	--	1,470	--	591
U Range	100 - 119	--	30 - 54	--	11 - 27	12 - 33	--	4.5 - 176
GMU	107	--	43	--	--	22	--	28
As Range	10 - 10.6	--	6.3 - 9.6	--	6.2 - 8.4	5.4 - 7.3	--	5.4 - 18
GMAs	10.3	--	7.7	--	--	6.6	--	10.0
Cd Range	12-14	--	0.7 - 1.2	--	0.6 - 1.2	0.5 - 1.4	--	0.7 - 3.9
GMCd	13	--	1.0	--	--	1.0	--	1.4
Pb Range	13 - 14	--	14 - 21	--	12 - 17	9 - 19	--	14 - 62
GMPb	13	--	18	--	--	14	--	23
Zn Range	471 - 505	--	80 - 110	--	98 - 201	72 - 291	--	80 - 905
GMZn	492	--	100	--	--	152	--	232

Conclusions

Geochemical and radionuclide data from sediment from cores taken in Blue Creek have shown that mining activities at the Midnite Mine site (1956–1981) on the Spokane Indian Reservation resulted in release of uranium and radionuclides from the mine site. Sediment in Blue Creek was contaminated by mining activity at the Midnite Mine site. Blue Creek is a down-cutting stream; consequently, sediment catchments in Blue Creek are scarce and the sedimentological record, where recovered, is incomplete. The historical record of contamination from the Midnite Mine has been reconstructed, in part, using ^{137}Cs dating of sediment intervals in the cores. Geochemical data from the cores were correlated downstream and tied with specific historical timelines in mine development that can in turn be tied to the public record of production at the Midnite Mine. Elevated base-metal and uranium concentrations in sediment associated with the Midnite Mine deposit were used to correlate individual events in the sedimentological record. Premining concentrations of uranium in sediment from the core immediately downstream of the mine site (GMU concentration of 106 ppm) indicated that weathering of uranium ore contributed uranium and its radioactive decay products to the stream sediment.

A more complete geochemical and sedimentological record was recovered from four cores from the Blue Creek delta. Premining geochemical background data from sediment in the delta prior to 1942 when Lake Roosevelt was filled clearly show that the concentrations of base metals, uranium (GMU concentration of 5.4 ppm), and radionuclides in sediment were low. Lake Roosevelt reached maximum pool elevation, submerging the Blue Creek delta, in mid-1942. The delta remained submerged from mid-1942 until changes in reservoir management practices were initiated in 1952. Historical water-elevation data from Lake Roosevelt gauge at Grand Coulee Dam (USGS # 12436000) show that the core sites in the Blue Creek delta have been exposed to a variable extent during drawdown each winter since 1952. Until the beginning of mining at the Midnite Mine in 1956, the sedimentological record shows that metal contamination from suspended sediment from the Coeur d'Alene mining district resulted in elevated concentrations of arsenic, cadmium, lead, and zinc in the sediment in Blue Creek delta.

Mining of uranium at the Midnite Mine resulted in contamination of sediment in the Midnite Mine tributary immediately downstream from the mine site. Base-metal geometric mean concentrations are enriched in sediment in Blue Creek delta by factors of slightly more than 1 to 4, for cadmium by factors of 10, and for uranium by factors between 16 and 55 times premining geochemical background for the Blue Creek delta.

During the postmining period (1981–2006), the geometric mean concentration of most of the base metals is between 1 and 3.3 times premining geochemical background, cadmium remains elevated by a factor of 7.7 (0.5 to 1.6 ppm), and uranium concentrations are elevated by factors of 9.6 to 18.7 (range of values from 11 to 33 ppm). Continued release of uranium from the mine site via ground-water transport to the surface-water drainage appears to be ongoing, as shown by the disruption of the radionuclide decay-chain in sediment from the core nearest the mine site.

Elevated uranium concentrations are present in surface sediment (0–5 cm depth) in the Blue Creek delta. Contamination by uranium in surface sediment does not extend beyond about 500 meters from the mouth of Blue Creek, as represented by the 1,290-ft elevation that marks the boundary between lands administered by the National Park Service and the Spokane Indian Tribe. The current data provide no evidence that contamination from mining at the Midnite Mine site can be traced downstream to sites within the Lake Roosevelt National Recreational Area at Porcupine Bay, A-Frame, and China Bar (2.1, 9.3, and 22 km downstream from the Blue Creek cove, respectively). Data from surficial sediment of Blue Creek cove show that sediment from Blue Creek is being diluted, and concentrations of uranium, cobalt, nickel, and manganese are reduced. Contaminants from the Coeur d'Alene mining district (arsenic, cadmium, lead, and zinc) brought in with suspended sediment by the Spokane River overwhelm the contributions of these metals from the Midnite Mine beyond the 500-meter distance out from the 1,290-ft elevation line.

References Cited

Ames, K.C., Matson, N.P., Suzuki, D.M., and Sak, P.B., 1996, Inventory, characterization, and water quality of springs, seeps, and streams near Midnite mine, Stevens County, Washington: U.S. Geological Survey Open-File Report 96-115, 53 p.

Babcock, L., Beck, P., Farley, W., Lechler, P., Lindgren, J., Miller, D., Pigott, J., Sayala, D., Trujillo, R., and Wayland, T., 1981, An exploration systems approach to the Spokane Mountain area uranium deposits, northeastern Washington: U.S. Department of Energy Report GJBX 200(81), 396 p.

Barlow, J.L., Hetand, D.L., Papulak, M.S., and Van Alstine, C.L., 1958, Preliminary report on uranium deposits of the Spokane Indian Reservation, Stevens County, Washington: U.S. Atomic Energy Commission RME-2067, Part I, 56 p.

Barrington, J., and Kerr, P.F., 1961, Uranium mineralization at the Midnite mine, Spokane, Washington: Economic Geology, v. 56, p. 241–258.

Becraft, G.E., and Weis, P.L., 1957, Preliminary geologic map of the Turtle Lake quadrangle, Lincoln and Stevens County, Washington : U.S. Geological Survey Miscellaneous Field Map MF–135, scale 1:62,500.

Becraft, G.E., and Weis, P.L., 1963, Geology and mineral deposits of the Turtle Lake quadrangle, Washington: U.S. Geological Survey Bulletin 1131, 73 p.

Carson Helicopters, 1982, NURE aerial gamma ray and magnetic detail survey of portions of northeast Washington: U.S. Department of Energy, Grand Junction Office Report GJBX-001(82), 12 volumes, scale 1:62,500.

Charles, M.J., and Hites, R.A., 1987, Sediments as archives of environmental pollution trends, *in* Hites, R.A., and Eisenreich, S.J., eds., Sources and fates of aquatic pollutants, Advances in chemistry series number 216: Washington, D.C., American Chemical Society, p. 365–389.

Cox, S.E., Bell, P.R., Lowther, S., and VanMeter, P.C., 2004, Vertical distribution of trace-element concentrations and occurrence of metallurgical slag particles in accumulated bed sediments of Lake Roosevelt, Washington, September, 2002: U.S. Geological Survey Scientific Investigations Report 2004-5090, 69 p.

Dalton, Stan, 1978, Washington state—Dawn; A first-generation plant with column ion exchange: Engineering and Mining Journal, v. 179, no. 11, p. 118–121.

Davis, J.C., 1973, Statistics and data analysis in geology: New York, John Wiley, 550 p.

Dean, N.E., Boldt, C.M.K., Schultz, L.E., Nilsen, D.N., Isaacson, A.E., Williams, B.C., Kirschner, F.E., Moore, B.W., Stroud, W.P., and Peters, D.C., 1996, Midnite Mine summary report: U.S. Bureau of Mines Report of Investigations 9604, 18 p.

Edgell, K., 1988, USEPA Method study 37—SW-846 method 3050 acid digestion of sediments, sludges, and soils, EPA contract No. 68-03-3254: URL: http://www.epa.gov/sw-846/pdfs/3050b.pdf.

Fortescue, J.A.S., 1992, Landscape geochemistry—Retrospect and prospect—1990: Journal of Applied Geochemistry, v. 7, p. 1–54.

Grosbois, C.A., Horowitz, A.J., Smith, J.J., and Elrick, K.A., 2002, The effect of mining and related activities on the sediment trace-element geochemistry of the Spokane River Basin, Washington, U.S.A.: Geochemistry—Exploration, Environment and Analysis, v. 2, p. 131–142.

Horowitz, A.J., Elrank, K.A., and Cook, R.B., 1993, Effect of mining and related activities on the sediment trace element geochemistry of Lake Coeur d'Alene, Idaho, U.S.A.—Part I, Surface sediments: Hydrological Processes, v. 7, p. 403–423.

Horowitz, A.J., Elrank, K.A., Robins, J.A., and Cook, R.B., 1995, Effect of mining and related activities on the sediment trace element geochemistry of Lake Coeur d'Alene, Idaho, U.S.A.—Part II, Subsurface sediments: Hydrological Processes, v. 9, p. 35–54.

Huntting, M.T., 1956, Inventory of Washington minerals—Part II, Metallic minerals: Washington Division of Mines and Geology Bulletin 37, 428 p.

International Commission on Radiological Protection (ICRP), 1983, Radionuclide transformations—Energy and intensity of emissions: New York, Pergamon Press, ICRP Publication 38, 288 p.

International Exploration, 1982, Geophysical interpretation of airborne magnetic data, Midnite-Sherwood mines, NE Washington: U.S. Department of Energy, Grand Junction Office Report GJBX-110(82), 45 p., scale 1:62,500.

Jackson, L.L., Brown, F.W., and Neil, S.T., 1987, Major and minor elements requiring individual determination, classical whole rock analysis, and rapid rock analysis, *in* Baedecker, P.A., ed., Methods for geochemical analysis: U.S. Geological Survey Bulletin 1770, p. G4–G6.

Lamothe, P.J., Meier, A.L., and Wilson, S.A., 2002, The determination of elements in aqueous samples by inductively coupled plasma–mass spectrometry, *in* Taggart, J.E., ed., Analytical methods for chemical analyses of geologic and other materials, U.S. Geological Survey: U.S. Geological Survey Open-File Report 02-223, Chapter H, p. H1–H11.

Lockheed Martin, 2005, Final report Midnite Mine site ecological risk assessment Wellpinit, Washington: Report prepared for U.S. EPA, contract No. EP-C-04-032, 1,513 p. URL: http://yosemite.epa.gov/R10/CLEANUP.NSF/738cdf3a6d72acce88256feb0074f9f4/9ef437f75171144588256fe500039e05/$FILE/Ecological%20Risk%20Assessment_.pdf

Long, K.R., 2001, Tailings under the bridge—Causes and consequences of river disposal of tailings, Coeur d'Alene mining region, 1886 to 1968: Mining History Journal, v. 8, p. 83–101.

Ludwig, K.R., Nash, J.T., and Naeser, C.W., 1981, U-Pb isotope systematics and age of uranium mineralization, Midnite Mine, Washington: Economic Geology, v. 76, p. 89–110.

Lydon, J.W., 2000, A synopsis of the current understanding of the geological environment of the Sullivan Deposit, *in* Lydon, J.W., Hoy, T., Slack, J.F., and Knapp, M.E., eds., Geological environment of the Sullivan Deposit, British Columbia: Geologic Association of Canada, Mineral Deposits Division, Special Publication 1, p. 12-31.

Millard, H.T., and Keaten, B.A., 1982, Precision of uranium and thorium determinations by delayed neutron counting: Journal of Radioanalytical Chemistry, v. 72, p. 489–500.

Moore, B.W., Price, J.W., and Gardner, T., 1996, Reactivity in the south spoils and hillside dump at the Midnite mine: U.S. Bureau of Mines Report of Investigations 9609, 222 p.

Munsell Soil Color Charts, 1998 ed.: New Windsor, New York, GrettagMacbeth, unpaginated.

Nash, J.T., 1977, Geology of the Midnite uranium mine area, Washington—Maps, description, and interpretation: U.S. Geological Survey Open-File Report 77-592, 39 p.

Nash, J.T., and Lehrman, N.J., 1975, Geology of the Midnite Mine area, Stevens County, Washington: U.S. Geological Survey Open-File Report 75-402, 36 p.

Newton, F.T., Collins, S.P., and Little, B.C., 2006, Nuclear power update: SEG Newsletter 67, p. 1, 8–15.

Otton, J.K., 1976, Uranium and trace element data on stream sediments in the Midnite Mine area, Stevens County, eastern Washington: U.S. Geological Survey Open-File Report 76-447, 18 p.

Owen, D.E., Otton, J.K., Hills, F.A., and Schumann, R.R., 1992, Uranium and other elements in Colorado Rocky Mountain wetlands—A reconnaissance study: U.S. Geological Survey Bulletin 1992, 33 p., 1 plate, scale 1:100,000.

Pearson, R.C., and Obradovich, J.D., 1977, Eocene rocks in northeastern Washington—Radiometric ages and correlation: U.S. Geological Survey Bulletin 1433, 41 p.

Potts, P.J., Tindle, A.G., Webb, P.C., 1992, Geochemical Reference Material Compositions; rocks, minerals, sediments, soils, carbonates, refractories, and ores used in research and industry: Boca Raton, Fla., CRC Press, 313 p.

Robbins, D.A., 1978, Applied geology in the discovery of the Spokane Mountain uranium deposit, Washington: Economic Geology, v. 73, p. 1523–1538.

Sheldon, R.F., 1959, Midnite Mine geology and development: Mining Engineering, v. 11, p. 531–534.

Simon, S.L., Bouville, André, and Beck, H.L., 2004, The geographic distribution of radionuclide deposition across the continental U.S. from atmospheric nuclear testing: Journal of Environmental Radioactivity, v. 74, p. 91–105.

Smith, S.M., 1997, National Geochemical Database reformatted data from the National Uranium Resource Evaluation (NURE) Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program: U.S. Geological Survey Open-File Report 97-492. URL http://pubs.er.usgs.gov/usgspubs/ofr/ofr97492.

Smith, S.M., Smith, D.B., and Bailey, E.A., 2003, The U.S. Geological Survey's National Geochemical Database: Geological Society of America Abstracts with Programs, v. 37, no. 7, p. 366.

Sumioka, S.S., 1991, Quality of water in an inactive uranium mine and its effects on the quality of water in Blue Creek, Stevens County, Washington, 1984: U.S. Geological Survey Water-Resources Investigations Report 89-4110, 62 p.

U.S. Environmental Protection Agency (U.S. EPA), 2001, Guidance for characterizing background chemical in soil at superfund sites, external review draft: 540-R-01-003, OSWER 9285.7-41, June 2001, 64 p. URL http://www.epa.gov/oswer/riskassessment/risk_ffrro.htm

U.S. Environmental Protection Agency (U.S. EPA), 2002, Guidance for comparing background and chemical concentrations in soil for CERCLA sites: EPA 540-R-01-003, OSWER 9285.7-41. URL http://www.epa.gov/oswer/riskassessment/risk_ffrro.htm

U.S. Environmental Protection Agency (U.S. EPA), 2007, Method 3050B Acid Digestion of Sediments, Sludges, and Soil, 1996: URL http://www.epa.gov/epaoswer/hazwaste/test/3_series.htm

Waggoner, S.Z., compiler, 1990, Geologic map of the Coulee Dam 1:100,000 quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 90-15, 40 p., 1 plate (J.E. Schuster, digital geology). URL http://home.comcast.net/~wa_geology/sources/html?

Weaver, C.E., 1920, The mineral resources of Stevens County: Washington Geological Survey Bulletin 20, 350 p.

Williams, B.C., Riley, J.A., Montgomery, J.R., and Robinson, J.A., 1996, Hydrologic and geophysical studies at Midnite Mine, Wellpinit, WA—Summary of 1995 field season: U.S. Bureau of Mines Report of Investigations 9607, 34 p.

Zielinski, R.A., and Budahn, J.R., 1998, Radionuclides in fly ash and bottom ash—Improved characterization based on radiography and low-energy gamma-ray spectrometry: Fuel, v. 77, p. 259–267.

Zielinski, R.A., Bush, C.A., and Rosholt, J.N., 1986, Uranium series disequilibrium in a young surficial uranium deposit, northeastern Washington, U.S.A.: Applied Geochemistry, v. 1, p. 503–511.

Appendix A.

Tables Showing Sample Descriptions, Locations, Weights of Sieved Core Segments by Grain Size; Tables Showing Analytical Data from Cores and Sediment Used in Study; Tables Showing Geochemical Background Statistical Data and Calculations, Including Statistical Description in Graphical Form for Each Element; and Photographs of Cores

Table A1. Sample intervals, descriptions, Munsell color, artifacts found in + 10 mesh fraction, total sample weight, and weights of different size fractions recovered after sieving of each interval, core 06MM01.

[Photographs of core 06MM01 showing cored intervals are in figure A1; depths are in centimeters (cm). Munsell colors determined using dry sample (Munsell, 1998). Samples sieved in new stacked Tyler sieves with pinched screens using standard procedures for 15 minutes. Amount of material recovered from each of the sieved intervals was weighed using calibrated top-loading laboratory balance; weights in grams (g); µm, micrometers]

Core No. sample interval	Depth top of interval sampled (cm)	Depth bottom of interval sampled (cm)	Description	Munsell color	Artifacts observed	Dry weight of total sample (g)	Dry weight of + 2 mm sized fraction (g)	Dry weight of -2 mm, +500 µm sized fraction (g)	Dry weight of -500 µm, +250 µm sized fraction (g)	Dry weight of -250 µm, +100 µm sized fraction (g)	Dry weight of -100 µm, +63 µm sized fraction (g)	Dry weight of -63 µm sized fraction (g)
06MM01.01	0	2.5	fine granitic sand and silt	10YR 4.5/2	none	47.34	5.3	12.1	7.8	7.5	5.9	4.8
06MM01.02	2.5	6	fine to medium granitic sand	2.5Y 5.5/2	none	97.36	10.1	25.6	24.1	22.5	6.7	2.7
06MM01.03	6	8	fine granitic sand and silt	2.5Y 5/2	none	78.95	13.6	21.1	15.1	14.1	5.9	4
06MM01.04	8	16	coarse granitic sand, some reconigizable schist fragments (Togo? Fm.) and large potassium feldspar phenocrysts	7.5YR 5.5/2	none	304.8	127.1	122.5	33.5	11.8	2.1	1.6
06MM01.05	16	25	coarse granitic sand, recognizable schist fragments (Togo? Fm.) and large potassium feldspar phenocrysts up to 2.5 cm	7.5YR 5.5/2	none	342.7	171.7	71.5	56.5	31.1	3.5	3.2
06MM01.06	25	31.5	coarse granitic sand with few recognizable schist fragments (Togo? Fm.); few large potassium feldspar phenocrysts up to 2.5 cm	7.5YR 6/2	none	206.3	103.4	47.4	33.1	13.6	1.7	1.2
06MM01.07	31.5	34	fine to medium granitic sand with dark iron-oxide staining	7.5YR 4/3	none	131.9	40.8	58.2	22.8	5.2	0.7	0.04
06MM01.08	34	37.5	medium granitic sand with schist fragments (Togo? Fm.) up to 1 cm diameter	10YR 5.5/2	none	107.6	39.9	41.4	16.9	3.4	0.05	0.2
06MM01.09	37.5	40.5	granitic sand layer with potassium feldspar phenocrysts up to 1 cm; minor amounts of dark shale or schist fragments	10YR 5/2	none	75.85	16.4	16.3	20	14.4	2.1	0.09
06MM01.10	40.5	42.5	fine granitic sand; abundant fissile, poorly consolidated sand/silt; some carbonaceous material (?)	10YR 5/2	none	53	2.3	5.3	7.6	12.2	5.8	7.5
06MM01.11	42.5	45	fine granitic sand; some fissile, poorly consolidated sand/silt	10YR 5/1	none	75.2	5.6	13.6	7	10.8	9.2	24.2
06MM01.12	45	54	fine to medium granitic sand; some fissile, poorly consolidated sand/silt; some silt layers	2.5Y 5/3	none	266.7	20.2	76	66	64.5	19.8	13.3
06MM01.13	54	60	silt; minor amounts of fissile, poorly consolidated sand/silt	10YR 6/3	none	172.8	9.5	29.1	23.9	56.7	28.1	18.9
06MM01.14	60	69	fine granitic sand with iron-oxide staining between 63 and 65 cm; some fissile, poorly consolidated sand/silt	7.5YR 5/3	none	291.9	22.2	82.9	84.7	79.4	11.1	1.4
06MM01.15	69	74	black silt (beaver pond sediment); some charcoal; some fissile, poorly consolidated sand/silt	10YR 5/2	none	103.3	4.1	16.5	9.1	19.7	20.8	26.7
06MM01.16	74	79	black silt (beaver pond sediment); some charcoal; some fissile, poorly consolidated sand/silt	10YR 5/2	none	116	2.6	13.7	11.1	27.7	24.9	29.3
06MM01.17	79	84	black silt (beaver pond sediment); lots of wood fragments; some fissile, poorly consolidated sand/silt	10YR 5/1	none	107.2	1.8	11.7	11.1	30	22.1	23.7
06MM01.18	84	89	black silt (beaver pond sediment); some fissile, poorly consolidated sand/silt	10YR 5/1	none	106.5	5.3	14.3	10.4	24.1	16.9	29.7
06MM01.19	89	94	black silt (beaver pond sediment); some fissile, poorly consolidated sand/silt	10YR 5/1	none	85.7	10.5	20.1	6.3	11.4	10.8	21
06MM01.20	94	99	black silt (beaver pond sediment); some fissile, poorly consolidated sand/silt	10YR 5/1	none	104.9	8	14.7	8.2	22.5	17.1	25.5
06MM01.21	99	104.5	black silt (beaver pond sediment); iron-oxide layer at base; some fissile, poorly consolidated sand/silt	10YR 5/1	none	146.8	11.3	19.4	14.3	32.3	24.5	38.4
06MM01.22	104.5	110	gray silt with iron-oxide staining on granitic sand; some fissile, poorly consolidated sand/silt	10YR 5/2	none	170.7	7	26.5	41.6	55.3	14.7	14.7
06MM01.23	110	115	gray silt with iron-oxide staining; some fissile, poorly consolidated sand/silt; large wood fragment (1x1x3 cm) discarded at 113 cm	10YR 6/2	none	163.5	16.4	41.4	31.2	38.5	13.5	15.7
06MM01.24	115	120	gray silt with iron-oxide staining on granitic rock fragments; some fissile, poorly consolidated sand/silt	10YR 6/2	none	172.1	13.7	40.7	34.6	43.4	15.1	17.8
06MM01.25	120	127	gray silt with iron-oxide staining; bottom 2 cm is coarse granitic sand; some fissile, poorly consolidated sand/silt	10YR 5/2	none	252.6	83	40.7	49.2	50	9.4	9.8

Table A2. Sample intervals, descriptions, Munsell color, artifacts found in + 10 mesh fraction, total sample weight, and weights of different size fractions recovered after sieving of each interval, core 06MM02.

[Photographs of core 06MM02 showing cored intervals are in figure A2; depths are in centimeters (cm). Munsell colors determined using dry sample (Munsell, 1998). Samples sieved in new stacked Tyler sieves with pinched screens using standard procedures for 15 minutes. Amount of material recovered from each of the sieved intervals was weighed using calibrated top-loading laboratory balance; weights in grams (g); µm, micrometer]

Core No. sample interval	Depth top of interval sampled (cm)	Depth bottom of interval sampled (cm)	Description	Munsell color	Artifacts observed	Dry weight of total sample (g)	Dry weight of + 2 mm sized fraction (g)	Dry weight of 2 mm, +500 µm sized fraction (g)	Dry weight of 500 µm, +250 µm sized fraction (g)	Dry weight of 250 µm, +100 µm sized fraction (g)	Dry weight of 100 µm, +63 µm sized fraction (g)	Dry weight of 63 µm sized fraction (g)
06MM02.01	0	10	medium granitic sand; minor schist fragments	7.5YR 5/2	none	317.4	49.2	166.1	69.5	23.1	1.7	1.1
06MM02.02	10	20	medium to coarse granitic sand	7.5YR 4.5/2.5	none	342.7	68.9	190.4	65.9	9.4	0.08	0.05
06MM02.03	20	30	medium granitic sand	7.5YR 5.5/2.5	none	344.6	75.8	183.9	65.3	9.6	1.1	0.6
06MM02.04	30	45	medium to coarse granitic sand with potassium feldspar phenocrysts up to 1.5 cm	7.5YR 5.5/2.5	none	513.8	258.6	183.6	47.2	14.9	1.5	1.5
06MM02.05	45	51.5	fine granitic sand; some carbonaceous material	10YR 4.5/1.5	none	201.6	22.1	20.3	83.1	63.8	4.7	1.4
06MM02.06	51.5	55	fine granitic sand; tan silt layers with large piece of burn wood at base; lots of wood fragments in core	2.5Y 5/2.5	none	107.2	1.7	4.3	9.6	50.8	23.6	10.7
06MM02.07	55	60	fine granitic sand; tan silt with thin carbonaceous layers	10YR 4.5/2	none	123.2	0.7	6.7	12	73.1	19.1	6.1
06MM02.08	60	65	fine granitic sand; tan silt with thin carbonaceous layers and some iron-oxide staining near base	10YR 5/2	none	137.3	0.3	7.9	15	79.5	21.2	6.9
06MM02.09	65	70	fine granitic sand; tan silt with thin carbonaceous layers	10YR 5/2	none	156.9	0.2	5.7	32.5	93.7	14.8	4.7
06MM02.10	70	75	fine granitic sand; tan silt with thin carbonaceous layers	10YR 5/2	none	133.5	0.3	2.8	17.8	85.2	16.2	5.5
06MM02.11	75	80	fine granitic sand; tan silt with thin carbonaceous layers	10YR 4.5/2	none	156.2	0.2	2.6	42.7	102	13.7	4.3
06MM02.12	80	86	fine granitic sand; tan silt with thin carbonaceous layers	10YR 4.5/2	none	164.6	1.3	7.9	26.1	105.7	13.3	4.5
06MM02.13	86	92	tan silt with thin carbonaceous layers at top	10YR 4.5/2	none	186.8	0.2	3.7	8.3	103	42.6	22.8
06MM02.14	92	93	black silt layer	2.5Y 4.5/2	none	46.17	2.9	8.4	3.7	9.2	6.9	9.5
06MM02.15	93	102	medium granitic sand; 1 cm potassium feldspar phenocrysts	10YR 5.5/2.5	none	260.6	46.8	114.2	62.9	23.1	3.1	3.4
06MM02.16	102	110	medium granitic sand; 1 cm potassium feldspar phenocrysts	10YR 5.5/2.5	none	253	57.6	124.1	50.3	12.6	1.4	1.3
06MM02.17	110	120	medium to coarse granitic sand; 1 cm potassium feldspar phenocrysts and lithic fragments	10YR 5/2	none	300.8	69.8	154.8	52.9	14.7	1.9	1.4
06MM02.18	120	130	medium to coarse granitic sand; 1 cm potassium feldspar phenocrysts	10YR 5/2	none	330	94.5	155.4	55.7	14.6	1.4	1.5
06MM02.19	130	140	medium to coarse granitic sand; 1 cm potassium feldspar phenocrysts	10YR 5/2	none	315.5	85.9	171.1	42.5	7.1	0.06	1.2
06MM02.20	140	150	medium granitic sand; up to 0.5 cm phenocrysts of potassium feldspar	10YR 5/2	none	293.9	73.4	164.2	39.5	8.7	1.1	1.3
06MM02.21	150	160	medium granitic sand; up to 0.5 cm phenocrysts of potassium feldspar; minor amoounts of schist	10YR 5/2	none	316	113.9	169	18.9	5.1	1.2	1.3
06MM02.22	160	170	medium granitic sand; up to 0.5 cm phenocrysts of potassium feldspar; minor amoounts of schist	10YR 5/2	none	324.8	105.6	174.1	32.5	5.1	1.1	1.4
06MM02.23	170	180	medium granitic sand; up to 0.5 cm phenocrysts of potassium feldspar; minor amoounts of schist	10YR 5/2.5	none	334.4	159.4	147.8	14.4	3.9	1.1	1.3
06MM02.24	180	190	medium granitic sand; up to 0.5 cm phenocrysts of potassium feldspar; minor amoounts of schist	10YR 5/2.5	none	309.2	132.1	154.5	11.1	2.8	1.2	1
06MM02.25	190	206	medium to coarse granitic sand; minor amounts of schist	10YR 5/2.5	none	483	371.8	88.9	7.6	5.1	1.7	2.1
06MM02.26	206	211	fine granitic sand/silt with iron-oxide staining	10YR 5/3	none	160.1	36.6	8.8	45	52.9	7.1	3.8

Table A3. Sample intervals, descriptions, Munsell color, artifacts found in + 10 mesh fraction, total sample weight, and weights of different size fractions recovered after sieving of each interval, core 06MM03.

[Photographs of core 06MM03 showing cored intervals are in figure A3; depths are in centimeters (cm). Munsell colors determined using dry sample (Munsell, 1998). Samples sieved in new stacked Tyler sieves with pinched screens using standard procedures for 15 minutes. Amount of material recovered from each of the sieved intervals was weighed using calibrated top-loading laboratory balance; weights in grams (g); µm, micrometer]

Core No. sample interval	Depth top of interval sampled (cm)	Depth bottom of interval sampled (cm)	Description	Munsell color	Artifacts observed	Dry weight of total sample (g)	Dry weight of + 2 mm sized fraction (g)	Dry weight of -2 mm, +500 µm sized fraction (g)	Dry weight of -500 µm, +250 µm sized fraction (g)	Dry weight of -250 µm, +100 µm sized fraction (g)	Dry weight of -100 µm, +63 µm sized fraction (g)	Dry weight of -63 µm sized fraction (g)
06MM03.01	0	3	fine sand and silt; abundant fissile, poorly consolidated sand/silt	10YR 5/2	none	64.8	2.6	17.1	14.5	14.1	6.9	3.9
06MM03.02	3	7	silt; some charcoal; abundant fissile, poorly consolidated sand/silt	2.5Y 5/2	none	135	20.9	46.5	22.5	18.6	7.9	11.9
06MM03.03	7	11	fine sand; abundant fissile, poorly consolidated sand/silt	2.5Y 4.5/1.5	none	143.2	4.2	47.6	40.2	34.8	6.6	4.7
06MM03.04	11	16.5	silt; some fissile, poorly consolidated sand/silt	2.5Y 5/2	none	157.5	19.5	46.7	20.3	20	10.9	33.1
06MM03.05	16.5	24	fine sand; some granitic and lithic fragments; some fissile, poorly consolidated sand/silt	2.5Y 5/2	none	229.7	22.3	73.6	59.8	40.6	11.1	16.6
06MM03.06	24	32	fine sand; some granitic and lithic fragments; some fissile, poorly consolidated sand/silt	2.5Y 5.5/2	none	274.7	15.6	80.8	81.5	58.8	14.8	17.5
06MM03.07	32	40	fine sand; some granitic and lithic fragments; some fissile, poorly consolidated sand/silt	2.5Y 5/2.5	none	291.8	17.8	81.8	88.1	63.4	16.1	17.4
06MM03.08	40	48	fine sand; at top of interval, large rounded fine-grained granitic clasts (2-3 cm)	10YR 5/2	none	320.4	72.8	85.2	73.9	52.2	14.9	15.9
06MM03.09	48	56	fine sand; charcoal fragments at depth of 50 and 52 cm; lithic and granitic clasts	10YR 5/3	none	282.9	29.2	98.2	67.7	49.3	14.6	14.6
06MM03.10	56	64	fine sand; granitic and many lithic clasts	10YR 6/3	none	307.9	37.1	122	68.7	45.8	13.7	13.7
06MM03.11	64	72	fine sand; granitic and many lithic clasts	10YR 5.5/3	none	295.2	34.2	122.5	72.4	39.9	9.7	9.8
06MM03.12	72	80	fine sand; granitic and some lithic clasts	10YR 5.5/3	none	300.8	26.9	104.5	92.7	53.5	8.7	7.9
06MM03.13	80	88	fine granitic sand	10YR 5.5/3	none	306.2	14.2	105.1	102.2	61.5	9.1	7.5
06MM03.14	88	96	fine granitic sand	10YR 5.5/3	none	268.4	19.1	98.2	87.9	45.1	5.3	5.6
06MM03.15	96	104	fine granitic sand	10YR 5.5/3	none	275	27.8	99.3	85.9	44.9	5.1	5
06MM03.16	104	112	fine granitic sand	10YR 5.5/3	none	295.5	22.3	96.9	93.4	61.6	8.7	6.6
06MM03.17	112	120	fine granitic sand; a few lithic clasts	10YR 5.5/3	none	283.5	13.8	70.9	94.1	78.8	11.6	8
06MM03.18	120	128	fine granitic sand; a few lithic clasts	10YR 5.5/3	none	276.4	11.1	70.8	94.6	73.7	10.9	8.9
06MM03.19	128	138	fine granitic sand	10YR 5/3	none	370.8	18.8	106	129.5	85.7	12.7	12.8
06MM03.20	138	148	fine granitic sand; some schist clasts (Togo? Fm.)	10YR 5/3	none	328.5	14.3	115.9	116.4	59.2	7.3	8.4

Table A4. Sample intervals, descriptions, Munsell color, artifacts found in + 10 mesh fraction, total sample weight, and weights of different size fractions recovered after sieving of each interval, core 06MM04.

[Photographs of core 06MM04 showing cored intervals are in figure A4; depths are in centimeters (cm). Munsell colors determined using dry sample (Munsell, 1998). Samples sieved in new stacked Tyler sieves with pinched screens using standard procedures for 15 minutes. Amount of material recovered from each of the sieved intervals was weighed using calibrated top-loading laboratory balance; weights in grams (g); µm, micrometer]

Core No. sample interval	Depth top of interval sampled (cm)	Depth bottom of interval sampled (cm)	Description	Munsell color	Artifacts observed	Dry weight of total sample (g)	Dry weight of + 2 mm sized fraction (g)	Dry weight of -2 mm, +500 µm sized fraction (g)	Dry weight of -500 µm, +250 µm sized fraction (g)	Dry weight of -250 µm, +100 µm sized fraction (g)	Dry weight of -100 µm, +63 µm sized fraction (g)	Dry weight of -63 µm sized fraction (g)
06MM04.01	0	5	dark-brown silt; fissile, poorly consolidated sand/silt	2.5Y 5/2		108.7	2.5	19.2	17.4	19.9	17.8	25.3
06MM04.02	5	10	dark-brown silt; granitic clasts; fissile, poorly consolidated sand/silt	2.5Y 5/2		95.46	2.2	19.2	12.9	15.8	14.1	23.4
06MM04.03	10	18	fine to medium sand with thin silt layers; granitic clasts; fissile, poorly consolidated sand/silt	10YR 5/2		244.3	42.4	109.4	49.6	25.5	4.8	6.2
06MM04.04	18	26	fine to medium granitic sand	7.5YR 5.5/2		278.3	40.5	97.5	90.9	39.6	1.5	1.2
06MM04.05	26	35	fine sand; coarse granitic sand layer at bottom	7.5YR 5.5/2.5		310.5	60.8	111.4	93.1	37.4	1.6	1.3
06MM04.06	35	45	fine to medium granitic sand; coarse granitic sand layer at bottom	7.5YR 5.5/3	none	358.5	76.4	133.4	87.4	50.2	2.1	1.4
06MM04.07	45	49	dark-brown silt; some granitic clasts	2.5Y 4.5/2	none	97.81	2.9	12.8	9.4	15.9	18.2	31.7
06MM04.08	49	57	medium granitic sand; thin, coarse granitic sand layer 54 cm; charcoal	10YR 6/3	none	205.4	57.6	56.4	51.3	30.4	2.2	2.2
06MM04.09	57	64	fine to medium granitic sand; coarse granitic sand layer at top and bottom; top layer contains charred wood fragments	2.5Y 5/2	none	236.6	76.2	75.6	50.4	24.6	1.7	1.3
06MM04.10	64	67.5	coarse granitic sand (grains up to 5 mm diameter) with +20% charred wood fragments; grades into dark silt layer	2.5Y 4.5/2	none	71.52	30.1	14.2	5.9	8.8	3.1	3.8
06MM04.11	67.5	73	tan fine granitic sand; some thin carbonaceous layers (1 mm)	2.5Y 5.5/2.5	none	149.1	0.08	8.2	12.4	80.5	28.6	12.7
06MM04.12	73	78	fine tan sand	2.5Y 5/2	none	141.5	0.01	4.3	25.9	86.1	14.1	4.5
06MM04.13	78	83	fine tan sand	2.5Y 5/3	none	140.3	0.03	2.5	17.2	89	19.1	6.7
06MM04.14	83	88	fine tan sand	2.5Y 5/3	none	138.7	0.01	3.6	14.2	83.1	23.4	9.0
06MM04.15	88	93	fine tan sand; thin carbonaceous layers (1 mm)	10YR 5/3	none	144.5	0.05	6.2	13.1	76.7	27.1	14.3
06MM04.16	93	98	fine tan sand with thin carbonaceous layers (1 mm)	10YR 4.5/2	none	139.6	0.02	5.2	10.9	77.3	27.1	13.3
06MM04.17	98	102.5	fine tan sand; thin carbonaceous layers (1 mm) and 5 mm dark-brown silt layer in middle of interval	10YR 4.5/2	none	125.5	1.1	6.1	8.1	51.9	31.8	21.5
06MM04.18	102.5	106.5	black organic silt (lake sediment); thin bed of organic matter (1 mm)	2.5Y 4.5/2	none	86.35	0.1	4.3	4.8	17.1	23.6	30.2
06MM04.19	106.5	110.5	black organic silt (lake sediment); fissile, poorly consolidated sand/silt	2.5Y 5/2	none	91.7	3.5	14.2	4.7	9.3	12.2	41.8
06MM04.20	110.5	115	fine tan sand; thin layers of carbonaceous layers (1 mm--same as seen in core 3); fissile, poorly consolidated sand/silt	10YR 4.5/2	none	99.31	1.5	8.8	9.6	57.2	13.4	4.9
06MM04.21	115	122	fine tan sand; some thin layers of carbonaceous layers (1 mm--same as seen in core 3); some granitic and lithic clasts	2.5Y 5/2	none	219.4	3.4	14.1	19.7	100.4	47.3	28.7
06MM04.22	122	128.5	fine sand grading to coarse sand at base (transitional layer); some granitic and lithic clasts	2.5Y 6/2	none	209.2	46.8	50.5	45.3	40.9	9.6	4.9

Table A5. Sample intervals, descriptions, Munsell color, artifacts found in + 10 mesh fraction, total sample weight, and weights of different size fractions recovered after sieving of each interval, core 06MM05.

[Photographs of core 06MM05 showing cored intervals are in figure A5; depths are in centimeters (cm). Munsell colors determined using dry sample (Munsell, 1998). Samples sieved in new stacked Tyler sieves with pinched screens using standard procedures for 15 minutes. Amount of material recovered from each of the sieved intervals was weighed using calibrated top-loading laboratory balance; weights in grams (g); µm, micrometer]

Core No. sample interval	Depth top of interval sampled (cm)	Depth bottom of interval sampled (cm)	Description	Munsell color	Artifacts observed	Dry weight of total sample (g)	Dry weight of + 2 mm sized fraction (g)	Dry weight of -2 mm, +500 µm sized fraction (g)	Dry weight of -500 µm, +250 µm sized fraction (g)	Dry weight of -250 µm, +100 µm sized fraction (g)	Dry weight of -100 µm, +63 µm sized fraction (g)	Dry weight of -63 µm sized fraction (g)
06MM05.01	0	11	medium granitic sand	7.5YR 5/2	none	337.3	71.6	37.6	189.4	29.7	3.1	1
06MM05.02	11	14.5	sandy silt; some carbonaceous material	2.5Y 5/2	none	75.17	4.1	20.2	15.2	20.5	5.8	3.7
06MM05.03	14.5	19	top 1 cm fine sand (no carbonaceous material); grades to sand and silt with carbonaceous material; carbonaceous layer at bottom of sequence (3 mm); some charcoal; two tiny clam shells in + 10 mesh fraction	2.5Y 5/2	none	81.24	4	20.6	19.3	24.1	4.8	3.3
06MM05.04	19	25.5	fine sand and silt with carbonaceous material; carbonaceous layer at bottom of sequence (5 mm); fissile, poorly consolidated sand/silt	2.5Y 5/2	none	187.6	2.3	79.2	65.1	27.6	4.7	2.9
06MM05.05	25.5	32	fine sand and silt with carbonaceous material; carbonaceous layer at bottom of sequence (1 cm); fissile, poorly consolidated sand/silt	2.5Y 5/2	none	179.5	9.1	40.3	76.4	36.7	5.8	6.1
06MM05.06	32	41	medium to coarse granitic sand; some granite and schist clasts (Togo? Fm.) up to 5 cm in length	7.5YR 5/2.5	none	332.2	76.7	189.9	38.8	14.8	3.3	3.2
06MM05.07	41	50.5	medium to coarse granitic sand; rounded to angular large charcoal fragments	7.5YR 5.5/2	none	331.8	52.5	185.5	66	17.5	2.8	2
06MM05.08	50.5	55	granitic sand and silt with carbonaceous material	2.5Y 4/2	none	70.6	9.9	22.5	12.6	12.5	4.2	3.1
06MM05.09	55	61	gray fine granitic sand; minor amounts of carbonaceous material	2.5Y 5/2	none	185.4	5.5	29.1	48.9	70.1	16.1	10.7

Table A6. Sample intervals, descriptions, Munsell color, artifacts found in + 10 mesh fraction, total sample weight, and weights of different size fractions recovered after sieving of each interval, core 06MM06.

[Photographs of core 06MM06 showing cored intervals are in figure A6; depths are in centimeters (cm). Munsell colors determined using dry sample (Munsell, 1998). Samples sieved in new stacked Tyler sieves with pinched screens using standard procedures for 15 minutes. Amount of material recovered from each of the sieved intervals was weighed using calibrated top-loading laboratory balance; weights in grams (g); µm, micrometer]

Core No. sample interval	Depth top of interval sampled (cm)	Depth bottom of interval sampled (cm)	Description	Munsell color	Artifacts observed	Dry weight of total sample (g)	Dry weight of + 2 mm sized fraction (g)	Dry weight of -2 mm, +500 µm sized fraction (g)	Dry weight of -500 µm, +250 µm sized fraction (g)	Dry weight of -250 µm, +100 µm sized fraction (g)	Dry weight of -100 µm, +63 µm sized fraction (g)	Dry weight of -63 µm sized fraction (g)
06MM06.01	0	2.5	humic-rich, angular, blocky, black silty/clay; lots of organic matter fragments (roots); some fissile, poorly consolidated sand/silt	2.5Y 4/2	none	45.14	0.8	11.6	7.3	7.8	4.3	7.2
06MM06.02	2.5	5.5	dark-brown clay/silt; some fissile, poorly consolidated sand/silt; organic matter fragments (roots)	2.5Y 4/2	none	74.6	4	22.7	11	13.9	6.9	10.5
06MM06.03	5.5	8.5	light-brown clay/silt; some fissile, poorly consolidated sand/silt	10YR 5/2	none	80.09	6.3	27.5	10.4	15.7	7.1	8.8
06MM06.04	8.5	10	sandy silt; removed root fragments but not detrital wood material	10YR 5/2	none	87.29	6.2	39.2	15.8	10.6	3.8	5.9
06MM06.05	10	12	silt with sand; removed root fragments but not detrital wood material	7.5YR 4/1.5	none	60.8	4.1	24.3	9.4	6.9	2.6	3.7
06MM06.06	12	15.5	fine sand; removed root fragments but not detrital wood material	10YR 5/2	none	116.5	3.2	54.9	23.2	16.9	5.7	7.6
06MM06.07	15.5	20	brown silt and fine sand; fissile, poorly consolidated sand/silt; removed root fragments but not detrital wood material	10YR 4/2	none	163.2	24.8	51.6	24.8	24.1	11.5	20
06MM06.08	20	25	brown silt and fine sand; fissile, poorly consolidated sand/silt; removed root fragments but not detrital wood material	10YR 5/2	none	149.2	23.9	47.8	21	19.4	11.3	19.5
06MM06.09	25	31	brown silt and fine sand with many root fragments, large root at 31 cm, carbonaceous layer at 31 cm material not removed	10YR 5/2	none	197.8	77.2	44.2	19.8	21.7	11.1	18.2
06MM06.10	31	36.5	brown silt and fine sand grades to fine sand; fissile, poorly consolidated sand/silt; removed root fragments but not detrital wood material; small sticks at 34 cm	10YR 6/2	none	154.4	39.4	49.5	24.9	20.7	7	8.2
06MM06.11	36.5	42	fine sand; both igneous and fissile, poorly consolidated sand/silt	10YR 6/3	none	216.6	31.4	98.9	44.2	27.1	5.1	3.8
06MM06.12	42	50.5	fine sand grades to medium granitic sand; fissile, poorly consolidated sand/silt	10YR 6/3	none	305.4	100.3	110.9	46	27.9	5.1	4

Table A7. Sample intervals, descriptions, Munsell color, artifacts found in + 10 mesh fraction, total sample weight, and weights of different size fractions recovered after sieving of each interval, core 06MM07.

[Photographs of core 06MM07 showing cored intervals are in figure A7; depths are in centimeters (cm). Munsell colors determined using dry sample (Munsell, 1998). Samples sieved in new stacked Tyler sieves with pinched screens using standard procedures for 15 minutes. Amount of material recovered from each of the sieved intervals was weighed using calibrated top-loading laboratory balance; weights in grams (g); µm, micrometer]

Core No. sample interval	Depth top of interval sampled (cm)	Depth bottom of interval sampled (cm)	Description	Munsell color	Artifacts observed	Dry weight of total sample (g)	Dry weight of + 2 mm sized fraction (g)	Dry weight of -2 mm, +500 µm sized fraction (g)	Dry weight of -500 µm, +250 µm sized fraction (g)	Dry weight of -250 µm, +100 µm sized fraction (g)	Dry weight of -100 µm, +63 µm sized fraction (g)	Dry weight of -63 µm sized fraction (g)
06MM07.01	0	8	coarse to medium granitic sand; has some silt and root fragments (core catcher removed); removed large roots but left some root matter	7.5YR 5.5/2.5	none	246.3	130.6	90.3	12.1	4.4	1.5	1.4
06MM07.02	8	15	medium to fine granitic sand, fairly clean layer	7.5YR 5.5/2.5	none	211	25.9	146.5	24.1	6.1	1.8	1.2
06MM07.03	15	22	medium to fine granitic sand; a lot of root matter	7.5YR 5/2	none	207.7	69.7	99.2	23.2	6.7	1.8	1.6

Table A8. Sample intervals, descriptions, Munsell color, artifacts found in + 10 mesh fraction, total sample weight, and weights of different size fractions recovered after sieving of each interval, core 06MM08.

[Photographs of core 06MM08 showing cored intervals are in figure A8; depths are in centimeters (cm). Munsell colors determined using dry sample (Munsell, 1998). Samples sieved in new stacked Tyler sieves with pinched screens using standard procedures for 15 minutes. Amount of material recovered from each of the sieved intervals was weighed using calibrated top-loading laboratory balance; weights in grams (g); µm, micrometer]

Core No. sample interval	Depth top of interval sampled (cm)	Depth bottom of interval sampled (cm)	Description	Munsell color	Artifacts observed	Dry weight of total sample (g)	Dry weight of + 2 mm sized fraction (g)	Dry weight of -2 mm, +500 µm sized fraction (g)	Dry weight of -500 µm, +250 µm sized fraction (g)	Dry weight of -250 µm, +100 µm sized fraction (g)	Dry weight of -100 µm, +63 µm sized fraction (g)	Dry weight of -63 µm sized fraction (g)
06MM08.01	0	3	dark-gray to dark-brown silty clay; fissile, poorly consolidated sand/silt; cored through solid root mass throughout (wetland sediment)	10YR 3/2	none	32.47	10.4	4.3	0.08	0.09	0.07	1.3
06MM08.02	3	6	dark-gray to dark-brown silty clay; fissile, poorly consolidated sand/silt; many root fragments (wetland sediment)	10YR 4/2	none	38.76	18.7	6.6	1.5	1.9	1.3	3.7
06MM08.03	6	9	dark-gray to dark-brown silty clay with many root fragments (wetland sediment)	10YR 3/2	none	36.22	4.8	4.4	8.8	3.3	3.3	5.7
06MM08.04	9	13	black silty clay; many wood and root fragments (wetland sediment)	10YR 3/1	none	47.17	3.9	9.4	6.2	7.8	5.2	9
06MM08.05	13	17	dark-gray silty clay; fissile, poorly consolidated sand/silt; many twig and some root fragments (wetland sediment)	10YR 2/1	none	34.38	4.2	6.8	3.7	5.4	3.1	5.3
06MM08.06	17	19.5	tan medium to fine sand; some root fragments; removed material along outer edges of core tube to reduce drag contamination; base of layer is 5 mm above manganese-oxide front	10YR 5/2	none	64.06	8.9	14.3	8.1	10.6	5.2	10
06MM08.07	19.5	24	grades from medium and fine sand to silt; manganese-oxide layer at 2.8 cm; some wood fragments; removed material along outer edges of core tube to reduce drag contamination	2.5Y 4.5/1.5	none	124.3	20.1	36.5	19.7	22.9	9.5	9.8
06MM08.08	24	29	coarse gravel with silt; granitic and schist clasts up to 4 cm diameter; some root fragments; remove material along outer edges of core tube to eliminate drag contamination	10YR 4/2	none	217.8	129.4	28.4	11.6	13.8	10.1	18.4
06MM08.09	29	35.5	medium to fine sand; contains granitic and some schist clasts (Togo? Fm.); angular contact with fine silt (minimum at 33.5, maximum at 37.5 cm); some root fragments	2.5Y 4/2	none	174.6	76.7	57.6	13.9	8.5	3.8	7.4
06MM08.10	35.5	38.5	fine sand and silt; contains granitic and some schist clasts (Togo? Fm.); more root material than previous sand	2.5Y 5/3	none	122.6	18.6	43.2	15.6	13.7	8.5	16.4
06MM08.11	38.5	43.5	black silt and clay; some fissile, poorly consolidated sand/silt; some granitic clasts	10YR 5/1	none	108.8	36.3	25.4	8.1	9.5	6.5	16.7
06MM08.12	43.5	48.5	black silt and clay; some fissile, poorly consolidated sand/silt; some granitic clasts	10YR 4/1	none	102.8	63.4	14.5	3.7	3.6	2.9	9.4
06MM08.13	48.5	56	black silt and clay; angular contact from 52 to 60 cm; some fissile, poorly consolidated sand/silt; some granitic clasts	10YR 4/2	none	167.8	95.6	30.7	8	6.1	4.6	14.8
06MM08.14	56	66.5	poorly sorted gravel grading down to a fine sand; collected sample from center of core leaving 20% of the sidewall material to prevent cross-contamination; some fissile, poorly consolidated sand/silt; some granitic clasts up to 3 cm diameter	10YR 4/2	none	230.7	105.1	77	17.1	11.2	4.2	6.4

Table A8. Sample intervals, descriptions, Munsell color, artifacts found in + 10 mesh fraction, total sample weight, and weights of different size fractions recovered after sieving of each interval, core 06MM08--Continued.

Core No. sample interval	Depth top of interval sampled (cm)	Depth bottom of interval sampled (cm)	Description	Munsell color	Artifacts observed	Dry weight of total sample (g)	Dry weight of + 2 mm sized fraction (g)	Dry weight of -2 mm, +500 µm sized fraction (g)	Dry weight of -500 µm, +250 µm sized fraction (g)	Dry weight of -250 µm, +100 µm sized fraction (g)	Dry weight of -100 µm, +63 µm sized fraction (g)	Dry weight of -63 µm sized fraction (g)
06MM08.15	66.5	75	medium to fine sand; clasts are granitic	7.5YR 4/2	none	285.9	86	138.5	27.2	14.1	5.4	8.8
06MM08.16	75	80.5	dark-brown fine sand and silt with large root fragment; some fissile, poorly consolidated sand/silt; some granitic clasts up to 0.5 cm	10YR 4/2	none	229.3	69.6	69.8	26.1	24	11.5	22.2
06MM08.17	80.5	86	dark-brown fine sand, silt, and clay; some fissile, poorly consolidated sand/silt	10YR 4/3	none	164.3	63.6	43.2	11.1	10.2	6.5	18.3
06MM08.18	86	91	dark-brown to light black silt and clay with small amounts of fine sand; some fissile, poorly consolidated sand/silt	10YR 4/2	none	164.2	73.5	33.4	11.2	13.1	7.3	14.6
06MM08.19	91	97	dark-brown to light black silt and clay with small amounts of fine sand; some fissile, poorly consolidated sand/silt	10YR 5/2	none	169.8	61.3	27.3	16.7	23.4	12.8	22
06MM08.20	97	105	dark-brown to light black fine sand with silt and clay; some fissile, poorly-consolidated sand/silt	10YR 5/2	none	194.2	64.1	34.6	23.1	28.7	13.2	19.7

Table A9. Analytical results for elements by ICP-MS with weight percent total carbon on selected sample intervals, core 06MM01.

[Samples prepared using EPA Method 3050B, see text for details; concentrations reported in parts per million (ppm). Total carbon determined on wetland silt samples, but not on granitic sand samples; --, no data]

Sample interval	Al ppm	As ppm	Ba ppm	Be ppm	Bi ppm	Ca ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cs ppm	Cu ppm	Dy ppm	Er ppm	Eu ppm	Fe ppm	Ga ppm	Gd ppm	Ho ppm	K ppm	La ppm	Li ppm	Lu ppm	Mg ppm	Mn ppm
06MM01.01	17,200	6.5	114	1.3	0.62	4,920	1.0	57.8	11.4	15.5	4.7	16.8	3.7	2.0	0.80	19,300	5.7	4.4	0.70	2,480	28.4	22.8	0.3	5,440	1,020
06MM01.02	14,600	5.4	102	1.1	0.52	4,340	0.88	57.1	12.2	38.8	4.2	15.9	3.9	2.2	0.88	18,000	5.0	4.8	0.77	2,300	27.9	20.7	0.3	5,260	527
06MM01.03	19,400	7.2	134	1.6	0.74	4,370	1.3	78.4	20.6	28.5	4.5	22.6	6.2	3.6	1.2	21,300	6.5	6.9	1.2	2,560	34.8	23.4	0.5	5,400	601
06MM01.04	14,900	6.7	124	1.4	0.66	4,100	1.4	77.8	22.0	53.3	4.0	19.8	6.1	3.6	1.1	17,800	5.4	6.9	1.2	2,240	36.7	21.5	0.5	4,530	2,320
06MM01.05	10,900	6.9	105	0.90	0.56	3,590	1.0	95.3	18.1	60.4	3.9	13.3	4.6	2.4	0.88	18,200	4.6	6.0	0.87	2,010	45.7	17.0	0.4	4,270	2,500
06MM01.06	10,800	7.3	110	0.85	0.52	3,740	0.94	83.0	16.0	32.1	3.5	12.9	5.0	2.7	0.97	17,000	4.5	6.3	0.94	1,950	40.8	16.8	0.4	3,980	2,520
06MM01.07	7,470	6.5	92.4	0.64	0.36	2,640	0.48	74.5	22.9	9.4	2.8	8.1	3.1	1.6	0.67	17,100	3.5	4.5	0.57	1,470	37.8	13.2	0.2	3,360	3,160
06MM01.08	13,100	11.3	114	1.0	0.94	4,600	0.73	104	21.7	25.0	4.6	24.4	6.1	3.4	1.1	22,300	5.4	7.4	1.2	2,390	49.0	17.4	0.5	4,740	1,560
06MM01.09	14,600	7.7	216	2.5	0.81	6,990	4.7	108	24.9	33.4	2.7	33.9	10.2	6.3	1.7	16,200	5.7	10.6	2.1	2,000	49.1	17.5	1.0	4,290	715
06MM01.10	17,500	11.3	209	1.7	0.90	3,390	1.2	82.2	22.4	14.8	4.2	24.2	6.8	4.1	1.2	21,000	6.5	7.2	1.4	2,580	38.0	24.0	0.6	4,450	1,220
06MM01.11	20,900	8.5	108	1.8	0.87	3,900	2.8	75.8	31.4	15.3	4.5	23.8	6.9	4.1	1.2	19,000	7.2	7.2	1.4	2,960	34.1	25.0	0.7	5,240	1,660
06MM01.12	18,100	9.6	162	1.2	0.76	4,070	1.4	69.2	13.8	20.4	4.5	22.4	4.3	2.3	1.0	24,600	6.6	5.4	0.81	2,920	31.0	21.5	0.3	6,450	4,760
06MM01.13	17,900	5.1	223	1.3	1.0	4,500	1.7	77.0	5.1	16.0	3.9	25.0	4.7	2.5	1.1	19,000	6.5	6.0	0.90	2,250	34.0	21.3	0.4	4,820	394
06MM01.14	14,800	14.1	238	0.99	0.84	3,830	0.63	66.2	8.0	15.6	3.9	19.6	3.7	1.9	0.87	25,700	5.2	4.9	0.70	2,190	33.3	19.4	0.3	4,940	513
06MM01.15	16,300	9.1	125	0.96	0.58	3,830	2.4	51.1	8.4	14.2	3.8	18.5	3.5	1.9	0.81	17,000	6.1	4.5	0.70	2,490	25.1	20.6	0.3	4,430	575
06MM01.16	17,000	7.1	152	0.94	0.59	3,870	2.1	51.0	5.2	15.4	3.9	19.8	3.3	1.6	0.84	18,400	6.0	4.3	0.62	2,880	24.9	21.5	0.2	5,290	208
06MM01.17	16,000	4.6	189	0.85	0.60	3,640	1.6	51.6	4.1	16.0	3.7	19.0	3.4	1.8	0.83	19,300	5.7	4.4	0.65	2,710	24.9	17.4	0.2	4,900	214
06MM01.18	18,000	8.5	225	0.96	0.80	3,760	1.6	51.6	4.9	16.7	4.1	21.9	3.6	1.8	0.86	19,900	6.2	4.5	0.69	2,970	24.8	19.3	0.3	5,090	253
06MM01.19	19,700	7.1	200	1.3	0.67	4,180	0.98	56.3	4.8	15.9	4.1	21.4	4.1	2.2	0.88	20,600	6.8	5.1	0.79	2,870	27.2	25.2	0.3	4,660	272
06MM01.20	18,600	8.5	189	1.0	0.82	4,300	0.65	54.8	5.0	19.0	4.3	23.7	3.9	2.1	0.89	25,400	6.4	4.9	0.72	3,060	25.9	20.7	0.3	5,460	338
06MM01.21	18,200	10.9	154	1.1	0.96	5,340	0.55	58.0	5.9	16.7	4.5	28.0	4.0	2.1	1.0	25,300	6.7	5.0	0.76	3,510	26.8	22.2	0.3	5,940	556
06MM01.22	17,500	16.4	137	1.1	1.1	5,560	0.33	66.4	7.5	19.8	4.3	28.7	4.0	2.0	0.99	27,900	6.4	5.1	0.76	3,290	28.9	24.2	0.3	6,080	621
06MM01.23	17,200	20.1	152	0.97	1.1	4,630	0.16	69.3	7.6	16.9	4.2	23.8	3.6	1.8	0.99	27,700	6.3	5.1	0.69	2,990	29.8	21.3	0.2	6,670	482
06MM01.24	18,400	25.4	121	0.97	1.0	4,600	0.10	70.8	6.8	22.3	4.1	20.6	3.5	1.7	0.98	35,700	6.5	5.0	0.65	2,890	30.6	21.4	0.2	7,000	472
06MM01.25	23,900	9.4	163	1.2	1.6	5,560	0.11	73.5	5.6	25.5	5.1	24.9	4.2	2.0	1.0	28,100	8.2	5.4	0.76	3,560	32.0	28.0	0.3	7,360	214

Table A9. Analytical results for elements by ICP-MS with weight percent total carbon on selected sample intervals, core 06MM01--Continued.

Sample interval	Mo ppm	Na ppm	Nb ppm	Nd ppm	Ni ppm	P ppm	Pb ppm	Pr ppm	Rb ppm	Sc ppm	Sm ppm	Sr ppm	Tb ppm	Th ppm	Ti ppm	Tl ppm	Tm ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm	Total Carbon wt. percent
06MM01.01	0.73	174	1.9	24.7	31	752	18.5	6.5	28.8	3.8	5.0	27.1	0.62	17.6	851	0.22	0.30	26.0	26.1	21.0	1.9	217	--
06MM01.02	0.62	159	1.2	28.1	44	750	16.9	7.4	25.5	3.2	5.7	22.5	0.68	16.0	788	0.20	0.32	11.7	24.6	20.0	2.0	229	--
06MM01.03	0.53	166	1.9	34.5	65	674	18.1	8.9	31.2	4.1	7.2	22.4	1.0	18.0	911	0.24	0.53	24.1	26.6	35.2	3.5	291	1.95
06MM01.04	1.2	146	0.97	36.2	79	708	15.1	9.5	27.4	3.5	7.7	20.4	1.0	27.5	701	0.21	0.53	33.1	24.8	33.8	3.4	214	--
06MM01.05	2.1	128	0.77	37.7	70	768	14.4	10.3	23.2	2.7	7.3	17.0	0.86	53.7	618	0.17	0.37	29.7	25.4	25.9	2.4	92.0	--
06MM01.06	1.6	135	0.49	40.2	47	790	12.3	10.8	22.2	2.6	8.0	18.6	0.90	45.3	598	0.16	0.39	24.9	24.9	24.5	2.6	90.3	--
06MM01.07	1.3	86	0.57	33.5	33	521	8.9	9.3	16.7	1.9	6.0	15.0	0.58	39.0	485	0.12	0.22	12.1	24.7	14.2	1.5	72.0	--
06MM01.08	1.6	149	2.0	42.3	49	966	20.0	11.3	28.4	3.7	8.7	23.5	1.0	28.9	750	0.20	0.49	120	30.7	34.7	3.3	99.6	--
06MM01.09	2.8	139	3.7	46.4	123	705	22.1	11.9	22.3	3.6	10.0	33.7	1.6	25.0	665	0.20	0.95	656	38.2	72.8	6.2	209	6.79
06MM01.10	1.8	159	1.3	34.9	50	632	18.2	9.1	35.2	4.4	7.4	23.7	1.1	23.0	760	0.26	0.61	71.5	27.5	42.4	4.1	176	1.03
06MM01.11	1.9	174	1.5	33.5	97	529	16.4	8.7	40.2	4.8	7.4	22.9	1.1	20.2	865	0.33	0.65	142	26.6	41.7	4.3	286	1.58
06MM01.12	0.80	195	0.81	30.7	28	825	31.9	8.0	31.1	4.3	6.2	26.7	0.76	15.3	1,030	0.32	0.33	38.3	31.7	21.8	2.1	293	1.04
06MM01.13	0.56	156	2.2	33.5	16	611	53.0	8.8	26.5	3.9	6.8	28.9	0.85	18.0	940	0.21	0.35	18.8	30.0	23.5	2.4	347	2.36
06MM01.14	0.80	151	1.4	29.6	13	915	31.8	7.8	25.0	3.5	5.7	29.0	0.68	18.8	803	0.18	0.27	11.4	30.6	18.6	1.8	235	--
06MM01.15	0.67	152	2.1	24.8	19	523	64.0	6.5	27.9	3.6	5.1	24.2	0.63	13.3	871	0.22	0.27	12.4	24.5	17.7	1.8	903	3.04
06MM01.16	0.33	173	2.0	25.1	12	634	90.7	6.5	27.2	3.7	5.0	23.3	0.58	12.0	976	0.22	0.24	8.54	27.5	15.2	1.5	697	2.92
06MM01.17	0.33	158	1.9	25.5	13	767	83.9	6.6	26.9	3.5	5.1	24.3	0.60	11.5	909	0.20	0.25	9.04	26.1	16.2	1.6	597	2.93
06MM01.18	0.37	163	2.3	25.5	13	644	62.6	6.6	30.1	4.0	5.2	26.1	0.63	11.2	960	0.21	0.28	13.2	28.4	17.5	1.8	559	3.54
06MM01.19	0.53	165	2.6	27.2	12	715	32.6	7.0	30.0	4.2	5.6	26.9	0.70	12.1	923	0.20	0.33	22.3	29.5	20.5	2.2	315	4.17
06MM01.20	0.50	168	2.2	26.3	16	870	25.3	6.7	30.7	4.2	5.4	28.4	0.69	13.1	925	0.21	0.30	14.2	30.2	19.7	2.0	207	3.66
06MM01.21	0.74	168	2.1	27.5	15	718	26.9	7.2	31.7	4.2	5.6	30.6	0.72	13.8	960	0.22	0.30	5.72	30.4	19.3	2.0	237	3.58
06MM01.22	0.99	165	2.1	28.6	18	796	27.4	7.5	29.6	4.1	5.8	30.2	0.71	14.5	956	0.21	0.29	4.27	33.8	18.7	1.8	93.5	3.15
06MM01.23	0.80	150	1.6	30.0	14	719	21.4	7.8	29.3	3.7	6.1	27.9	0.67	15.9	860	0.20	0.26	4.48	34.2	17.0	1.6	73.9	1.74
06MM01.24	0.91	134	1.3	30.7	17	785	21.3	8.0	27.7	3.7	6.1	27.2	0.66	14.9	852	0.19	0.25	5.38	37.0	15.9	1.6	66.6	1.46
06MM01.25	1.0	165	1.6	32.0	16	632	25.2	8.3	36.0	4.9	6.4	30.8	0.74	18.5	1,130	0.24	0.30	33.7	40.9	19.1	1.9	85.4	1.82

Table A10. Analytical results for elements by ICP-MS with weight percent total carbon on selected sample intervals, core 06MM02.

[Samples prepared using EPA Method 3050B, see text for details; concentrations reported in parts per million (ppm). Total carbon determined on wetland silt samples, but not on granitic sand samples; --, no data]

Sample interval	Al ppm	As ppm	Ba ppm	Be ppm	Bi ppm	Ca ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cs ppm	Cu ppm	Dy ppm	Er ppm	Eu ppm	Fe ppm	Ga ppm	Gd ppm	Ho ppm	K ppm	La ppm	Li ppm	Lu ppm	Mg ppm	Mn ppm
06MM02.01	15,500	8.4	155	1.1	1.7	4,890	1.2	79.4	22.2	123	5.3	22.7	5.1	2.8	0.99	22,600	5.8	6.1	0.97	2,880	38.9	22.4	0.4	6,630	3,060
06MM02.02	8,730	6.2	91.5	0.66	0.42	3,270	0.56	82.0	15.1	15.2	3.8	9.2	3.4	1.8	0.70	18,000	4.2	4.8	0.63	1,890	41.0	16.2	0.2	4,170	1,900
06MM02.03	12,700	9.8	167	1.0	0.50	4,910	1.2	74.6	30.9	36.1	4.6	15.7	5.2	2.8	1.0	20,300	5.1	6.3	0.98	2,500	34.7	21.1	0.4	5,920	4,220
06MM02.04	12,100	10.5	199	1.1	0.63	4,590	1.7	81.7	36.9	27.4	3.8	16.0	5.1	2.8	0.90	18,600	4.9	6.0	0.96	2,280	38.7	19.4	0.4	4,700	6,320
06MM02.05	14,800	12.1	182	1.2	0.68	4,640	1.6	95.0	41.2	15.1	3.6	22.8	6.2	3.4	1.2	21,200	6.1	7.5	1.2	2,490	40.6	19.2	0.5	5,720	5,060
06MM02.06	12,600	5.7	83.8	1.1	0.86	3,230	1.2	82.4	13.9	12.4	3.0	14.3	5.3	3.0	0.93	14,600	4.9	6.2	1.0	1,730	38.9	15.4	0.5	3,060	754
06MM02.07	13,900	5.1	250	1.6	0.87	3,600	2.1	90.2	24.8	11.5	2.8	22.6	7.1	4.1	1.2	15,200	5.4	7.7	1.4	1,930	41.1	18.0	0.6	3,510	1,490
06MM02.08	13,300	11.0	202	1.4	1.1	3,330	1.8	89.8	28.2	11.4	3.0	20.6	6.5	3.8	1.2	17,800	5.2	7.3	1.3	1,890	43.5	18.9	0.6	3,460	2,020
06MM02.09	13,000	13.3	159	1.2	0.67	3,480	1.4	84.1	32.8	11.7	3.0	19.0	5.9	3.4	1.1	18,500	5.2	6.7	1.2	1,970	37.2	16.2	0.5	3,900	4,640
06MM02.10	13,800	11.1	153	1.2	0.84	3,600	1.2	83.6	28.1	13.5	3.3	18.9	5.6	3.2	1.1	18,300	5.6	6.7	1.1	2,140	37.6	18.4	0.5	4,250	6,840
06MM02.11	14,000	10.2	140	1.1	0.72	3,560	1.1	89.9	25.7	15.4	3.5	17.3	5.3	3.0	1.0	19,300	5.8	6.4	1.0	2,180	40.8	17.7	0.4	4,490	8,150
06MM02.12	14,500	10.4	135	1.4	0.85	4,180	1.2	90.8	28.3	20.0	3.8	22.5	5.6	3.1	1.1	20,400	6.0	6.8	1.1	2,380	43.0	20.7	0.5	4,820	8,040
06MM02.13	13,500	7.9	99.5	1.2	1.0	3,980	0.94	74.2	22.5	11.3	3.5	15.3	5.1	2.8	0.91	16,200	5.2	6.0	0.99	2,100	34.0	18.8	0.4	3,920	2,940
06MM02.14	19,900	6.3	115	2.1	0.93	4,730	2.1	79.5	32.8	14.4	4.1	26.0	7.2	4.5	1.3	18,300	6.8	7.6	1.5	2,710	36.3	24.6	0.7	4,770	2,920
06MM02.15	15,900	9.5	174	1.3	2.8	4,420	1.2	68.7	28.0	19.1	4.6	20.8	4.8	2.7	0.99	20,400	5.7	5.7	0.94	2,890	31.3	23.0	0.4	5,980	4,880
06MM02.16	15,100	10.2	140	1.1	0.57	4,680	0.99	78.2	22.7	16.5	4.9	15.6	4.2	2.2	0.90	22,300	5.7	5.4	0.78	2,910	35.7	23.0	0.3	6,800	3,060
06MM02.17	14,100	10.4	143	1.0	0.58	4,410	1.1	69.1	23.6	15.7	4.5	14.7	4.1	2.2	0.83	21,300	5.4	5.2	0.76	2,700	32.5	20.8	0.3	6,680	3,050
06MM02.18	13,300	11.0	154	1.0	0.54	4,700	1.2	79.9	26.6	18.7	4.7	16.3	4.7	2.5	0.94	20,600	5.3	5.9	0.90	2,650	37.7	21.7	0.4	6,180	3,660
06MM02.19	12,600	9.6	143	0.90	0.56	4,330	1.0	76.3	24.6	13.4	4.4	13.4	4.4	2.4	0.81	19,500	5.0	5.4	0.82	2,520	34.9	20.0	0.3	5,360	3,380
06MM02.20	13,500	10.8	159	0.97	0.49	4,650	1.2	79.0	27.9	14.3	4.5	14.8	4.6	2.5	0.90	20,200	5.3	5.7	0.89	2,590	36.2	21.8	0.4	5,990	3,850
06MM02.21	11,800	9.9	179	0.94	0.53	4,290	1.5	78.8	32.9	20.0	4.2	23.1	5.1	2.8	0.88	18,300	4.9	6.0	0.97	2,300	37.6	19.1	0.4	4,670	5,280
06MM02.22	13,600	9.6	148	0.96	0.54	4,340	1.2	73.5	24.9	20.7	4.2	13.7	4.4	2.4	0.83	20,200	5.2	5.4	0.81	2,520	34.7	20.1	0.3	5,510	4,260
06MM02.23	11,500	8.5	217	1.1	0.56	4,250	2.2	81.8	37.2	12.1	3.9	15.2	5.6	3.2	0.94	16,900	4.8	6.5	1.1	2,250	40.7	18.7	0.5	4,310	7,200
06MM02.24	11,900	9.8	280	1.2	0.47	4,190	4.3	82.4	36.5	12.7	4.0	17.4	5.8	3.3	0.96	17,500	5.0	6.7	1.2	2,290	41.8	19.0	0.5	4,290	6,730
06MM02.25	12,400	20.7	138	1.5	0.71	4,300	0.93	82.2	34.8	12.6	3.5	17.0	5.8	3.3	0.90	20,700	5.0	6.2	1.1	2,180	38.0	18.7	0.5	3,670	3,360
06MM02.26	14,500	22.0	167	1.4	0.85	4,930	0.72	74.2	19.9	31.2	3.6	20.2	5.2	2.9	0.96	23,100	5.3	5.9	1.0	2,360	34.1	21.4	0.5	4,930	448

Table A10. Analytical results for elements by ICP-MS with weight percent total carbon on selected sample intervals, core 06MM02--Continued.

Sample interval	Mo ppm	Na ppm	Nb ppm	Nd ppm	Ni ppm	P ppm	Pb ppm	Pr ppm	Rb ppm	Sc ppm	Sm ppm	Sr ppm	Tb ppm	Th ppm	Ti ppm	Tl ppm	Tm ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm	Total Carbon wt. percent
06MM02.01	2.7	185	0.58	34.0	120	914	17.2	8.9	32.5	3.8	6.9	26.1	0.87	33.0	946	0.25	0.40	26.7	30.3	29.7	2.7	201	--
06MM02.02	0.94	104	0.67	34.3	36	564	12.3	9.4	22.5	2.6	6.4	16.4	0.65	52.7	625	0.16	0.25	11.2	28.3	17.4	1.6	98.4	--
06MM02.03	1.8	137	0.36	35.5	67	897	16.9	9.3	27.2	3.1	7.4	22.7	0.91	31.0	726	0.22	0.41	16.9	25.9	25.7	2.6	186	--
06MM02.04	2.1	150	0.58	33.0	86	798	16.1	8.8	25.4	3.0	6.9	25.0	0.86	32.1	585	0.21	0.42	40.1	24.1	29.6	2.7	172	--
06MM02.05	1.3	152	0.83	39.7	57	792	26.4	10.3	26.5	3.5	8.3	25.8	1.1	30.8	854	0.23	0.50	64.8	29.2	33.7	3.2	204	1.44
06MM02.06	0.90	148	1.3	35.7	35	665	13.9	9.4	23.3	2.9	7.2	19.5	0.89	35.1	642	0.17	0.46	91.3	24.0	31.3	3.0	112	0.83
06MM02.07	1.3	151	2.0	40.0	54	700	19.0	10.6	23.0	3.3	8.5	22.5	1.2	33.9	689	0.19	0.62	227	28.0	40.9	4.0	130	1.51
06MM02.08	1.6	141	1.3	38.2	55	717	18.6	10.0	23.5	3.3	7.8	22.6	1.0	37.5	667	0.18	0.56	93.3	27.9	39.2	3.8	130	1.29
06MM02.09	1.6	139	0.97	37.0	50	743	18.2	9.6	22.7	3.0	7.6	23.2	1.0	29.6	698	0.18	0.50	41.7	25.7	33.3	3.3	135	1.00
06MM02.10	1.7	145	0.94	36.6	47	719	18.4	9.6	24.5	3.2	7.5	26.5	0.96	28.1	719	0.19	0.49	33.4	26.0	31.1	3.2	132	0.86
06MM02.11	1.3	148	0.69	37.8	46	732	17.6	9.8	26.1	3.3	7.5	30.5	0.91	32.0	764	0.20	0.44	45.1	28.1	30.0	2.9	129	0.69
06MM02.12	1.4	149	0.70	38.2	63	742	21.3	10.2	28.2	3.6	7.8	31.3	0.97	34.5	803	0.22	0.46	49.5	29.3	32.5	3.1	157	0.88
06MM02.13	1.1	145	0.99	32.7	47	642	14.3	8.7	24.7	3.2	6.8	23.2	0.88	27.1	710	0.18	0.43	31.4	23.1	27.7	2.8	123	0.58
06MM02.14	1.2	165	0.91	35.6	82	623	15.8	9.2	33.9	4.4	7.6	28.2	1.2	20.0	830	0.26	0.67	173	25.1	44.3	4.4	211	1.56
06MM02.15	1.1	163	0.61	31.7	50	684	20.1	8.3	31.7	3.8	6.5	27.8	0.81	19.5	865	0.26	0.40	57.5	26.9	24.7	2.5	266	--
06MM02.16	1.3	178	0.50	31.0	44	835	18.7	8.4	31.3	3.5	6.4	28.4	0.73	22.8	828	0.26	0.32	34.8	27.4	23.2	2.2	233	--
06MM02.17	1.2	151	0.45	29.2	44	821	18.8	7.7	29.2	3.4	6.0	25.5	0.72	23.0	856	0.25	0.33	29.2	27.3	23.0	2.1	255	--
06MM02.18	1.5	134	0.63	33.7	53	805	18.8	8.8	30.1	3.4	6.8	25.2	0.81	25.8	766	0.26	0.38	32.4	26.7	25.3	2.5	232	--
06MM02.19	1.4	138	0.44	30.9	46	822	17.1	8.1	27.6	3.0	6.3	23.2	0.76	30.2	676	0.23	0.34	23.2	24.8	24.4	2.2	197	--
06MM02.20	1.7	150	0.81	32.2	53	850	20.6	8.5	28.3	3.3	6.6	26.3	0.81	28.6	783	0.25	0.36	33.7	25.8	26.7	2.5	248	--
06MM02.21	2.1	148	0.59	33.6	68	808	30.0	8.9	26.5	3.2	6.9	24.6	0.86	29.4	615	0.23	0.42	33.6	24.9	29.0	2.8	223	--
06MM02.22	1.5	157	0.38	30.6	54	823	20.4	8.2	26.7	3.3	6.2	26.2	0.76	25.1	772	0.25	0.35	37.8	26.0	25.0	2.3	261	--
06MM02.23	2.1	149	1.0	36.2	103	762	17.1	9.6	25.6	3.0	7.4	24.9	0.94	33.7	534	0.24	0.47	66.7	23.0	32.7	3.2	292	--
06MM02.24	2.6	163	0.89	36.2	97	799	15.8	9.6	26.2	3.3	7.5	26.6	0.97	33.9	652	0.26	0.49	47.3	25.3	33.5	3.4	274	--
06MM02.25	3.3	158	1.5	32.6	43	945	18.9	8.6	26.4	3.4	6.7	22.5	0.95	31.7	530	0.22	0.50	67.8	28.3	35.2	3.4	190	--
06MM02.26	1.7	156	2.1	29.8	55	868	22.0	7.8	28.0	3.7	6.1	27.6	0.86	20.9	731	0.22	0.46	92.6	28.6	32.4	2.9	171	--

Table A11. Analytical results for elements by ICP-MS, core 06MM03.

[Samples prepared using EPA Method 3050B, see text for details; concentrations reported in parts per million (ppm)]

Sample interval	Al ppm	As ppm	Ba ppm	Be ppm	Bi ppm	Ca ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cs ppm	Cu ppm	Dy ppm	Er ppm	Eu ppm	Fe ppm	Ga ppm	Gd ppm	Ho ppm	K ppm	La ppm	Li ppm	Lu ppm	Mg ppm
06MM03.01	18,400	8.0	129	0.86	0.91	5,780	1.8	56.7	10.8	20.8	4.4	22.0	2.9	1.5	0.86	24,500	6.0	4.0	0.54	2,820	27.0	21.1	0.2	7,720
06MM03.02	25,400	10.8	155	1.2	0.85	5,230	3.9	61.2	13.4	36.8	4.8	29.7	3.6	1.9	1.0	29,900	7.8	4.8	0.69	3,620	29.6	25.5	0.3	8,430
06MM03.03	19,800	8.3	116	0.89	0.71	4,620	2.6	59.9	8.8	21.5	4.3	26.1	3.1	1.6	0.88	23,600	6.3	4.3	0.56	3,150	29.5	21.3	0.2	7,340
06MM03.04	21,300	12.1	134	1.2	0.98	4,700	3.4	60.1	9.5	20.9	4.9	27.1	4.0	2.1	1.0	25,500	7.1	5.1	0.76	3,390	29.3	25.9	0.3	6,880
06MM03.05	20,500	7.7	127	0.89	0.84	4,880	1.8	53.7	8.0	22.0	4.7	36.1	3.0	1.5	0.87	23,200	6.7	4.0	0.56	3,940	26.1	24.0	0.2	8,320
06MM03.06	17,800	9.9	116	0.89	0.73	4,340	0.25	48.6	6.5	18.8	4.7	28.5	3.1	1.5	0.89	21,900	5.8	4.2	0.56	3,870	23.5	24.1	0.2	8,440
06MM03.07	17,900	14.4	117	0.86	0.95	4,490	0.19	48.3	6.2	25.2	4.9	27.5	3.2	1.6	0.90	23,400	5.9	4.3	0.57	3,870	23.8	23.8	0.2	8,800
06MM03.08	20,800	14.9	133	0.93	0.74	4,380	0.17	56.9	6.8	30.3	5.5	27.5	3.1	1.5	0.90	26,800	6.8	4.2	0.58	4,180	28.0	27.4	0.2	9,080
06MM03.09	18,400	13.7	125	0.81	0.68	4,210	0.15	52.8	6.0	25.2	5.3	24.7	2.8	1.4	0.82	24,200	6.2	4.0	0.52	3,830	26.5	25.5	0.2	8,210
06MM03.10	18,600	15.1	130	0.89	0.65	3,790	0.12	51.1	5.9	21.7	5.3	24.7	3.1	1.5	0.88	25,000	6.2	4.3	0.58	3,840	25.6	26.4	0.2	8,210
06MM03.11	19,100	15.9	129	0.84	0.68	3,940	0.08	56.2	6.5	28.0	5.4	23.3	2.9	1.4	0.82	25,800	6.2	4.0	0.52	3,600	27.0	25.3	0.2	8,170
06MM03.12	18,900	16.7	128	0.93	1.0	4,410	0.09	68.0	7.3	31.9	5.6	22.0	3.3	1.7	0.91	26,600	6.3	4.8	0.61	3,560	32.0	25.5	0.2	8,740
06MM03.13	18,300	15.0	121	0.88	0.65	4,600	0.08	64.5	7.8	19.4	5.6	19.4	3.0	1.5	0.86	26,200	6.1	4.3	0.55	3,460	29.7	24.0	0.2	9,230
06MM03.14	18,400	15.5	126	0.87	0.75	4,670	0.10	61.5	8.3	32.3	5.7	19.4	3.4	1.7	0.92	25,800	6.1	4.8	0.60	3,470	27.8	25.4	0.2	9,360
06MM03.15	18,800	16.6	133	0.93	0.67	4,920	0.12	63.4	9.1	20.4	5.9	19.7	3.5	1.7	0.99	26,800	6.1	5.0	0.65	3,440	28.8	26.9	0.2	9,740
06MM03.16	19,700	18.8	135	0.99	0.75	5,150	0.12	76.3	10.5	20.8	6.2	21.2	3.3	1.6	0.96	28,500	6.6	4.7	0.61	3,420	33.1	27.4	0.2	10,400
06MM03.17	16,600	17.2	118	0.92	0.72	4,740	0.12	67.6	9.3	19.0	5.4	19.3	3.3	1.6	0.95	24,900	5.8	4.9	0.60	2,910	29.7	24.7	0.2	9,150
06MM03.18	18,000	18.2	124	0.84	0.84	4,980	0.14	70.3	10.0	21.4	5.8	20.2	3.3	1.5	0.93	27,000	6.2	4.5	0.56	3,150	32.2	25.8	0.2	10,100
06MM03.19	17,900	17.2	125	0.88	0.67	4,700	0.11	68.6	10.2	29.5	5.9	18.8	3.0	1.5	0.88	26,700	6.2	4.4	0.54	3,130	30.9	25.6	0.2	10,400
06MM03.20	16,800	16.8	131	0.92	0.62	4,670	0.17	67.4	9.3	29.2	5.8	18.2	3.4	1.6	0.96	25,200	5.9	4.9	0.61	3,110	29.9	26.2	0.2	10,100

Table A11. Analytical results for elements by ICP-MS, core 06MM03--Continued.

Sample interval	Mn ppm	Mo ppm	Na ppm	Nb ppm	Nd ppm	Ni ppm	P ppm	Pb ppm	Pr ppm	Rb ppm	Sc ppm	Sm ppm	Sr ppm	Tb ppm	Th ppm	Ti ppm	Tl ppm	Tm ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm
06MM03.01	528	0.45	269	0.84	24.4	20	947	41.3	6.4	28.5	4.5	4.7	27.3	0.53	10.5	1,030	0.25	0.20	4.52	31.6	14.6	1.2	546
06MM03.02	358	0.53	249	0.62	27.1	33	837	62.4	7.0	36.4	5.9	5.4	28.2	0.65	11.8	1,220	0.35	0.28	7.40	38.1	19.4	1.8	905
06MM03.03	240	0.39	208	0.68	26.3	18	763	51.6	6.9	30.5	4.5	5.1	25.0	0.57	14.2	1,100	0.27	0.22	5.03	32.4	15.8	1.4	750
06MM03.04	256	0.46	195	0.95	29.8	17	644	63.2	7.8	36.3	4.9	6.1	23.4	0.71	12.9	1,150	0.28	0.30	6.52	34.4	18.4	1.9	605
06MM03.05	217	0.36	274	1.4	23.5	18	633	70.4	6.1	34.8	4.9	4.8	26.7	0.54	9.79	1,340	0.27	0.20	4.37	32.1	14.8	1.3	388
06MM03.06	219	0.30	255	0.72	24.7	16	615	15.8	6.4	32.7	4.1	5.1	24.2	0.57	9.15	1,160	0.24	0.20	2.29	29.1	13.4	1.3	83.1
06MM03.07	236	0.39	206	0.62	24.7	20	627	15.9	6.4	34.0	4.1	4.9	24.6	0.59	9.02	1,120	0.25	0.21	2.21	30.4	13.8	1.3	78.8
06MM03.08	264	0.53	200	0.88	25.2	23	655	17.5	6.6	38.7	4.9	5.0	26.4	0.56	12.0	1,400	0.29	0.21	2.59	35.6	15.3	1.3	82.5
06MM03.09	240	0.48	159	0.82	24.4	18	579	17.2	6.3	36.9	4.7	4.8	26.5	0.52	10.2	1,260	0.27	0.18	3.00	33.5	13.5	1.2	75.8
06MM03.10	280	0.36	146	0.40	26.4	16	610	15.3	6.8	35.1	4.4	5.3	24.7	0.57	10.6	1,230	0.25	0.21	1.89	33.8	13.5	1.3	73.8
06MM03.11	336	0.50	141	0.35	24.0	20	695	15.1	6.3	32.9	4.7	4.8	24.5	0.52	12.8	1,180	0.24	0.19	2.02	33.6	14.2	1.2	68.2
06MM03.12	418	0.58	149	0.28	28.9	23	893	16.1	7.6	32.9	4.9	5.6	25.9	0.61	14.3	1,120	0.24	0.23	3.61	34.8	16.0	1.4	69.2
06MM03.13	493	0.36	159	0.23	26.6	14	944	16.1	7.0	31.8	4.4	5.2	25.0	0.56	14.1	1,110	0.23	0.21	1.99	32.8	15.0	1.3	64.3
06MM03.14	577	0.48	171	0.25	28.6	23	916	17.0	7.6	31.4	4.4	5.8	25.4	0.63	13.3	1,100	0.23	0.23	1.91	31.4	14.6	1.4	65.0
06MM03.15	668	0.39	187	0.24	30.2	15	946	18.2	7.8	31.9	4.5	5.9	26.7	0.66	12.9	1,150	0.24	0.24	1.80	32.9	15.2	1.5	67.6
06MM03.16	789	0.40	200	0.24	29.4	16	1,010	21.2	7.7	33.2	4.7	5.7	28.9	0.64	15.6	1,170	0.25	0.23	3.18	35.0	16.3	1.4	70.9
06MM03.17	694	0.37	163	0.22	30.6	15	909	18.0	8.0	29.2	3.9	6.0	24.9	0.63	13.3	992	0.22	0.22	1.94	31.0	14.2	1.4	63.9
06MM03.18	701	0.46	180	0.28	28.4	16	914	18.4	7.6	32.2	4.3	5.6	26.8	0.60	14.8	1,120	0.24	0.22	2.38	33.4	15.5	1.4	67.8
06MM03.19	730	0.48	183	0.20	27.6	22	850	17.6	7.3	32.3	4.2	5.3	25.4	0.58	14.2	1,110	0.25	0.21	1.70	32.6	14.6	1.3	66.0
06MM03.20	796	0.52	201	0.24	31.0	22	851	17.4	8.0	31.1	3.9	6.1	25.2	0.63	12.6	1,050	0.24	0.23	2.98	30.6	14.2	1.4	66.5

Table A12. Analytical results for elements by ICP-MS with weight percent total carbon on selected sample intervals, core 06MM04.

[Samples prepared using EPA Method 3050B, see text for details; concentrations reported in parts per million (ppm). Total carbon determined on wetland silt samples, but not on granitic sand samples; --, no data]

Sample interval	Al ppm	As ppm	Ba ppm	Be ppm	Bi ppm	Ca ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cs ppm	Cu ppm	Dy ppm	Er ppm	Eu ppm	Fe ppm	Ga ppm	Gd ppm	Ho ppm	K ppm	La ppm	Li ppm	Lu ppm	Mg ppm	Mn ppm
06MM04.01	21,300	11.9	178	1.4	0.76	5,030	1.8	65.1	14.9	21.5	5.4	25.0	4.0	2.1	0.98	27,200	7.2	4.9	0.77	3,230	30.2	27.4	0.3	7,310	1,360
06MM04.02	22,500	8.4	178	1.5	0.84	5,010	2.0	68.8	17.9	21.2	4.9	25.2	4.9	2.8	1.1	25,300	7.4	5.8	0.97	3,060	30.7	26.0	0.4	6,940	940
06MM04.03	22,200	6.7	145	1.6	0.97	6,340	2.0	79.0	21.0	31.2	5.8	39.3	4.9	2.8	1.2	25,100	7.4	5.8	0.98	3,370	38.7	26.7	0.4	8,100	793
06MM04.04	15,000	10.9	111	0.98	1.3	19,100	0.70	78.0	15.6	28.7	5.4	21.7	4.1	2.1	0.98	22,800	5.7	5.4	0.80	2,670	39.0	23.2	0.3	8,610	1,120
06MM04.05	15,400	12.8	156	1.0	0.71	18,600	0.92	81.0	22.0	52.6	5.6	22.6	4.4	2.4	1.0	24,200	6.0	5.8	0.83	2,860	39.6	23.2	0.3	8,190	2,410
06MM04.06	16,400	17.1	214	1.3	1.1	19,300	2.1	87.9	31.7	29.0	5.2	34.4	5.2	2.8	1.1	24,000	6.3	6.2	1.0	2,760	43.6	23.5	0.4	8,420	5,820
06MM04.07	18,500	7.0	94.6	1.7	0.78	4,660	1.8	79.4	27.8	14.9	4.7	21.0	6.4	3.8	1.1	19,100	6.7	6.8	1.3	2,810	36.2	27.0	0.6	5,200	686
06MM04.08	20,600	8.8	92.6	1.9	1.1	8,890	1.4	83.7	23.3	24.2	4.8	30.7	6.4	3.8	1.3	23,100	7.2	7.1	1.3	3,100	42.1	29.1	0.6	7,200	651
06MM04.09	18,100	12.4	95.2	1.8	1.1	10,300	1.5	83.9	25.4	100	4.2	182	6.1	3.6	1.2	24,100	6.5	7.0	1.2	2,770	42.5	24.8	0.6	7,560	888
06MM04.10	19,800	5.9	91.0	1.8	1.1	9,040	1.3	75.9	34.7	47.9	4.2	27.1	6.2	3.6	1.2	18,400	6.7	6.8	1.2	2,890	39.4	26.5	0.6	6,160	811
06MM04.11	15,000	5.8	60.8	1.3	1.2	4,300	1.2	76.8	18.4	15.4	4.0	20.0	5.2	3.0	1.0	17,200	5.4	6.1	1.0	2,260	38.7	20.6	0.5	4,680	1,250
06MM04.12	15,400	14.7	144	1.3	0.88	4,520	1.2	87.4	27.7	48.3	4.5	69.5	5.1	2.8	1.0	20,400	5.7	6.2	1.0	2,400	43.6	20.4	0.4	5,270	4,110
06MM04.13	15,300	15.3	156	1.3	1.1	4,430	1.0	82.4	31.8	15.7	4.1	20.3	5.3	3.0	1.0	20,400	5.7	6.4	1.1	2,360	41.1	21.0	0.5	5,170	3,350
06MM04.14	14,000	16.1	169	1.2	1.1	4,080	1.1	79.1	27.0	15.5	4.0	19.0	4.8	2.8	0.92	19,000	5.3	6.0	0.96	2,130	40.1	17.6	0.4	4,580	2,890
06MM04.15	15,700	10.0	103	1.4	1.3	4,430	0.82	76.9	25.6	14.3	4.2	19.6	5.4	3.1	1.0	20,400	5.7	6.2	1.1	2,380	39.0	20.5	0.5	4,860	1,510
06MM04.16	15,200	7.4	120	1.2	0.90	4,460	1.0	79.4	23.3	16.7	4.1	19.2	5.3	3.0	1.0	19,700	5.6	6.2	1.0	2,320	39.8	19.6	0.5	4,720	2,040
06MM04.17	16,500	8.2	138	1.5	0.88	4,270	1.2	77.2	26.3	14.9	4.2	20.7	5.7	3.3	1.1	20,200	5.8	6.3	1.1	2,400	38.2	22.3	0.5	4,880	2,150
06MM04.18	17,000	7.5	131	1.6	0.88	4,590	1.8	78.8	25.4	15.7	4.0	22.0	6.2	3.7	1.1	18,600	6.3	6.8	1.2	2,500	36.4	23.1	0.6	4,820	1,940
06MM04.19	22,100	10.5	154	2.1	0.97	5,540	2.2	88.3	35.2	16.6	4.6	28.1	7.8	4.8	1.4	22,300	7.8	8.1	1.6	3,010	40.0	28.0	0.8	5,010	3,420
06MM04.20	16,000	5.0	123	1.5	1.0	6,060	0.79	79.2	23.7	16.1	3.7	20.8	5.6	3.3	1.1	17,900	5.7	6.4	1.1	2,330	40.6	22.5	0.5	5,570	381
06MM04.21	16,800	4.5	90.8	1.5	0.84	5,440	1.4	80.7	19.5	18.1	4.2	21.6	5.6	3.2	1.1	18,700	5.9	6.6	1.1	2,490	40.8	24.3	0.5	5,640	228
06MM04.22	17,000	10.4	109	1.2	0.90	8,100	0.73	79.9	12.3	58.3	5.0	89.2	4.3	2.3	1.0	23,900	6.2	5.6	0.82	2,990	39.7	23.7	0.3	8,580	289

Table A12. Analytical results for elements by ICP-MS with weight percent total carbon on selected sample intervals, core 06MM04--Continued.

Sample interval	Mo ppm	Na ppm	Nb ppm	Nd ppm	Ni ppm	P ppm	Pb ppm	Pr ppm	Rb ppm	Sc ppm	Sm ppm	Sr ppm	Tb ppm	Th ppm	Ti ppm	Tl ppm	Tm ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm	Total Carbon wt. percent
06MM04.01	0.58	187	1.1	27.7	39	881	33.0	7.2	35.6	4.9	5.6	28.6	0.69	13.3	1,040	0.27	0.31	18.2	32.9	22.2	2.1	382	2.03
06MM04.02	0.45	184	1.3	30.2	58	714	30.6	7.9	34.9	4.9	6.2	25.9	0.86	14.1	1,050	0.27	0.41	33.8	31.2	27.3	2.7	411	2.17
06MM04.03	1.0	219	0.88	31.5	58	725	32.1	8.3	39.1	5.6	6.6	32.6	0.87	17.4	1,160	0.32	0.41	28.2	35.9	30.8	2.7	466	--
06MM04.04	1.1	168	0.59	33.1	40	807	17.7	8.7	29.9	3.8	6.7	45.0	0.74	26.6	958	0.23	0.32	7.39	31.1	22.2	2.0	155	--
06MM04.05	1.6	179	0.65	33.4	65	813	19.4	8.9	32.0	4.1	6.9	47.8	0.78	24.1	1,040	0.24	0.36	8.98	31.4	24.7	2.2	158	--
06MM04.06	2.2	206	0.50	35.6	87	813	22.1	9.4	33.3	4.4	7.2	54.2	0.92	29.6	956	0.28	0.42	14.2	32.3	31.2	2.7	212	--
06MM04.07	1.5	177	1.5	33.6	70	576	16.0	8.7	39.6	4.6	7.2	23.6	1.0	21.1	819	0.30	0.59	102	27.2	39.6	3.9	212	1.30
06MM04.08	1.3	210	1.9	35.2	61	624	25.7	9.3	38.9	5.4	7.4	34.9	1.1	22.5	991	0.30	0.58	40.5	30.4	40.2	3.8	210	--
06MM04.09	2.8	213	2.0	34.6	126	744	31.7	9.0	33.8	5.0	7.0	38.5	1.0	23.0	939	0.26	0.54	59.6	31.3	41.0	3.6	252	--
06MM04.10	1.2	203	3.4	33.1	92	545	21.2	8.9	35.1	4.9	7.1	33.3	1.0	20.1	878	0.31	0.55	108	29.4	39.0	3.6	200	--
06MM04.11	0.67	171	1.3	32.2	48	633	18.2	8.6	28.8	3.8	6.8	22.5	0.89	26.9	768	0.22	0.44	38.9	27.8	32.2	2.9	168	--
06MM04.12	1.6	187	1.1	34.7	71	748	26.0	9.3	30.3	4.1	7.2	28.5	0.90	30.3	798	0.23	0.42	24.0	29.1	32.5	2.8	169	--
06MM04.13	1.1	172	1.1	35.0	45	743	20.1	9.3	28.7	3.8	7.1	24.6	0.93	28.4	799	0.22	0.45	29.3	29.4	32.2	3.0	143	--
06MM04.14	0.95	172	0.79	31.9	40	718	18.8	8.4	28.1	3.6	6.6	24.3	0.86	34.0	715	0.21	0.41	30.6	26.9	31.6	2.7	151	--
06MM04.15	0.78	178	1.1	32.6	49	718	19.9	8.6	30.9	4.0	6.7	24.4	0.90	24.8	786	0.23	0.44	40.8	27.5	32.9	3.0	164	--
06MM04.16	0.82	175	1.1	33.5	46	700	19.5	8.8	29.1	3.9	6.8	23.9	0.92	30.5	805	0.22	0.45	34.1	28.4	33.4	3.0	161	--
06MM04.17	0.68	167	1.3	32.3	50	680	19.5	8.6	30.8	4.0	6.7	24.0	0.96	26.0	794	0.23	0.51	32.6	27.9	35.4	3.4	173	--
06MM04.18	0.99	172	1.2	33.4	60	616	16.7	8.7	33.2	4.1	7.0	24.4	1.0	23.5	805	0.25	0.55	85.0	25.8	37.7	3.6	188	1.48
06MM04.19	1.5	180	1.2	36.2	77	581	17.7	9.5	41.0	5.1	7.8	25.7	1.3	19.9	918	0.31	0.73	125	29.7	49.4	4.8	216	2.18
06MM04.20	0.58	170	1.7	34.2	48	638	19.0	9.0	27.9	3.9	6.9	26.3	0.95	27.6	790	0.22	0.49	38.1	27.6	35.6	3.2	159	--
06MM04.21	0.61	183	1.5	35.0	46	636	17.5	9.2	30.8	4.2	7.2	25.0	0.95	26.5	836	0.23	0.49	13.8	26.2	34.6	3.2	168	--
06MM04.22	1.3	198	0.82	32.8	59	803	24.5	8.7	31.4	4.6	6.6	33.8	0.78	25.8	1,020	0.26	0.34	8.52	32.1	25.5	2.2	265	--

Table A13. Analytical results for elements by ICP-MS, core 06MM05.

[Samples prepared using EPA Method 3050B, see text for details; concentrations reported in parts per million (ppm)]

Sample interval	Al ppm	As ppm	Ba ppm	Be ppm	Bi ppm	Ca ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cs ppm	Cu ppm	Dy ppm	Er ppm	Eu ppm	Fe ppm	Ga ppm	Gd ppm	Ho ppm	K ppm	La ppm	Li ppm	Lu ppm	Mg ppm
06MM05.01	15,100	6.3	93.0	1.2	1.2	6,300	0.74	80.2	10.1	25.8	4.3	15.4	4.4	2.4	0.89	19,000	5.4	5.7	0.85	1,970	41.9	22.1	0.4	4,460
06MM05.02	18,600	7.0	116	1.4	0.72	6,090	0.98	69.1	10.5	19.1	4.9	18.8	4.3	2.4	0.89	19,100	6.2	5.1	0.81	2,340	35.4	26.1	0.4	4,880
06MM05.03	19,300	7.7	131	1.6	0.82	6,640	1.2	62.6	14.4	19.1	5.0	20.6	4.1	2.3	0.86	19,700	6.5	4.9	0.81	2,390	31.9	28.4	0.4	5,000
06MM05.04	21,600	8.0	124	1.6	0.89	7,360	1.0	65.6	12.3	17.6	5.5	20.2	4.1	2.3	0.90	21,400	7.0	5.0	0.79	2,680	33.3	30.4	0.3	6,110
06MM05.05	24,800	8.0	98.6	1.7	0.87	6,920	0.95	67.8	11.2	34.2	6.5	22.5	4.5	2.5	0.95	23,200	7.7	5.3	0.88	2,860	33.7	35.7	0.4	6,320
06MM05.06	22,100	9.6	109	1.6	2.1	6,670	0.97	85.0	19.7	19.1	5.9	21.6	5.0	2.8	1.0	24,600	7.4	6.1	0.99	2,710	41.5	30.7	0.4	5,330
06MM05.07	19,900	25.8	232	1.6	0.78	6,090	1.3	71.6	42.4	29.6	4.6	19.6	4.8	2.7	0.96	26,900	6.7	5.6	0.97	2,440	36.0	28.1	0.4	5,300
06MM05.08	22,100	6.3	172	2.3	0.91	6,980	1.7	78.4	18.2	19.8	4.7	27.0	6.4	3.9	1.2	19,500	7.2	7.0	1.3	2,480	42.2	32.2	0.6	5,080
06MM05.09	18,300	8.3	147	1.7	1.4	5,150	0.84	82.9	17.3	16.5	4.2	19.9	5.6	3.2	1.1	20,200	6.2	6.3	1.1	2,290	41.3	27.4	0.5	4,920

Table A13. Analytical results for elements by ICP-MS, core 06MM05--Continued.

Sample interval	Mn ppm	Mo ppm	Na ppm	Nb ppm	Nd ppm	Ni ppm	P ppm	Pb ppm	Pr ppm	Rb ppm	Sc ppm	Sm ppm	Sr ppm	Tb ppm	Th ppm	Ti ppm	Tl ppm	Tm ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm
06MM05.01	999	1.2	171	1.5	35.1	35	856	14.2	9.4	24.1	3.4	6.7	29.2	0.80	45.6	840	0.17	0.36	29.6	30.9	25.3	2.4	79.5
06MM05.02	1,310	0.95	188	1.7	29.3	36	706	16.8	7.8	28.0	4.0	5.9	35.8	0.74	24.1	829	0.20	0.35	44.8	27.7	24.9	2.3	94.6
06MM05.03	2,380	1.2	175	1.6	26.5	43	712	18.2	7.0	28.4	4.2	5.4	38.2	0.68	20.6	822	0.21	0.35	53.9	28.4	24.5	2.3	110
06MM05.04	1,550	0.91	201	1.5	28.3	36	762	19.0	7.4	31.2	4.6	5.8	38.1	0.72	18.8	915	0.21	0.34	43.7	31.8	24.0	2.3	102
06MM05.05	315	1.1	200	2.1	28.8	45	719	20.7	7.6	34.5	5.2	5.8	38.0	0.79	18.9	968	0.22	0.37	52.8	33.5	26.9	2.5	103
06MM05.06	385	1.0	199	2.3	34.1	35	875	20.2	9.0	33.6	4.9	6.9	37.8	0.91	30.5	960	0.22	0.43	39.0	35.0	30.6	2.8	110
06MM05.07	3,580	2.3	183	0.77	30.0	70	1,220	16.3	8.0	28.4	4.2	6.1	34.1	0.84	22.7	824	0.22	0.42	40.5	34.4	28.8	2.6	131
06MM05.08	1,400	1.2	200	2.3	32.9	71	725	17.7	8.6	33.6	4.8	7.0	36.4	1.1	24.5	862	0.24	0.59	122	31.0	45.8	3.9	170
06MM05.09	489	0.94	180	1.8	33.8	38	694	17.9	9.0	28.9	4.2	6.9	28.1	0.96	28.8	854	0.20	0.48	56.7	29.6	34.5	3.2	117

Table A14. Analytical results for elements by ICP-MS with weight percent total carbon on selected sample intervals, core 06MM06.

[Samples prepared using EPA Method 3050B, see text for details; concentrations reported in parts per million (ppm). Total carbon determined on wetland silt samples, but not on granitic sand samples; --, no data]

Sample interval	Al ppm	As ppm	Ba ppm	Be ppm	Bi ppm	Ca ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cs ppm	Cu ppm	Dy ppm	Er ppm	Eu ppm	Fe ppm	Ga ppm	Gd ppm	Ho ppm	K ppm	La ppm	Li ppm	Lu ppm	Mg ppm
06MM06.01	15,400	2.9	144	0.99	1.4	5,600	0.23	55.6	5.2	16.1	3.4	13.0	3.6	2.0	0.67	17,300	5.9	4.4	0.70	3,170	26.7	22.1	0.3	3,520
06MM06.02	18,000	3.7	187	1.2	0.82	6,440	0.26	68.2	5.8	12.6	3.6	13.8	4.7	2.6	0.88	18,100	6.5	5.7	0.91	3,390	32.0	23.7	0.4	3,900
06MM06.03	18,100	4.2	171	1.3	0.87	5,530	0.15	70.8	5.9	15.2	3.5	13.6	5.0	2.8	0.94	18,100	6.4	6.0	0.98	3,100	38.8	23.4	0.4	3,400
06MM06.04	15,900	3.7	157	1.0	0.84	4,410	0.12	63.9	5.2	12.9	3.4	12.3	3.7	2.1	0.68	16,000	5.5	4.5	0.73	2,780	32.8	21.6	0.3	2,810
06MM06.05	17,000	3.8	238	1.2	2.2	5,560	0.19	63.7	6.4	20.0	3.4	18.9	4.4	2.4	0.78	17,400	5.8	5.1	0.84	2,860	33.5	23.3	0.4	2,780
06MM06.06	16,800	4.4	151	1.1	1.4	3,940	0.12	75.1	5.4	14.9	3.9	13.8	4.3	2.4	0.76	17,900	6.0	5.4	0.82	3,000	38.7	23.4	0.4	2,900
06MM06.07	21,200	4.4	165	1.6	0.99	4,870	0.14	83.5	6.3	18.4	4.4	20.0	6.0	3.3	1.1	20,300	7.5	7.2	1.2	3,360	46.2	28.2	0.5	3,640
06MM06.08	18,300	5.2	106	1.3	0.96	3,830	0.08	69.9	5.6	15.4	4.1	13.9	4.8	2.7	0.92	18,000	6.3	5.8	0.96	2,920	37.5	27.3	0.4	3,100
06MM06.09	23,800	5.4	101	1.7	0.90	4,230	0.11	76.1	6.1	19.2	4.0	19.4	6.1	3.5	1.2	20,600	7.8	7.1	1.2	2,840	41.2	34.6	0.6	3,340
06MM06.10	31,000	4.7	106	2.0	1.1	5,400	0.11	89.1	5.5	24.3	4.3	22.7	7.5	4.4	1.3	25,400	9.9	8.8	1.5	3,010	48.7	43.7	0.7	3,770
06MM06.11	30,700	4.0	96.7	2.0	1.7	5,790	0.07	85.2	3.7	22.6	4.2	21.0	7.8	4.5	1.3	25,100	10.1	9.0	1.6	2,820	54.0	44.9	0.8	3,610
06MM06.12	28,800	7.7	133	1.9	1.7	5,570	0.17	125	10.3	30.4	4.5	20.4	7.7	4.4	1.2	28,300	10.0	9.1	1.5	2,760	64.7	41.8	0.8	3,510

Table A14. Analytical results for elements by ICP-MS with weight percent total carbon on selected sample intervals, core 06MM06--Continued.

Sample interval	Mn ppm	Mo ppm	Na ppm	Nb ppm	Nd ppm	Ni ppm	P ppm	Pb ppm	Pr ppm	Rb ppm	Sc ppm	Sm ppm	Sr ppm	Tb ppm	Th ppm	Ti ppm	Tl ppm	Tm ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm	Total Carbon wt. percent
06MM06.01	631	0.90	196	3.8	24.5	13	696	20.6	6.4	38.1	4.0	5.1	36.9	0.61	18.3	858	0.24	0.30	11.4	21.9	19.7	2.0	63.4	4.48
06MM06.02	694	0.88	190	4.0	30.7	11	682	20.8	8.0	38.1	4.4	6.4	41.0	0.80	20.5	919	0.24	0.39	18.5	24.4	24.9	2.6	55.5	4.49
06MM06.03	567	0.87	197	3.2	31.8	11	588	17.8	8.3	35.4	4.6	6.6	39.6	0.84	23.8	860	0.23	0.42	28.6	28.0	29.5	2.8	46.4	--
06MM06.04	509	1.1	190	3.2	26.9	10	395	14.0	7.3	32.9	3.8	5.4	33.6	0.66	24.4	831	0.22	0.32	19.4	25.4	21.2	2.1	37.2	--
06MM06.05	710	1.4	164	4.3	27.7	16	462	16.6	7.3	31.9	4.3	5.8	43.6	0.75	21.8	811	0.24	0.36	18.1	23.7	24.3	2.4	41.2	--
06MM06.06	396	1.3	148	3.0	31.4	11	386	15.0	8.6	36.9	4.3	6.3	32.5	0.75	30.6	911	0.25	0.35	13.8	25.2	23.3	2.4	41.4	--
06MM06.07	464	1.1	166	2.7	37.8	15	390	17.0	9.8	47.3	5.8	7.8	41.5	1.0	29.0	1,050	0.29	0.52	28.8	28.2	36.3	3.4	50.9	--
06MM06.08	323	1.4	131	3.0	31.0	11	316	14.3	8.3	39.3	4.8	6.5	30.0	0.82	25.7	941	0.26	0.40	30.5	27.0	28.2	2.7	42.6	--
06MM06.09	370	1.2	161	1.5	36.3	14	315	15.4	9.3	39.0	5.6	7.8	31.3	1.0	23.4	955	0.25	0.51	50.8	27.9	36.6	3.5	46.6	--
06MM06.10	326	0.66	208	1.5	42.0	16	354	17.8	10.8	41.6	7.0	9.2	38.7	1.2	33.2	1,100	0.26	0.67	69.1	27.8	45.5	4.5	57.3	--
06MM06.11	213	0.47	205	1.5	45.1	12	470	16.7	11.9	39.7	7.2	9.4	38.4	1.3	49.8	1,020	0.23	0.69	72.4	26.1	47.2	4.7	59.6	--
06MM06.12	1,130	1.4	226	0.56	49.3	21	708	24.2	13.4	41.1	6.8	10.1	36.3	1.3	62.0	861	0.25	0.67	69.0	32.6	49.2	4.6	64.8	--

Table A15. Analytical results for elements by ICP-MS, core 06MM07.

[Samples prepared using EPA Method 3050B, see text for details; concentrations reported in parts per million (ppm)]

Sample interval	Al ppm	As ppm	Ba ppm	Be ppm	Bi ppm	Ca ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cs ppm	Cu ppm	Dy ppm	Er ppm	Eu ppm	Fe ppm	Ga ppm	Gd ppm	Ho ppm	K ppm	La ppm	Li ppm	Lu ppm	Mg ppm
06MM07.01	17,200	3.3	130	1.4	0.43	5,630	0.65	102	6.4	15.3	3.3	12.0	6.2	3.4	1.0	17,700	6.6	7.6	1.2	2,190	61.3	22.4	0.6	2,510
06MM07.02	19,800	2.9	119	1.5	0.52	4,930	0.21	98.1	5.7	12.8	3.7	12.6	6.8	3.7	1.1	20,500	7.3	8.3	1.3	2,340	62.9	27.0	0.6	2,760
06MM07.03	24,800	3.8	152	2.0	0.58	5,380	0.44	105	4.8	47.4	3.1	22.9	7.0	4.0	1.2	19,700	8.3	8.2	1.4	2,300	57.2	30.1	0.7	2,830

Table A15. Analytical results for elements by ICP-MS, core 06MM07--Continued.

Sample interval	Mn ppm	Mo ppm	Na ppm	Nb ppm	Nd ppm	Ni ppm	P ppm	Pb ppm	Pr ppm	Rb ppm	Sc ppm	Sm ppm	Sr ppm	Tb ppm	Th ppm	Ti ppm	Tl ppm	Tm ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm
06MM07.01	554	0.83	156	5.3	47.8	12	1,100	17.7	13.1	30.4	4.1	9.3	42.4	1.1	63.3	507	0.21	0.53	21.2	25.7	36.7	3.5	56.4
06MM07.02	501	0.73	141	3.0	49.7	10	1,180	17.7	13.5	35.1	4.7	10.1	37.1	1.2	59.5	598	0.23	0.58	20.2	30.0	40.3	3.8	57.3
06MM07.03	291	2.5	172	5.9	46.3	35	910	22.4	12.5	31.5	5.2	9.5	42.6	1.2	44.9	755	0.22	0.62	30.5	44.6	42.8	4.2	63.1

Table A16. Analytical results for elements by ICP-MS with weight percent total carbon on selected sample intervals, core 06MM08.

[Samples prepared using EPA Method 3050B, see text for details; concentrations reported in parts per million (ppm). Total carbon determined on wetland silt samples, but not on granitic sand samples; --, no data]

Sample interval	Al ppm	As ppm	Ba ppm	Be ppm	Bi ppm	Ca ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cs ppm	Cu ppm	Dy ppm	Er ppm	Eu ppm	Fe ppm	Ga ppm	Gd ppm	Ho ppm	K ppm	La ppm	Li ppm	Lu ppm	Mg ppm	Mn ppm
06MM08.01	23,000	10.0	229	3.3	0.66	11,900	13.6	58.8	31.0	31.2	8.5	21.9	7.9	5.2	1.3	19,200	8.1	7.6	1.8	2,520	35.6	37.0	0.8	5,210	34,900
06MM08.02	24,400	10.6	230	3.3	0.68	10,800	11.7	66.9	31.4	23.7	8.8	22.6	7.9	5.2	1.3	20,600	8.3	7.6	1.8	2,720	36.0	38.7	0.8	5,430	33,900
06MM08.03	22,400	10.2	295	2.7	0.63	10,200	12.3	60.6	35.3	21.7	8.4	21.2	7.5	4.8	1.3	19,800	8.4	7.4	1.6	2,680	35.6	35.3	0.7	5,100	44,100
06MM08.04	21,100	11.6	442	3.4	0.56	12,400	14.6	90.0	51.1	20.4	7.5	21.0	13.2	8.8	1.9	17,800	10.2	12.7	3.0	2,540	72.9	46.1	1.2	4,890	>77,000
06MM08.05	19,800	15.7	739	4.0	0.47	14,200	20.4	110	65.4	26.2	5.7	22.0	16.1	11.0	2.1	14,100	9.1	15.1	3.7	2,160	102	49.2	1.5	3,900	>77,000
06MM08.06	25,400	8.8	106	3.3	0.72	4,640	3.0	71.8	13.3	18.4	7.9	26.5	5.9	3.6	1.2	20,200	7.3	6.2	1.2	2,530	38.6	45.4	0.6	3,780	5,710
06MM08.07	20,400	10.4	150	2.8	0.75	5,580	3.4	88.1	31.8	16.1	5.9	27.0	7.7	4.7	1.3	18,200	6.8	7.6	1.6	2,300	41.1	39.1	0.8	4,070	16,200
06MM08.08	23,400	17.1	124	2.5	2.5	4,490	1.2	97.4	36.6	25.1	7.4	27.8	8.5	5.0	1.4	23,900	8.3	8.6	1.7	3,440	45.6	37.4	0.8	4,790	4,980
06MM08.09	28,600	22.0	150	3.3	3.5	5,440	2.8	107	94.1	28.7	8.3	38.8	10.4	6.5	1.6	27,900	9.9	9.8	2.2	3,790	49.4	40.6	1.1	5,800	16,600
06MM08.10	25,800	24.0	154	4.0	2.5	6,580	1.7	95.5	92.7	26.1	5.6	79.7	17.8	12.7	2.3	23,600	8.4	13.6	3.9	3,100	46.3	46.2	2.3	5,480	11,100
06MM08.11	24,700	25.8	137	3.3	2.6	7,280	4.8	77.4	64.2	17.4	3.8	68.4	15.1	10.9	1.9	22,300	7.6	11.4	3.4	2,780	34.8	34.8	1.8	5,250	4,420
06MM08.12	23,900	13.2	134	2.2	1.5	7,360	4.1	56.1	33.4	19.4	3.9	34.9	8.3	5.5	1.2	22,200	7.9	7.2	1.8	2,690	26.9	34.6	0.9	4,590	1,800
06MM08.13	27,200	9.2	166	2.1	1.0	6,560	1.5	57.7	23.0	20.6	5.1	34.4	7.3	4.8	1.1	22,900	8.7	6.9	1.6	2,960	26.5	37.8	0.8	4,620	1,230
06MM08.14	29,500	12.5	146	2.7	1.4	6,110	1.4	86.3	39.5	31.7	5.0	37.7	9.9	6.8	1.3	25,300	9.5	8.6	2.2	3,260	40.1	44.4	1.1	4,220	4,650
06MM08.15	24,200	11.9	92.9	1.9	1.1	4,110	0.57	65.0	11.9	23.6	4.6	20.8	5.1	3.1	0.76	22,200	7.6	5.3	1.0	3,020	29.8	35.7	0.5	3,260	1,820
06MM08.16	24,500	10.3	138	1.6	0.95	4,330	0.66	66.8	10.8	19.4	4.5	16.8	5.0	2.8	0.89	22,400	7.7	5.5	0.97	2,910	31.8	37.3	0.5	3,670	1,350
06MM08.17	23,600	15.4	169	1.5	0.83	4,760	0.48	58.0	11.2	22.2	4.2	18.5	5.2	3.0	0.93	26,000	7.8	5.9	1.0	2,890	27.5	33.2	0.5	3,920	1,180
06MM08.18	24,600	10.6	112	1.5	0.98	5,090	0.52	65.3	6.6	20.2	4.2	19.8	5.7	3.4	0.98	25,600	8.3	6.2	1.2	2,970	28.4	34.0	0.6	3,930	388
06MM08.19	24,800	5.6	90.4	1.6	1.1	4,500	0.42	71.7	5.8	20.7	4.2	18.7	5.6	3.3	0.97	21,000	8.2	6.2	1.1	2,960	29.6	35.7	0.5	3,820	239
06MM08.20	23,900	5.0	87.5	1.6	1.1	4,450	0.47	73.1	5.8	16.7	4.2	19.0	5.4	3.2	0.94	20,600	8.1	6.1	1.1	2,940	29.5	34.6	0.5	3,720	344

Table A16. Analytical results for elements by ICP-MS with weight percent total carbon on selected sample intervals, core 06MM08--Continued.

Sample interval	Mo ppm	Na ppm	Nb ppm	Nd ppm	Ni ppm	P ppm	Pb ppm	Pr ppm	Rb ppm	Sc ppm	Sm ppm	Sr ppm	Tb ppm	Th ppm	Ti ppm	Tl ppm	Tm ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm	Total Carbon wt. percent
06MM08.01	15.0	246	1.8	29.9	456	549	12.9	7.8	35.8	4.2	6.4	50.2	1.2	9.36	781	0.37	0.78	119	26.2	60.7	5.0	505	4.89
06MM08.02	14.4	234	1.6	30.4	466	488	13.9	7.9	37.9	4.5	6.5	46.0	1.2	9.54	865	0.37	0.77	101	28.1	59.6	5.0	471	3.84
06MM08.03	20.4	218	1.3	29.8	468	420	13.1	7.9	37.8	4.2	6.2	49.8	1.2	10.0	839	0.33	0.72	99.8	27.0	57.7	4.6	499	2.72
06MM08.04	24.5	220	1.4	45.6	1,000	470	10.7	12.3	35.3	3.8	9.0	61.9	2.0	8.45	763	0.40	1.3	202	28.5	129	7.6	888	3.43
06MM08.05	34.7	193	1.7	53.8	1,750	578	9.7	14.6	27.5	3.4	10.6	70.9	2.4	11.0	584	0.44	1.5	391	29.4	174	9.4	1,640	3.57
06MM08.06	2.5	152	0.96	32.0	110	578	13.5	8.4	35.7	6.0	7.1	23.6	0.97	28.4	867	0.26	0.58	103	28.8	38.3	4.0	200	--
06MM08.07	4.9	182	0.95	36.2	208	609	13.9	9.5	33.2	4.5	8.1	26.9	1.2	28.8	748	0.26	0.74	92.6	28.5	47.2	5.0	258	--
06MM08.08	4.2	172	1.1	40.5	64	548	20.6	10.7	55.3	6.3	9.0	25.0	1.4	34.5	806	0.40	0.78	92.5	34.2	49.4	5.4	119	--
06MM08.09	6.2	204	1.1	41.1	129	478	23.7	10.6	64.2	7.4	9.4	33.0	1.7	34.3	799	0.49	1.0	154	39.2	68.6	7.0	190	--
06MM08.10	3.7	209	1.4	44.6	172	463	20.6	11.3	45.2	6.4	11.1	37.6	2.6	22.4	774	0.39	2.1	108	33.1	118	14.2	206	--
06MM08.11	3.0	226	2.1	37.5	235	468	21.5	9.4	38.2	5.2	9.0	34.2	2.1	16.1	801	0.33	1.7	365	25.8	113	11.7	315	3.15
06MM08.12	2.3	239	2.6	29.0	197	345	20.0	7.4	40.9	5.1	6.6	30.8	1.2	14.6	849	0.28	0.88	320	26.0	52.6	6.1	316	3.40
06MM08.13	1.4	239	2.2	28.6	110	313	17.3	7.3	48.0	5.6	6.5	30.3	1.2	13.9	906	0.26	0.74	198	26.0	43.9	5.2	175	2.34
06MM08.14	3.0	203	1.4	36.0	86	506	19.5	9.4	47.7	6.8	8.1	27.7	1.5	28.4	910	0.34	1.1	169	34.2	70.3	7.1	138	--
06MM08.15	2.8	158	1.3	25.7	37	363	18.0	6.7	41.5	5.6	5.6	20.9	0.81	23.6	915	0.30	0.49	108	32.5	34.6	3.3	82.4	--
06MM08.16	1.7	185	1.2	28.0	33	312	17.2	7.4	42.8	5.6	6.1	23.9	0.83	21.2	1,040	0.28	0.44	109	34.1	27.7	3.0	88.0	--
06MM08.17	1.6	164	1.9	28.3	42	330	16.2	7.4	43.7	5.2	6.2	24.7	0.88	17.2	996	0.26	0.47	117	33.1	26.9	3.2	91.7	1.29
06MM08.18	1.0	162	2.2	30.0	44	295	18.3	7.8	46.1	5.4	6.6	23.2	0.96	18.8	944	0.26	0.52	117	28.0	30.4	3.6	88.8	1.54
06MM08.19	0.83	163	1.9	30.9	37	255	18.4	8.1	44.7	5.3	6.8	20.8	0.94	19.4	981	0.26	0.50	91.8	23.3	29.2	3.5	75.2	1.29
06MM08.20	0.89	156	2.5	30.2	36	257	18.7	8.0	43.0	5.2	6.6	20.5	0.91	18.9	958	0.26	0.50	94.2	23.4	28.7	3.4	75.8	1.32

Table A17. Sample localities and analytical results for elements determined by ICP-MS on 1979 NURE sediment samples collected in the Blue Creek and Sand Creek basins.

[Samples prepared using EPA Method 3050B, see text for details; concentrations reported in parts per million (ppm); Dup, blind duplicate digestion and analysis; Mean, mean of two analyses for sample]

Sample No.	Latitude N.	Longitude W.	Al ppm	As ppm	Ba ppm	Be ppm	Bi ppm	Ca ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cs ppm	Cu ppm	Dy ppm	Er ppm	Eu ppm	Fe ppm	Ga ppm	Gd ppm	Ho ppm	K ppm	La ppm	Li ppm	Lu ppm
Detection Limit			*< 50*	*< 1*	*< 0.2*	*< 0.03*	*< 0.06*	*< 100*	*< 0.007*	*< 0.1*	*< 0.03*	*< 0.5*	*< 0.003*	*< 2*	*< 0.04*	*< 0.05*	*< 0.005*	*< 50*	*< 0.02*	*< 0.02*	*< 0.02*	*< 20*	*< 0.05*	*< 0.3*	*< 0.1*
Blue Creek basin:																									
DSOR100S1	47.92360	118.04220	17,800	3.6	154	0.74	0.32	2,740	0.31	54.8	7.2	14.4	2.9	12.9	2.2	1.1	0.63	17,300	5.7	3.2	0.39	3,100	28.3	18.3	0.1
DSOR100S1-Dup	47.92360	118.04220	18,600	3.5	154	0.77	0.41	2,820	0.31	54.7	7.4	14.7	2.9	13.0	2.2	1.1	0.65	17,900	5.8	3.1	0.40	3,230	28.0	18.5	0.1
DSOR100S1-Mean	47.92360	118.04220	18,200	3.6	154	0.8	0.4	2,780	0.31	54.8	7.3	14.6	2.9	13.0	2.2	1.1	0.64	17,600	5.8	3.2	0.40	3,165	28.2	18.4	0.1
DSOR101S1	47.92160	118.05460	18,500	3.0	190	0.86	0.28	3,470	0.14	60.6	8.7	15.7	2.9	15.0	2.5	1.2	0.75	18,300	5.6	3.6	0.45	3,670	30.2	16.7	0.2
DSOR102S1	47.91560	118.05410	26,200	3.5	194	1.3	0.31	4,660	0.17	65.8	6.7	18.1	3.0	16.6	3.3	1.8	0.84	20,000	7.4	4.3	0.64	2,910	29.9	26.0	0.3
DSOR118S1	47.91400	118.07400	15,700	7.9	133	0.77	0.50	2,660	0.16	70.1	6.8	17.1	3.6	16.6	2.6	1.2	0.84	19,800	5.8	4.0	0.46	4,250	33.8	19.6	0.2
DSOR119S1	47.91450	118.08360	16,700	3.0	132	0.75	0.39	3,360	0.11	53.5	5.9	10.2	3.1	11.4	2.3	1.2	0.54	14,500	5.3	3.1	0.42	2,700	24.0	21.7	0.2
DSOR120S1	47.90440	118.08300	21,900	4.0	116	1.4	0.76	4,430	0.19	79.0	5.2	11.0	6.2	12.3	3.6	1.9	0.68	19,400	7.3	4.6	0.66	2,590	33.8	36.3	0.3
DSOR121S1	47.89890	118.09450	14,600	8.5	111	1.0	0.64	3,100	0.33	85.7	6.8	14.3	7.1	15.7	3.6	1.8	0.91	19,200	5.8	5.0	0.64	3,840	40.3	24.1	0.2
DSOR126S1	47.88900	118.10150	25,400	3.9	194	0.87	0.34	3,280	0.26	38.8	5.0	10.1	3.6	21.7	1.9	0.98	0.46	15,000	6.3	2.3	0.35	3,230	16.3	21.5	0.1
DSOR127S1	47.88980	118.10750	15,500	4.6	167	1.0	0.39	4,840	0.35	63.8	6.5	12.6	4.9	12.4	3.0	1.5	0.67	17,700	5.6	3.9	0.53	3,790	31.5	20.9	0.2
DSOR128S1	47.92510	118.07980	27,300	4.8	198	1.6	0.86	7,610	0.25	74.6	6.0	16.9	3.9	16.1	4.1	2.3	0.83	21,200	7.8	5.0	0.80	3,180	34.5	33.1	0.4
DSOR129S1	47.92980	118.09870	13,100	7.7	95.4	0.82	0.82	14,300	0.15	78.9	5.6	11.3	3.2	10.8	4.2	2.3	0.66	16,000	4.6	5.0	0.79	2,290	37.0	15.9	0.4
DSOR129S1-Dup	47.92980	118.09870	13,400	7.2	95.7	0.78	0.54	14,500	0.14	83.6	5.9	11.4	3.2	21.7	4.0	2.2	0.70	16,500	4.7	5.2	0.75	2,360	39.9	16.1	0.4
DSOR129S1-Mean	47.92980	118.09870	13,250	7.5	96	0.8	0.7	14,400	0.15	81.3	5.8	11.4	3.2	16.3	4.1	2.3	0.68	16,250	4.7	5.1	0.77	2,325	38.5	16.0	0.4
DSOR131S1	47.91600	118.10880	25,700	4.0	134	1.2	0.51	4,150	0.19	52.6	5.1	12.1	3.8	16.4	3.2	1.8	0.71	19,200	7.3	4.0	0.61	3,320	24.6	38.4	0.2
DSOR133S1	47.91700	118.10040	14,400	5.2	89.7	0.90	0.53	3,380	0.14	71.4	4.9	12.1	5.1	14.6	3.6	1.9	0.67	16,400	5.5	4.6	0.68	2,890	33.3	21.7	0.3
DSOR134S1	47.91070	118.10630	17,200	5.3	104	1.3	0.61	3,180	0.24	79.6	4.8	11.9	8.1	13.7	3.6	1.9	0.72	19,400	6.4	4.8	0.67	2,980	37.2	39.0	0.3
DSOR134S1-Dup	47.91070	118.10630	17,600	5.3	105	1.2	0.60	3,340	0.22	90.4	4.8	12.3	8.5	13.8	3.9	2.0	0.79	19,400	6.5	5.2	0.73	3,060	42.1	38.9	0.3
DSOR134S1-Mean	47.91070	118.10630	17,400	5.3	105	1.3	0.6	3,260	0.23	85.0	4.8	12.1	8.3	13.8	3.8	2.0	0.76	19,400	6.5	5.0	0.70	3,020	39.7	39.0	0.3
DSOR135S1	47.90100	118.12340	13,000	21.2	102	0.68	0.68	12,200	0.27	67.6	7.4	16.4	4.0	18.4	2.6	1.2	0.84	21,700	4.8	4.0	0.45	2,720	33.3	22.0	0.2
DSOR136S1	47.90040	118.11530	10,200	4.3	68.8	0.91	2.57	4,200	0.57	163	10.1	17.1	4.6	8.6	5.3	2.5	0.92	27,800	5.3	8.1	0.92	1,710	83.9	18.0	0.3
DSOR137S1	47.92470	118.08960	13,400	16.3	92.2	2.0	7.13	3,820	6.4	99.5	97.5	13.7	4.0	35.2	7.5	5.0	0.94	19,500	5.1	7.4	1.6	1,980	48.4	23.4	0.8
DSOR313S1	47.93570	118.10190	30,200	23.9	156	1.8	1.23	4,820	0.20	65.4	13.6	26.4	5.9	28.3	5.9	3.6	0.92	28,700	9.1	6.1	1.2	4,610	31.8	41.0	0.6
DSOR313S1-Dup	47.93570	118.10190	28,800	24.0	162	1.8	0.99	4,850	0.20	65.3	13.0	25.9	5.7	28.7	5.7	3.6	0.89	28,000	9.3	6.0	1.2	4,540	31.7	41.0	0.6
DSOR313S1-Mean	47.93570	118.10190	29,500	24.0	159	1.8	1.1	4,835	0.20	65.4	13.3	26.2	5.8	28.5	5.8	3.6	0.91	28,350	9.2	6.1	1.2	4,575	31.8	41.0	0.6
DSOR314S1	47.94210	118.09950	23,300	6.2	190	0.93	0.41	3,590	0.16	57.2	9.1	18.3	3.0	17.9	3.0	1.5	0.80	19,700	6.6	4.0	0.54	3,730	28.8	22.6	0.2
DSOR340S1	47.89250	118.14360	14,100	20.2	137	0.78	0.73	19,400	0.23	68.7	9.8	19.6	4.3	22.8	2.7	1.3	0.86	24,900	5.2	4.0	0.47	2,880	32.8	23.0	0.2
DSOR341S1	47.89830	118.13670	11,700	20.0	98.3	0.66	0.70	15,000	0.18	61.2	7.1	15.6	3.4	18.5	2.4	1.1	0.83	20,400	4.3	3.8	0.41	2,570	29.2	20.1	0.1
DSOR403S1	47.93740	118.03570	14,900	2.4	109	1.1	0.60	3,800	0.24	98.7	5.0	7.2	5.8	8.3	4.2	2.3	0.86	15,800	6.0	5.4	0.79	3,690	51.8	27.3	0.3
DSOR404S1	47.93450	118.03470	14,700	2.3	170	0.54	0.24	2,520	0.19	29.3	2.9	7.4	3.1	8.3	1.2	0.59	0.31	12,400	5.2	1.8	0.21	2,190	20.2	18.6	< 0.1
DSOR419S1	47.94410	118.04130	11,900	1.7	135	0.58	0.16	2,000	0.10	63.4	5.8	13.5	1.9	9.3	3.1	1.5	0.94	13,000	4.2	4.4	0.56	2,130	37.8	14.1	0.2
DSOR420S1	47.95190	118.04050	22,600	2.4	151	1.2	0.24	2,480	0.10	84.5	6.4	12.4	4.1	11.7	3.4	1.7	0.78	20,700	8.0	4.4	0.60	3,980	48.9	34.9	0.2
DSOR421S1	47.93610	118.05300	21,800	5.0	153	1.2	0.41	2,490	0.15	82.4	5.2	12.5	4.0	13.8	3.9	1.9	0.90	20,600	7.1	5.3	0.69	2,910	45.1	24.9	0.2
DSOR422S1	47.93380	118.06270	25,600	2.2	167	1.0	0.25	4,370	0.26	47.4	4.8	11.4	2.6	14.7	2.4	1.3	0.56	15,300	6.6	3.0	0.46	2,670	22.1	24.4	0.2
DSOR423S1	47.94560	118.06860	23,800	2.7	201	1.0	0.30	3,720	0.23	66.8	7.2	14.1	3.6	14.9	3.4	1.8	0.73	18,400	7.2	4.2	0.63	4,060	34.0	28.7	0.3
DSOR425S1	47.94870	118.06260	23,500	3.4	218	0.83	0.28	3,550	0.44	49.4	7.5	15.3	2.5	15.4	2.4	1.2	0.68	18,500	6.7	3.3	0.43	3,400	25.5	18.0	0.2
DSOR426S1	47.94180	118.05730	20,400	1.7	183	1.0	0.26	2,680	0.17	66.1	5.7	13.4	3.7	10.8	3.1	1.6	0.66	16,900	7.0	4.0	0.56	3,190	36.0	31.4	0.2
DSOR441S1	47.93240	118.07480	23,000	8.5	164	1.5	0.82	4,970	0.30	81.7	7.2	13.5	3.8	15.1	4.5	2.5	0.82	20,500	8.0	5.3	0.87	3,460	37.0	33.9	0.4
DSOR442S1	47.93150	118.08070	19,500	3.7	414	0.80	0.27	27,400	0.33	35.5	6.5	15.4	2.9	23.3	2.2	1.2	0.52	14,700	5.7	2.7	0.41	5,580	16.7	18.4	0.2
DSOR443S1	47.93950	118.08320	19,800	3.9	202	0.84	0.31	5,630	0.33	44.9	7.4	18.4	2.2	16.5	2.5	1.3	0.71	17,200	5.8	3.2	0.47	3,490	23.2	16.1	0.2
DSOR460S1	47.93180	118.09490	21,200	15.6	127	1.8	1.57	3,540	0.49	66.7	13.3	15.4	4.9	22.8	5.7	3.5	0.84	21,000	6.9	6.1	1.1	3,420	33.1	30.8	0.6
RZAH027S1	47.94310	118.04980	16,600	2.7	102	1.2	0.23	2,930	0.04	84.3	4.9	11.2	3.5	9.5	4.0	2.2	0.81	16,500	6.0	5.3	0.77	2,270	48.6	30.6	0.4
RZAH028S1	47.92490	118.08900	13,700	15.6	71.3	1.8	1.3	2,900	2.8	71.4	19.7	13.8	5.1	18.7	5.6	3.5	0.78	18,100	4.9	5.7	1.1	2,610	34.6	23.8	0.6
RZAH037S1	47.90070	118.11940	19,000	3.9	124	1.3	0.39	3,590	0.09	78.6	5.2	13.0	2.6	15.2	4.3	2.4	0.98	17,500	5.8	5.5	0.82	2,230	41.7	20.4	0.4

Table A17. Sample localities and analytical results for elements determined by ICP-MS on 1979 NURE sediment samples collected in the Blue Creek and Sand Creek basins--Continued.

Sample No.	Mg ppm	Mn ppm	Mo ppm	Na ppm	Nb ppm	Nd ppm	Ni ppm	P ppm	Pb ppm	Pr ppm	Rb ppm	Sc ppm	Sm ppm	Sr ppm	Th ppm	Ti ppm	Tl ppm	Tm ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm	U/Th
Detection Limit	*< 6*	*< 0.7*	*< 0.05*	*< 20*	*< 0.1*	*< 0.2*	*< 0.3*	*< 5*	*< 0.4*	*< 0.05*	*< 0.01*	*< 0.04*	*< 0.02*	*< 0.8*	*< 0.1*	*< 40*	*< 0.08*	*< 0.006*	*< 0.02*	*< 0.2*	*< 0.05*	*< 0.006*	*< 3*	
Blue Creek basin:																								
DSOR100S1	3,250	674	0.48	171	2.2	21.5	12.4	473	18.1	5.9	36.1	3.8	4.0	26.1	11.5	1,180	0.25	0.14	1.38	30.8	10.4	0.9	61.6	0.120
DSOR100S1-Dup	3,320	691	0.48	177	2.1	21.7	12.6	487	18.1	6.0	36.3	3.9	4.1	26.0	16.4	1,210	0.26	0.15	1.57	31.4	10.6	1.0	62.2	0.096
DSOR100S1-Mean	3,285	683	0.48	174	2.2	21.6	12.5	480	18.1	6.0	36.2	3.9	4.1	26.1	14.0	1,195	0.26	0.15	1.48	31.1	10.5	1.0	61.9	0.106
DSOR101S1	3,380	747	0.50	170	1.5	24.8	14.3	475	13.4	6.7	35.2	4.0	4.6	30.0	13.2	1,170	0.26	0.17	1.46	31.6	11.4	1.1	56.6	0.111
DSOR102S1	3,100	548	0.33	274	2.3	26.4	12.5	627	14.1	6.9	30.5	4.9	5.1	44.6	18.0	1,090	0.22	0.27	25.4	30.9	17.2	1.7	58.2	1.411
DSOR118S1	4,360	391	1.2	150	1.1	28.7	14.2	480	14.6	7.5	37.3	3.7	5.4	23.6	10.9	1,040	0.25	0.18	2.26	30.7	11.8	1.1	58.6	0.207
DSOR119S1	2,920	559	0.43	352	1.7	19.7	8.8	458	12.2	5.2	29.0	3.1	3.9	33.2	11.5	855	0.21	0.17	5.04	22.0	11.7	1.1	49.4	0.438
DSOR120S1	3,430	331	0.26	295	2.0	27.2	9.4	674	22.2	7.4	32.5	3.9	5.3	34.8	26.2	822	0.20	0.28	11.9	27.6	18.8	1.9	80.4	0.454
DSOR121S1	5,060	641	0.53	152	1.7	32.4	12.1	498	22.1	8.8	37.0	3.5	6.3	23.3	16.8	962	0.24	0.25	2.73	27.7	16.9	1.6	90.2	0.163
DSOR126S1	2,360	639	0.44	511	1.5	14.6	9.2	679	14.4	3.8	26.8	3.4	2.8	33.1	6.0	1,120	0.17	0.14	1.93	22.2	8.9	0.9	73.0	0.323
DSOR127S1	3,910	903	0.76	203	2.3	24.8	10.7	611	21.2	6.8	36.7	3.7	4.8	40.4	17.5	956	0.27	0.22	2.32	27.8	14.3	1.4	82.8	0.133
DSOR128S1	3,680	652	0.47	301	2.4	29.6	12.9	617	16.9	7.8	35.9	5.3	5.9	44.6	31.6	1,080	0.23	0.35	13.9	29.9	21.6	2.3	62.1	0.440
DSOR129S1	3,720	648	1.6	258	1.5	32.2	8.1	495	12.1	8.6	22.8	2.8	6.3	32.2	41.0	680	0.24	0.37	43.6	33.0	21.2	2.4	42.8	1.063
DSOR129S1-Dup	3,800	669	1.5	270	1.6	34.5	8.9	507	12.5	9.3	23.2	2.8	6.7	32.8	43.0	703	0.24	0.35	46.5	32.6	20.4	2.3	44.0	1.081
DSOR129S1-Mean	3,760	659	1.6	264	1.6	33.4	8.5	501	12.3	9.0	23.0	2.8	6.5	32.5	42.0	692	0.24	0.36	45.1	32.8	20.8	2.4	43.4	1.073
DSOR131S1	3,580	480	0.64	428	1.4	22.2	9.7	357	16.8	5.8	35.2	4.5	4.5	32.9	10.5	1,140	0.23	0.26	22.3	24.3	16.4	1.7	68.5	2.124
DSOR133S1	3,230	420	0.76	263	1.4	29.2	9.0	444	12.3	7.7	39.7	3.5	5.6	27.3	21.4	835	0.22	0.29	3.39	26.7	18.2	1.9	58.1	0.158
DSOR134S1	4,100	427	0.30	182	1.6	30.0	9.3	456	17.1	8.2	45.3	3.8	5.7	26.3	22.4	939	0.23	0.27	9.52	28.1	18.2	1.8	98.1	0.425
DSOR134S1-Dup	3,870	439	0.31	177	2.0	35.4	9.1	469	17.2	9.6	44.6	3.7	6.8	26.4	25.3	1,000	0.23	0.31	9.27	29.2	18.4	1.9	98.0	0.366
DSOR134S1-Mean	3,985	433	0.31	180	1.8	32.7	9.2	463	17.2	8.9	45.0	3.8	6.3	26.4	23.9	970	0.23	0.29	9.40	28.7	18.3	1.9	98.1	0.394
DSOR135S1	8,500	482	0.49	150	1.2	27.2	13.5	711	18.8	7.2	25.7	3.0	5.3	28.4	13.4	888	0.19	0.16	2.80	27.6	11.4	1.0	67.4	0.209
DSOR136S1	2,810	885	1.6	158	1.8	63.7	24.6	770	14.1	17.8	21.9	2.6	11.2	23.6	121	802	0.14	0.37	45.6	58.7	26.3	2.4	80.6	0.377
DSOR137S1	2,580	14,000	4.0	195	1.1	39.2	295	448	14.2	10.7	30.4	3.4	8.1	24.3	94.9	704	0.25	0.77	166	38.0	49.3	5.5	392	1.749
DSOR313S1	5,390	871	3.8	227	2.4	29.2	24.3	559	19.5	7.6	61.8	7.6	6.5	36.6	28.8	1,080	0.52	0.60	198	45.4	32.9	4.2	72.9	6.875
DSOR313S1-Dup	5,280	856	4.0	224	2.9	28.1	23.7	549	19.3	7.3	60.9	7.6	6.2	37.7	26.1	1,070	0.52	0.56	192	43.9	33.2	4.0	74.9	7.356
DSOR313S1-Mean	5,335	864	3.90	226	2.7	28.7	24.0	554	19.4	7.5	61.4	7.6	6.4	37.2	27.5	1,075	0.52	0.58	195	44.7	33.1	4.1	73.9	7.104
DSOR314S1	3,300	592	2.6	148	2.0	25.7	15.0	451	12.6	6.7	32.6	4.6	5.0	33.4	12.0	1,230	0.24	0.21	8.65	33.4	13.6	1.3	51.4	0.721
DSOR340S1	9,170	540	0.50	159	1.0	27.3	17.3	760	20.3	7.3	25.6	3.8	5.3	41.0	11.7	953	0.20	0.16	1.87	34.4	11.8	1.1	69.1	0.160
DSOR341S1	8,560	453	0.42	131	1.3	26.7	12.8	717	16.8	6.9	20.5	2.8	4.9	32.0	9.4	792	0.15	0.15	1.02	26.4	10.0	0.9	58.0	0.109
DSOR403S1	3,220	958	1.2	269	3.7	40.4	5.6	565	22.9	11.2	53.8	4.1	7.3	33.8	49.4	959	0.33	0.34	20.9	24.6	20.8	2.3	72.2	0.423
DSOR404S1	2,160	529	0.44	388	2.0	14.2	5.7	623	12.7	4.1	28.1	2.4	2.4	26.0	14.9	940	0.20	0.09	1.64	20.0	5.7	0.6	115	0.110
DSOR419S1	2,370	583	0.30	119	2.2	30.7	11.1	263	7.15	8.2	25.2	3.2	5.6	21.1	13.2	1,160	0.19	0.20	1.96	27.9	14.6	1.3	37.9	0.148
DSOR420S1	4,030	707	0.30	154	1.8	32.8	10.8	503	9.77	9.5	54.7	5.3	5.8	25.9	32.6	1,430	0.38	0.25	4.87	33.2	16.5	1.7	71.6	0.149
DSOR421S1	4,280	515	0.56	151	1.5	36.6	10.1	603	16.8	9.9	40.2	4.6	6.8	25.5	20.4	1,130	0.29	0.27	6.05	32.4	18.9	1.8	70.2	0.297
DSOR422S1	2,630	503	0.31	629	1.8	19.0	9.8	402	12.8	5.0	27.7	4.1	3.6	48.8	14.0	1,130	0.20	0.19	4.54	23.6	12.0	1.3	55.7	0.324
DSOR423S1	3,800	726	0.63	258	1.9	28.0	10.4	722	12.1	7.6	43.6	5.1	5.3	37.9	22.5	1,250	0.31	0.26	9.47	29.8	16.7	1.7	61.3	0.421
DSOR425S1	3,380	596	0.65	220	1.5	21.1	11.8	640	13.4	5.7	33.0	4.6	4.0	39.8	10.5	1,250	0.24	0.18	1.98	29.4	11.4	1.1	62.2	0.189
DSOR426S1	3,740	725	0.36	270	1.7	26.8	11.6	357	10.0	7.5	43.9	4.6	5.0	35.1	29.2	1,280	0.31	0.23	4.75	27.9	15.8	1.6	53.9	0.163
DSOR441S1	3,800	960	0.98	248	2.0	32.3	12.7	587	14.7	8.4	41.0	5.2	6.4	30.1	26.4	999	0.30	0.39	22.6	28.5	23.8	2.6	70.0	0.856
DSOR442S1	5,660	716	0.91	395	2.8	14.8	11.5	1,520	17.6	3.8	31.9	4.0	3.0	102	7.6	966	0.21	0.17	8.78	21.5	11.3	1.1	108	1.158
DSOR443S1	3,740	515	0.40	197	1.8	20.0	13.1	574	18.3	5.2	23.2	4.3	3.8	41.9	7.6	1,190	0.17	0.19	2.66	30.2	12.2	1.2	56.3	0.350
DSOR460S1	3,660	828	3.9	206	2.6	29.2	29.0	448	17.5	7.6	48.3	5.4	6.4	27.7	26.2	753	0.38	0.55	127	30.0	32.5	3.9	78.7	4.847
RZAH027S1	2,890	456	0.25	214	1.9	36.0	8.2	538	9.92	10.0	35.5	4.4	6.6	29.8	58.5	929	0.24	0.34	11.8	25.5	22.0	2.4	41.6	0.202
RZAH028S1	2,920	4,060	4.3	170	1.6	29.7	79.9	368	14.2	8.0	42.2	3.8	6.2	18.4	42.9	599	0.32	0.57	102	29.3	33.9	3.8	174	2.378
RZAH037S1	2,670	493	0.32	287	1.5	34.1	11.3	500	13.8	9.2	25.0	4.2	6.6	35.4	60.8	846	0.18	0.34	24.1	30.2	22.5	2.4	43.6	0.396

Table A17. Sample localities and analytical results for elements determined by ICP-MS on 1979 NURE sediment samples collected in the Blue Creek and Sand Creek basins--Continued.

Sample No.	Latitude N.	Longitude W.	Al ppm	As ppm	Ba ppm	Be ppm	Bi ppm	Ca ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cs ppm	Cu ppm	Dy ppm	Er ppm	Eu ppm	Fe ppm	Ga ppm	Gd ppm	Ho ppm	K ppm	La ppm	Li ppm	Lu ppm
Sand Creek basin:																									
DSOR315S1	47.94070	118.11190	27,200	11.6	169	1.1	0.46	3,320	0.16	64.7	10.4	23.1	5.3	29.2	3.7	1.8	1.00	23,200	8.0	5.1	0.68	4,270	32.3	21.8	0.20
DSOR376S1	47.99510	118.05580	23,400	22.8	149	1.1	0.58	2,800	0.15	67.4	9.4	25.6	4.9	24.5	3.0	1.4	1.00	23,300	7.0	4.9	0.54	4,760	36.0	18.5	0.20
DSOR378S1	47.96490	118.12680	25,100	21.5	127	1.0	0.71	3,520	0.09	73.6	9.0	23.4	4.5	38.8	4.7	2.4	1.30	24,100	7.4	6.4	0.90	4,120	38.2	19.6	0.30
DSOR379S1	47.97090	118.12740	26,200	17.3	330	1.1	0.75	5,030	0.26	50.1	9.4	18.5	5.2	38.8	3.1	1.6	0.86	20,900	7.6	4.0	0.60	3,540	22.9	21.3	0.20
DSOR387S1	47.96500	118.11690	32,900	41.3	223	1.9	2.1	2,870	0.24	82.4	16.2	44.0	16.0	39.3	4.6	2.1	1.40	35,400	10	6.9	0.81	10,900	43.7	41.7	0.20
DSOR388S1	47.97140	118.10750	21,400	4.3	152	1.1	2.7	3,740	0.07	48.9	7.8	14.1	3.2	13.4	4.4	2.3	0.82	21,000	6.6	5.1	0.84	2,620	25.2	14.8	0.30
DSOR389S1	47.98200	118.10730	16,100	14.0	159	1.8	32	3,360	0.22	53.2	6.7	10.9	5.3	18.9	4.8	2.4	0.63	19,000	5.5	5.6	0.88	2,690	27.8	17.3	0.30
DSOR395S1	47.95350	118.12600	17,400	8.1	146	0.69	0.66	2,340	0.08	61.7	7.0	18.4	5.0	18.4	2.5	1.1	0.87	20,400	5.6	4.0	0.42	4,340	30.5	16.9	0.10
DSOR398S1	47.97020	118.09850	39,100	42.9	266	2.6	1.0	4,070	0.16	80.6	17.6	36.4	14.9	39.4	3.8	1.6	1.30	41,600	10	6.1	0.64	11,000	44.6	33.2	0.20
DSOR399S1	47.97780	118.10210	30,000	7.6	344	1.1	0.49	5,230	0.28	61.8	11.4	22.1	3.9	24.2	4.1	2.0	1.10	25,100	8.7	5.3	0.73	4,230	31.8	20.7	0.20
DSOR400S1	47.96070	118.09850	24,200	28.8	233	1.5	0.69	4,750	0.33	69.8	11.2	23.6	5.9	34.0	5.0	2.4	1.50	22,300	7.3	7.1	0.90	4,360	39.3	17.6	0.30
DSOR414S1	47.98120	118.04210	16,600	2.9	157	1.4	4.6	2,960	0.14	47.1	6.6	12.4	3.3	12.6	3.6	2.0	0.90	14,700	5.3	4.6	0.68	2,050	28.1	24.4	0.30
DSOR415S1	47.98650	118.03880	25,100	2.8	342	1.1	0.58	4,290	0.25	37.1	6.3	12.9	4.8	12.9	1.6	0.8	0.36	17,300	7.2	2.0	0.28	2,280	16.2	31.2	0.10
DSOR416S1	47.99130	118.04320	21,200	14.8	109	1.5	0.82	2,730	0.10	85.0	10.4	17.1	5.7	18.2	4.2	2.2	1.00	20,500	6.7	5.9	0.77	2,390	41.8	24.6	0.40
DSOR417S1	47.99860	118.04330	44,100	4.0	432	1.7	0.34	3,490	0.20	42.7	7.8	18.6	4.4	27.8	3.3	1.8	0.80	23,800	11	3.8	0.63	2,410	24.5	36.2	0.30
DSOR418S1	47.99860	118.03500	32,200	18.3	290	1.0	0.43	5,320	0.32	44.7	9.9	14.0	3.2	26.2	2.4	1.2	0.71	20,800	8.8	3.3	0.45	1,900	18.7	22.7	0.10
DSOR424S1	47.95150	118.06920	27,400	8.5	358	3.0	2.0	9,360	0.36	98.7	11.0	18.7	5.3	22.6	9.0	5.2	1.80	26,600	9.4	11	1.8	4,790	61.2	40.2	0.80
DSOR438S1	47.95390	118.08040	33,900	44.4	144	2.0	0.79	9,620	0.22	79.7	17.5	28.8	8.6	43.2	5.8	3.1	1.40	37,400	10	6.8	1.1	4,230	37.2	33.7	0.40
DSOR439S1	47.95830	118.07870	20,900	37.3	257	0.70	0.67	4,680	0.29	55.2	6.4	14.5	4.7	23.9	1.8	0.7	0.51	22,100	6.6	2.8	0.26	2,770	26.6	11.0	< 0.1
DSOR440S1	47.96030	118.08270	30,500	182	324	1.3	2.4	4,090	0.65	76.1	20.4	19.6	7.7	46.9	6.3	3.2	1.70	31,800	9.0	8.0	1.2	2,710	44.0	19.2	0.40
DSOR445S1	47.98400	118.05540	28,100	7.7	172	1.8	0.62	2,890	0.23	78.7	10.4	19.9	6.0	21.2	3.1	1.3	1.00	23,200	7.6	5.2	0.53	6,540	40.3	23.0	0.20
DSOR446S1	47.97940	118.05700	31,100	7.0	343	1.4	0.65	2,930	0.19	59.0	10.6	24.6	5.7	23.5	1.9	0.7	0.65	25,700	9.0	3.4	0.29	4,900	26.9	21.3	< 0.1
DSOR447S1	47.97440	118.06340	32,700	10.1	296	1.7	0.51	4,620	0.59	65.5	14.4	26.6	5.6	34.7	5.4	2.7	1.80	28,700	9.7	7.6	1.0	3,830	41.3	26.5	0.30
DSOR448S1	47.96790	118.07090	47,000	76.3	226	2.0	1.4	4,610	0.52	92.7	41.1	33.0	13.8	61.9	5.7	2.8	1.60	49,500	13	7.0	1.0	6,310	41.1	29.5	0.30
DSOR449S1	47.96440	118.06300	17,400	2.1	192	1.1	0.21	3,030	0.22	64.0	7.1	9.8	5.2	9.0	3.3	1.8	0.66	17,800	6.7	4.1	0.62	3,910	36.0	32.5	0.30
DSOR450S1	47.98130	118.06960	38,200	80.6	207	2.0	1.1	4,650	0.14	68.6	19.6	41.0	15.1	40.2	3.3	1.3	1.10	39,800	10	4.8	0.53	10,200	34.0	25.6	0.10
DSOR451S1	47.98600	118.07210	29,200	25.2	199	1.5	0.62	4,170	0.20	81.0	12.0	25.5	6.0	26.5	5.0	2.4	1.60	27,100	8.1	7.3	0.91	5,870	44.7	29.3	0.30
DSOR451S1-Dup	47.98600	118.07210	26,700	23.0	184	1.3	0.62	3,840	0.17	79.3	10.6	23.5	5.7	24.2	4.7	2.3	1.50	24,000	7.3	6.9	0.83	5,550	43.7	27.4	0.30
DSOR451S1-Mean	47.98600	118.07210	27,950	24.1	192	1.4	0.62	4,000	0.19	80.2	11.3	24.5	5.9	25.4	4.9	2.4	1.55	25,550	7.7	7.1	0.87	5,710	44.2	28.4	0.30
DSOR452S1	47.99060	118.07960	33,900	62.7	357	1.4	3.3	5,160	0.61	50.2	18.6	27.0	14.6	42.1	2.8	1.3	0.78	34,600	10	3.4	0.48	6,860	23.0	27.2	0.20
DSOR455S1	47.97710	118.08290	16,600	21.3	110	1.0	0.52	1,910	0.06	57.4	7.5	14.6	5.0	20.1	2.3	1.0	0.75	19,700	5.2	3.7	0.40	4,380	28.7	13.1	0.10
DSOR455S1-Dup	47.97710	118.08290	16,700	21.4	108	0.91	0.55	1,940	0.10	55.1	7.0	14.5	4.9	19.4	2.2	0.9	0.73	19,000	5.2	3.5	0.36	4,320	28.2	13.1	0.10
DSOR455S1-Mean	47.97710	118.08290	16,650	21.4	109	0.94	0.54	1,925	0.08	56.3	7.3	14.6	5.0	19.8	2.3	1.0	0.74	19,350	5.2	3.6	0.38	4,350	28.5	13.1	0.10
DSOR456S1	47.97060	118.08940	21,100	79.2	143	1.4	1.8	3,300	0.14	76.7	10.7	20.8	7.3	27.4	3.7	1.7	1.20	25,500	6.5	5.6	0.66	4,960	38.0	21.5	0.20
DSOR457S1	47.95280	118.10830	13,400	12.4	34	1.0	0.86	887	0.06	69.7	7.3	15.3	10.5	55.2	2.5	1.0	0.80	24,500	5.1	4.2	0.38	4,040	44.5	6.7	0.10
DSOR457S1-Dup	47.95280	118.10830	15,200	13.4	38	1.1	0.90	890	0.15	78.6	7.6	16.5	11.0	58.3	2.7	1.0	0.92	25,900	5.6	4.8	0.42	4,210	48.4	7.2	0.10
DSOR457S1-Mean	47.95280	118.10830	14,300	12.9	36	1.0	0.88	889	0.11	74.2	7.5	15.9	10.8	56.8	2.6	1.0	0.86	25,200	5.4	4.5	0.40	4,125	46.5	7.0	0.10
DSOR458S1	47.95190	118.10030	25,100	97.4	197	1.6	1.8	3,210	0.21	78.3	21.6	21.0	6.5	39.1	5.0	2.6	1.10	33,300	8.3	6.2	0.93	3,890	39.8	23.2	0.30
DSOR458S1-Dup	47.95190	118.10030	25,100	99.4	201	1.7	1.9	3,170	0.22	77.0	21.8	21.6	6.5	40.3	5.0	2.7	1.20	33,200	8.8	6.2	0.96	3,880	38.8	25.0	0.40
DSOR458S1-Mean	47.95190	118.10030	25,100	98.4	199	1.7	1.8	3,190	0.22	77.7	21.7	21.3	6.5	39.7	5.0	2.7	1.15	33,250	8.6	6.2	0.95	3,885	39.3	24.1	0.35
RZAH021S1	47.96520	118.12430	21,500	39.1	111	0.85	0.53	3,760	0.08	87.2	15.0	21.2	3.9	32.1	4.2	1.8	1.20	26,100	6.7	6.0	0.73	3,300	41.2	16.6	0.20
RZAH021S1-Dup	47.96520	118.12430	19,700	40.4	111	0.87	0.57	3,590	0.08	87.8	14.8	20.9	4.0	32.7	4.5	2.1	1.40	25,600	6.4	6.4	0.79	3,150	42.2	17.8	0.20
RZAH021S1-Mean	47.96520	118.12430	20,600	39.8	111	0.86	0.55	3,675	0.08	87.5	14.9	21.1	4.0	32.4	4.4	2.0	1.30	25,850	6.6	6.2	0.76	3,225	41.7	17.2	0.20

Table A17. Sample localities and analytical results for elements determined by ICP-MS on 1979 NURE sediment samples collected in the Blue Creek and Sand Creek basins--Continued.

Sample No.	Mg ppm	Mn ppm	Mo ppm	Na ppm	Nb ppm	Nd ppm	Ni ppm	P ppm	Pb ppm	Pr ppm	Rb ppm	Sc ppm	Sm ppm	Sr ppm	Th ppm	Ti ppm	Tl ppm	Tm ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm	U/Th
Sand Creek basin:																								
DSOR315S1	3,890	560	0.90	206	1.0	31.2	18.7	470	12.4	8.2	41.9	5.6	6.2	29.4	10.3	1,340	0.29	0.26	3.06	39.1	16.9	1.60	49.6	0.297
DSOR376S1	5,160	356	0.39	243	0.77	32.5	22.4	588	8.6	8.6	52.7	4.6	6.1	24.7	10.8	1,300	0.36	0.18	2.02	34.6	12.8	1.10	44.8	0.187
DSOR378S1	4,970	483	0.36	201	0.67	35.7	18.2	388	16.0	9.2	40.7	5.7	7.1	30.0	10.2	1,530	0.32	0.33	2.40	44.5	22.7	2.00	51.1	0.235
DSOR379S1	6,770	522	0.42	384	0.81	23.2	16.0	567	20.4	5.9	40.2	4.7	4.7	24.6	6.6	1,480	0.28	0.22	0.97	33.4	14.5	1.40	49.8	0.148
DSOR387S1	8,920	684	4.4	154	1.1	42.2	33.2	481	13.7	10.9	120	7.0	8.3	26.8	13.8	2,060	0.92	0.29	2.68	53.9	19.4	1.70	72.9	0.194
DSOR388S1	3,700	532	0.77	200	1.1	25.2	10.8	562	12.1	6.3	28.6	4.9	5.6	38.3	10.6	1,270	0.21	0.32	2.04	40.5	20.5	2.10	43.2	0.192
DSOR389S1	2,930	591	3.5	252	1.2	27.3	9.2	558	24.4	6.9	39.4	3.3	6.1	23.5	17.8	1,110	0.28	0.35	3.19	36.3	21.8	2.20	49.0	0.179
DSOR395S1	4,560	313	0.40	132	0.56	28.3	15.8	459	11.6	7.4	37.3	3.6	5.2	21.3	10.5	1,050	0.26	0.16	1.41	28.8	10.1	0.95	51.6	0.134
DSOR398S1	7,110	716	1.7	181	1.5	40.1	32.5	809	12.1	10.8	104	6.0	7.6	40.5	14.9	1,850	0.89	0.21	2.18	44.5	15.0	1.30	85.2	0.146
DSOR399S1	3,890	887	0.85	249	2.2	30.6	19.8	751	17.1	8.0	43.9	6.2	6.1	56.7	9.6	1,700	0.32	0.27	2.09	39.1	18.5	1.70	74.9	0.217
DSOR400S1	3,820	769	0.84	282	1.6	39.2	20.1	808	25.5	10.2	46.6	5.1	8.0	41.0	10.2	1,470	0.35	0.32	2.68	35.6	22.8	1.90	70.7	0.263
DSOR414S1	2,530	700	0.69	193	1.7	26.1	10.4	508	14.3	6.7	30.5	4.2	5.3	32.7	13.7	856	0.22	0.29	36.6	24.9	17.4	2.10	44.0	2.672
DSOR415S1	2,910	1,150	0.52	327	3.6	13.7	12.4	1,050	18.7	3.6	37.9	4.3	2.6	38.7	10.4	1,180	0.29	0.13	4.06	26.5	7.2	0.88	85.1	0.390
DSOR416S1	2,870	491	0.87	236	2.0	38.7	15.7	455	17.2	10.5	35.9	4.1	7.5	24.7	24.7	1,090	0.31	0.34	18.9	33.8	19.2	2.30	38.1	0.765
DSOR417S1	3,710	656	0.36	684	0.79	21.4	22.6	843	14.9	5.6	33.9	5.7	4.3	44.6	9.4	1,680	0.26	0.26	7.22	35.2	15.5	1.70	79.6	0.766
DSOR418S1	2,390	596	0.84	512	2.2	18.4	20.4	1,330	18.3	4.7	22.4	4.2	3.7	53.8	6.1	1,320	0.24	0.18	1.94	28.7	11.1	1.00	75.2	0.318
DSOR424S1	5,010	1,710	1.5	222	3.4	54.7	18.6	870	22.4	14.3	59.8	8.3	11.6	56.0	45.2	1,620	0.41	0.83	23.9	41.3	49.5	5.40	95.6	0.529
DSOR438S1	6,010	829	1.5	210	0.85	36.6	33.1	754	16.1	9.2	49.4	7.7	7.4	38.7	12.9	1,220	0.32	0.42	3.48	42.4	29.3	2.70	72.9	0.270
DSOR439S1	2,560	510	2.9	159	1.8	21.8	13.9	921	19.9	6.0	31.2	3.7	4.0	37.1	9.3	904	0.28	0.09	2.26	33.8	6.3	0.53	41.9	0.244
DSOR440S1	3,260	735	3.1	123	1.1	42.6	43.4	773	24.6	10.7	56.5	6.0	8.6	36.1	12.5	1,190	0.47	0.43	13.7	39.6	35.7	2.50	68.0	1.096
DSOR445S1	6,340	463	0.51	268	1.2	35.8	20.4	608	8.6	9.4	66.6	4.3	6.8	27.9	15.4	1,620	0.42	0.17	2.57	27.9	12.2	1.00	54.4	0.167
DSOR446S1	4,540	571	0.43	353	1.0	24.6	20.7	1,120	10.8	6.5	61.5	4.8	4.4	29.9	9.8	1,800	0.39	0.09	1.17	37.8	6.1	0.50	73.3	0.120
DSOR447S1	4,200	708	1.2	288	1.6	41.7	33.3	1,070	16.9	10.6	50.3	6.3	8.6	43.7	11.0	1,450	0.41	0.36	11.2	44.4	25.1	2.20	126	1.018
DSOR448S1	7,730	1,170	2.5	168	0.81	39.0	52.2	1,130	18.6	10.0	82.2	8.2	8.0	43.6	13.0	1,780	0.68	0.39	4.02	59.2	25.6	2.30	118	0.309
DSOR449S1	3,760	1,230	0.48	158	2.2	27.6	9.8	500	16.3	7.6	62.3	4.9	5.1	31.0	31.5	1,240	0.38	0.28	5.36	27.6	16.7	1.90	57.9	0.170
DSOR450S1	8,370	784	0.63	155	1.9	30.7	34.2	1,200	11.3	8.0	93.6	6.9	6.0	39.0	11.5	1,750	0.68	0.18	1.48	59.1	12.4	1.00	61.2	0.129
DSOR451S1	5,860	597	0.47	253	1.5	43.1	23.7	645	14.0	11.0	53.2	4.9	8.7	34.5	11.5	1,500	0.40	0.33	4.70	35.4	22.3	2.00	55.1	0.409
DSOR451S1-Dup	5,390	531	0.50	254	1.7	42.3	21.5	590	13.0	11.0	50.8	4.6	8.5	32.0	10.8	1,430	0.39	0.30	4.28	33.0	20.4	1.90	49.1	0.396
DSOR451S1-Mean	5,625	564	0.49	254	1.6	42.7	22.6	618	13.5	11.0	52.0	4.8	8.6	33.3	11.2	1,465	0.40	0.32	4.49	34.2	21.4	1.95	52.1	0.403
DSOR452S1	5,750	1,060	0.69	273	0.44	20.8	30.8	1,320	30.1	5.4	79.2	5.9	4.1	51.5	8.6	1,910	0.61	0.18	1.33	59.8	12.0	1.10	91.8	0.154
DSOR455S1	3,480	300	0.45	183	0.10	25.8	14.2	425	7.4	6.8	44.1	2.8	4.8	22.2	10.0	1,070	0.35	0.13	1.49	25.3	9.2	0.79	33.5	0.149
DSOR455S1-Dup	3,420	289	0.40	185	0.20	25.1	13.6	424	8.0	6.5	43.1	2.6	4.7	21.6	9.2	1,080	0.34	0.12	1.41	25.2	8.8	0.77	32.0	0.153
DSOR455S1-Mean	3,450	295	0.43	184	0.15	25.5	13.9	425	7.7	6.7	43.6	2.7	4.8	21.9	9.6	1,075	0.35	0.13	1.45	25.3	9.0	0.78	32.8	0.151
DSOR456S1	4,930	440	0.54	160	1.3	35.3	18.9	575	12.8	9.2	55.8	4.1	6.8	27.8	13.6	1,190	0.50	0.23	3.01	33.6	15.0	1.30	49.6	0.221
DSOR457S1	2,670	91	0.79	35	0.43	34.1	10.3	190	4.8	9.1	74.5	3.8	5.9	8.2	13.4	626	0.60	0.13	3.64	21.7	8.0	0.85	16.0	0.272
DSOR457S1-Dup	2,710	96	0.98	34	0.29	38.0	11.3	201	4.9	10.5	77.0	4.2	6.6	8.5	14.5	683	0.62	0.14	3.93	23.3	8.9	0.91	17.0	0.271
DSOR457S1-Mean	2,690	93	0.89	35	0.36	36.1	10.8	196	4.8	9.8	75.8	4.0	6.3	8.4	14.0	655	0.61	0.14	3.79	22.5	8.5	0.88	16.5	0.271
DSOR458S1	3,940	780	8.6	88	1.2	36.9	34.4	592	14.8	9.5	54.4	6.1	7.4	31.3	19.1	1,070	0.42	0.38	7.88	40.2	23.2	2.40	52.4	0.413
DSOR458S1-Dup	3,800	775	9.2	87	1.2	37.1	35.6	576	15.6	9.9	56.8	6.3	7.5	32.6	19.4	1,120	0.44	0.40	8.16	41.4	23.9	2.50	53.7	0.421
DSOR458S1-Mean	3,870	778	8.9	87	1.2	37.0	35.0	584	15.2	9.7	55.6	6.2	7.5	32.0	19.3	1,095	0.43	0.39	8.02	40.8	23.6	2.45	53.1	0.417
RZAH021S1	4,320	628	0.54	152	0.34	38.4	17.6	431	13.8	9.8	31.0	4.7	7.4	24.7	11.6	1,500	0.26	0.25	1.76	46.7	17.1	1.50	38.3	0.152
RZAH021S1-Dup	4,090	609	0.54	130	0.38	41.5	18.3	412	15.0	11.0	31.8	4.6	8.0	25.0	11.7	1,340	0.28	0.27	1.81	46.2	17.9	1.60	37.9	0.155
RZAH021S1-Mean	4,205	619	0.54	141	0.36	40.0	18.0	422	14.4	10.4	31.4	4.7	7.7	24.9	11.7	1,420	0.27	0.26	1.79	46.5	17.5	1.55	38.1	0.153

Table A18. Geochemical data and statistical summary of analytical results from duplicate sediment samples from the Blue Creek delta.

[All concentrations are reported in parts per million (ppm). Data interpretation qualifiers: J, value is estimated quantity; U, analyte was analyzed but not detected at the detection limit; --, no data; Std. Dev., standard deviation. Certified analytical results from ACE Laboratory]

Sample No.	Latitude (UTM)	Longitude (UTM)	Al	Interp Qual	Sb	Interp Qual	As	Interp Qual	Ba	Interp Qual	Be	Interp Qual	Cd	Interp Qual	Ca	Interp Qual	Cr	Interp Qual	Co	Interp Qual	Cu	Interp Qual	Fe	Interp Qual	Pb	Interp Qual
			ppm		ppm		ppm		ppm		ppm		ppm		ppm		ppm		ppm		ppm		ppm		ppm	
Detection Limit			*3*		*0.2*		*0.3*		*0.3*		*0.2*		*0.05*		*20*		*1*		*1*		*1*		*1*		*0.05*	
LR05092005-007	5304458.6	414711.21	26,500		0.4	J	11.5		166	J	1.3		2.65		6,980		24		15		26		31,100		54.6	
LR05092005-008	5304458.6	414711.21	26,000		0.4	J	11.8		162	J	1.2		2.71		6,350		23		14		26		31,000		55.5	
LR05092005-009	5304458.6	414711.21	28,000		0.4	J	11.8		164	J	1.4		3.13		7,000		24		15		28		32,100		56.4	
Mean			26,833		0.4		11.7		164		1.3		2.83		6,777		24		15		27		31,400		55.5	
Std. Dev.			1,041		--		0.17		2		0.1		0.26		370		0.58		0.58		1.15		608		0.9	
RSD			0.039		--		0.01		0.01		0.08		0.09		0.05		0.02		0.04		0.04		0.02		0.02	
LR05092005-011	5304514.4	414732.32	23,100		0.4	J	22.6		177	J	1		2.76		6,550		23		10		28		39,500		48	
LR05092005-012	5304514.4	414732.32	22,300		0.4	J	20.6		179	J	1	J	2.38		5,720		23		10		26		39,100		45.1	
LR05092005-013	5304514.4	414732.32	22,800		0.4	J	21.2		184	J	1		2.48		5,360		24		11		29		40,200		47.3	
Mean			22,733		0.4		21.5		180		1		2.54		5,877		23		10		28		39,600		46.8	
Std. Dev.			404		--		1.03		3.6		--		0.20		610		0.58		0.58		1.53		557		1.51	
RSD			0.018		--		0.05		0.02		--		0.08		0.10		0.02		0.06		0.06		0.01		0.03	

Table A18. Geochemical data and statistical summary of analytical results from duplicate sediment samples from the Blue Creek delta--Continued.

Sample ID	Mg	Interp Qual	Mn	Interp Qual	Hg	Interp Qual	Mo	Interp Qual	Ni	Interp Qual	K	Interp Qual	Se	Interp Qual	Si	Interp Qual	Ag	Interp Qual	Na	Interp Qual	Ta	Interp Qual	Utot	Interp Qual	V	Interp Qual	Zn	Interp Qual
	ppm		ppm		ppm		ppm		ppm		ppm		ppm		ppm		ppm		ppm		ppm		ppm		ppm		ppm	
Detection Limit	*20*		*0.5*		*0.07*		*1*		*1*		*30*		*0.5*		*20*		*0.5*		*30*		*0.05*		*0.05*		*0.5*		*1*	
LR05092005-007	7,940		847		0.07	U	2	J	27		3,870		0.5	U	3,210	J	0.5	U	300		0.35		9.63		42.6		749	
LR05092005-008	7,830		768		0.09	U	2	J	24		3,810		0.5	U	4,470	J	0.5	U	300		0.33		7.98		41		715	
LR05092005-009	7,910		887		0.08	U	1	J	29		3,970		0.5	U	4,760	J	0.5	U	300		0.36		9.38		43		746	
Mean	7,893		834		0.080		1.7		27		3,883		0.5		4,147		0.5		300		0.35		9.00		42.2		737	
Std. Dev.	57		61		0.010		0.58		2.52		81		--		824		--		--		0.02		0.89		1.06		19	
RSD	0.01		0.07		0.125		0.35		0.09		0.02		--		0.20		--		--		0.04		0.10		0.03		0.03	
LR05092005-011	8,280		403		0.06	U	2	J	17		4,070		0.5	U	3,830	J	0.5	U	260		0.31		3.47		42		593	
LR05092005-012	8,060		355		0.05	U	1	J	17		3,910		0.5	U	4,060	J	0.5	U	270		0.3	J	2.85		41		551	
LR05092005-013	8,190		340		0.06	U	1	U	18		3,960		0.5	U	4,300	J	0.5	U	280		0.31		2.99		41.4		614	
Mean	8,177		366		0.057		1.3		17		3,980		0.5		4,063		0.5		270		0.31		3.10		41.5		586	
Std. Dev.	111		33		0.006		0.58		0.58		82		--		235		--		10		0.01		0.33		0.50		32	
RSD	0.01		0.09		0.102		0.43		0.03		0.02		--		0.06		--		0.04		0.02		0.10		0.01		0.05	

Table A19. Radionuclide data from ACE Laboratory for duplicate samples, 2005 AESE, Inc., study of sediment samples from the Blue Creek delta.

[All concentrations are reported in picocuries per gram (pCi/g); Error is the counting error in pCi/g; LLD is the lower limit of detection for the method. Data qualifiers: J, value is estimated quantity; U, analyte was analyzed but not detected at the detection limit; UJ, analyte was analyzed but not detected above the detection limit]

Sample ID	Latitude (UTM)	Longitude (UTM)	^{210}Pb	Error	LLD	Interp Qual	^{210}Po	Error	LLD	Interp Qual	^{226}Ra	Error	LLD	Interp Qual	^{228}Ra	Error	LLD	Interp Qual	^{228}Th	Error	LLD	Interp Qual
LR05092005-007	5304458.6	414711.21	0.0	2.0	5.4	UJ	3.4	0.7	1.1	J	3.6	0.7	1.0		1.0	1.3	3.8	J	2.1	0.41	0.26	
LR05092005-008	5304458.6	414711.21	1.8	2.2	6.0	J	3.6	0.7	1.1	J	3.4	0.7	1.1		1.3	1.4	3.8	J	1.1	0.30	0.32	
LR05092005-009	5304458.6	414711.21	4.1	2.2	5.9	J	3.0	0.6	0.8	J	3.0	0.6	0.9		2.5	1.5	3.6	J	1.7	0.37	0.27	
Mean			2.0				3.3				3.3				1.6				1.6			
Std. Dev.			2.1				0.3				0.3				0.8				0.5			
RSD			1.0				0.1				0.1				0.5				0.3			
LR05092005-011	5304514.4	414732.32	3.8	1.6	4.0	J	3.3	0.8	1.4	J	2.4	0.6	1.0		1.8	1.2	3.1	J	1.6	0.38	0.25	
LR05092005-012	5304514.4	414732.32	0.0	2.0	5.3	UJ	2.9	0.7	1.3	J	2.4	0.6	1.0		2.2	1.1	3.0	J	1.5	0.37	0.25	
LR05092005-013	5304514.4	414732.32	2.5	2.3	6.3	J	1.8	0.5	0.8	J	2.3	0.6	1.0		1.1	1.1	3.0	J	1.6	0.39	0.22	
Mean			2.1				2.7				2.4				1.7				1.6			
Std. Dev.			1.9				0.8				0.1				0.6				0.1			
RSD			0.9				0.3				0.0				0.3				0.0			

Table A19. Radionuclide data from ACE Laboratory for duplicate samples, 2005 AESE, Inc., study of sediment samples from the Blue Creek delta--Continued.

Sample ID	^{230}Th	Error	LLD	Interp Qual	^{232}Th	Error	LLD	Interp Qual	^{234}U	Error	LLD	Interp Qual	^{235}U	Error	LLD	Interp Qual	^{238}U	Error	LLD	Interp Qual
LR05092005-007	2.1	0.67	0.67		1.36	0.56	0.26		4.0	0.58	0.19		0.26	0.21	0.19		3.78	0.60	0.19	
LR05092005-008	1.9	0.77	0.84		1.78	0.71	0.32		3.0	0.47	0.22		0.30	0.21	0.22		3.34	0.53	0.22	
LR05092005-009	2.8	0.77	0.72		1.79	0.64	0.27		2.9	0.48	0.21		0.14	0.19	0.21	J	3.51	0.56	0.21	
Mean	2.27				1.64				3.3				0.23				3.54			
Std. Dev.	0.47				0.25				0.6				0.08				0.22			
RSD	0.21				0.15				0.2				0.36				0.06			
LR05092005-011	0.81	0.52	0.66		1.3	0.55	0.25		1.2	0.35	0.16	U	0.09	0.18	0.16	J	1.56	0.44	0.16	
LR05092005-012	0.47	0.48	0.66	J	1.84	0.61	0.25		1.0	0.3	0.19	U	0.15	0.19	0.19	J	1.31	0.39	0.19	
LR05092005-013	0.66	0.45	0.58		1.12	0.48	0.22		1.4	0.37	0.17	U	0.20	0.2	0.17		1.16	0.39	0.17	
Mean	0.65				1.42				1.2				0.15				1.34			
Std. Dev.	0.17				0.37				0.2				0.06				0.20			
RSD	0.26				0.26				0.2				0.38				0.15			

Table A20. Geochemical background statistical data and calculations, Case I.

[Concentrations are reported in parts per million (ppm); Std. Dev., Standard Deviation; CV, coefficient of variation; UCL95, 95th upper confidence limit of the mean calculated from log-transformed data; samples indicated by S1* are the mean value of duplicate analyses; blanks in data set indicate outliers rejected for the statistical calculations. Statistical descriptions are shown in graphic form for each element following the table]

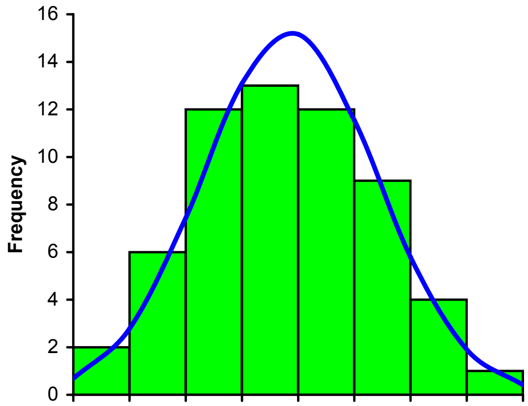
Sample No.	Al ppm	As ppm	Ba ppm	Ca ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cu ppm	Fe ppm	K ppm	Mg ppm	Mn ppm	Mo ppm	Na ppm	Ni ppm	P ppm	Pb ppm	Sr ppm	Th ppm	Ti ppm	U ppm	V ppm	Zn ppm	U/Th
DSOR404S1	14,700	2.3	170	2,520	0.19	29.3	2.9	7.4	8.3	12,400	2,190	2,160	529	0.44	388	5.7	623	12.7	26.0	14.9	940	1.6	20.0	115	0.11
DSOR415S1[1]	25,100	2.8	342	4,290	0.25	37.1	6.3	12.9	12.9	17,300	2,280	2,910	1,150	0.52	327	12.4	1,050	18.7	38.7	10.4	1,180	4.1	26.5	85.1	0.39
DSOR126S1	25,400	3.9	194	3,280	0.26	38.8	5.0	10.1	21.7	15,000	3,230	2,360	639	0.44	511	9.2	679	14.4	33.1	6.0	1,120	1.9	22.2	73.0	0.32
DSOR417S1[1]	44,100	4.0	432	3,490	0.20	42.7	7.8	18.6	27.8	23,800	2,410	3,710	656	0.36	684	22.6	843	14.9	44.6	9.4	1,680	7.2	35.2	79.6	0.77
DSOR418S1[1]	32,200	18.3	290	5,320	0.32	44.7	9.9	14.0	26.2	20,800	1,900	2,390	596	0.84	512	20.4	1,330	18.3	53.8	6.1	1,320	1.9	28.7	75.2	0.32
DSOR443S1	19,800	3.9	202	5,630	0.33	44.9	7.4	18.4	16.5	17,200	3,490	3,740	515	0.40	197	13.1	574	18.3	41.9	7.6	1,190	2.7	30.2	56.3	0.35
DSOR414S1[1]	16,600	2.9	157	2,960	0.14	47.1	6.6	12.4	12.6	14,700	2,050	2,530	700	0.69	193	10.4	508	14.3	32.7	13.7	856		24.9	44.0	
DSOR422S1	25,600	2.2	167	4,370	0.26	47.4	4.8	11.4	14.7	15,300	2,670	2,630	503	0.31	629	9.8	402	12.8	48.8	14.0	1,130	4.5	23.6	55.7	0.32
DSOR388S1	21,400	4.3	152	3,740	0.07	48.9	7.8	14.1	13.4	21,000	2,620	3,700	532	0.77	200	10.8	562	12.1	38.3	10.6	1,270	2.0	40.5	43.2	0.19
DSOR425S1	23,500	3.4	218	3,550	0.44	49.4	7.5	15.3	15.4	18,500	3,400	3,380	596	0.65	220	11.8	640	13.4	39.8	10.5	1,250	2.0	29.4	62.2	0.19
DSOR379S1	26,200	17.3	330	5,030	0.26	50.1	9.4	18.5	38.8	20,900	3,540	6,770	522	0.42	384	16.0	567	20.4	24.6	6.6	1,480	1.0	33.4	49.8	0.15
DSOR452S1	33,900	62.7	357	5,160	0.61	50.2	18.6	27.0	42.1	34,600	6,860	5,750	1,060	0.69	273	30.8	1,320	30.1	51.5	8.6	1,910	1.3	59.8	91.8	0.15
DSOR389S1	16,100	14.0	159	3,360	0.22	53.2	6.7	10.9	18.9	19,000	2,690	2,930	591		252	9.2	558	24.4	23.5	17.8	1,110	3.2	36.3	49.0	0.18
DSOR119S1	16,700	3.0	132	3,360	0.11	53.5	5.9	10.2	11.4	14,500	2,700	2,920	559	0.43	352	8.8	458	12.2	33.2	11.5	855	5.0	22.0	49.4	0.44
DSOR100S1*	18,200	3.6	154	2,780	0.31	54.8	7.3	14.6	13.0	17,600	3,165	3,285	683	0.48	174	12.5	480	18.1	26.1	14.0	1,195	1.5	31.1	61.9	0.11
DSOR439S1[2]	20,900	37.3	257	4,680	0.29	55.2	6.4	14.5	23.9	22,100	2,770	2,560	510	2.90	159	13.9	921	19.9	37.1	9.3	904	2.3	33.8	41.9	0.24
DSOR455S1*	16,650	21.4	109	1,925	0.08	56.3	7.3	14.6	19.8	19,350	4,350	3,450	295	0.43	184	13.9	425	7.7	21.9	9.6	1,075	1.5	25.3	32.8	0.15
DSOR446S1	31,100	7.0	343	2,930	0.19	59.0	10.6	24.6	23.5	25,700	4,900	4,540	571	0.43	353	20.7	1,120	10.8	29.9	9.8	1,800	1.2	37.8	73.3	0.12
DSOR101S1	18,500	3.0	190	3,470	0.14	60.6	8.7	15.7	15.0	18,300	3,670	3,380	747	0.50	170	14.3	475	13.4	30.0	13.2	1,170	1.5	31.6	56.6	0.11
DSOR341S1	11,700	20.0	98	15,000	0.18	61.2	7.1	15.6	18.5	20,400	2,570	8,560	453	0.42	131	12.8	717	16.8	32.0	9.4	792	1.0	26.4	58.0	0.11
DSOR395S1	17,400	8.1	146	2,340	0.08	61.7	7.0	18.4	18.4	20,400	4,340	4,560	313	0.40	132	15.8	459	11.6	21.3	10.5	1,050	1.4	28.8	51.6	0.13
DSOR399S1	30,000	7.6	344	5,230	0.28	61.8	11.4	22.1	24.2	25,100	4,230	3,890	887	0.85	249	19.8	751	17.1	56.7	9.6	1,700	2.1	39.1	74.9	0.22
DSOR419S1	11,900	1.7	135	2,000	0.10	63.4	5.8	13.5	9.3	13,000	2,130	2,370	583	0.30	119	11.1	263	7.2	21.1	13.2	1,160	2.0	27.9	37.9	0.15
DSOR127S1	15,500	4.6	167	4,840	0.35	63.8	6.5	12.6	12.4	17,700	3,790	3,910	903	0.76	203	10.7	611	21.2	40.4	17.5	956	2.3	27.8	82.8	0.13
DSOR449S1[1]	17,400	2.1	192	3,030	0.22	64.0	7.1	9.8	9.0	17,800	3,910	3,760	1,230	0.48	158	9.8	500	16.3	31.0	31.5	1,240	5.4	27.6	57.9	0.17
DSOR315S1	27,200	11.6	169	3,320	0.16	64.7	10.4	23.1	29.2	23,200	4,270	3,890	560	0.90	206	18.7	470	12.4	29.4	10.3	1,340	3.1	39.1	49.6	0.30
DSOR447S1[1]	32,700	10.1	296	4,620	0.59	65.5	14.4	26.6	34.7	28,700	3,830	4,200	708	1.20	288	33.3	1,070	16.9	43.7	11.0	1,450		44.4	126	
DSOR426S1	20,400	1.7	183	2,680	0.17	66.1	5.7	13.4	10.8	16,900	3,190	3,740	725	0.36	270	11.6	357	10.0	35.1	29.2	1,280	4.8	27.9	53.9	0.16
DSOR423S1	23,800	2.7	201	3,720	0.23	66.8	7.2	14.1	14.9	18,400	4,060	3,800	726	0.63	258	10.4	722	12.1	37.9	22.5	1,250	9.5	29.8	61.3	0.42
DSOR376S1	23,400	22.8	149	2,800	0.15	67.4	9.4	25.6	24.5	23,300	4,760	5,160	356	0.39	243	22.4	588	8.6	24.7	10.8	1,300	2.0	34.6	44.8	0.19
DSOR135S1	13,000	21.2	102	12,200	0.27	67.6	7.4	16.4	18.4	21,700	2,720	8,500	482	0.49	150	13.5	711	18.8	28.4	13.4	888	2.8	27.6	67.4	0.21
DSOR450S1	38,200		207	4,650	0.14	68.6	19.6	41.0	40.2	39,800	10,200	8,370	784	0.63	155	34.2	1,200	11.3	39.0	11.5	1,750	1.5	59.1	61.2	0.13
DSOR340S1	14,100	20.2	137	19,400	0.23	68.7	9.8	19.6	22.8	24,900	2,880	9,170	540	0.50	159	17.3	760	20.3	41.0	11.7	953	1.9	34.4	69.1	0.16
DSOR400S1	24,200	28.8	233	4,750	0.33	69.8	11.2	23.6	34.0	22,300	4,360	3,820	769	0.84	282	20.1	808	25.5	41.0	10.2	1,470	2.7	35.6	70.7	0.26
DSOR118S1	15,700	7.9	133	2,660	0.16	70.1	6.8	17.1	16.6	19,800	4,250	4,360	391	1.20	150	14.2	480	14.6	23.6	10.9	1,040	2.3	30.7	58.6	0.21
DSOR133S1	14,400	5.2	90	3,380	0.14	71.4	4.9	12.1	14.6	16,400	2,890	3,230	420	0.76	263	9.0	444	12.3	27.3	21.4	835	3.4	26.7	58.1	0.16
DSOR378S1	25,100	21.5	127	3,520	0.09	73.6	9.0	23.4	38.8	24,100	4,120	4,970	483	0.36	201	18.2	388	16.0	30.0	10.2	1,530	2.4	44.5	51.1	0.24
DSOR457S1*	14,300	12.9	36	889	0.11	74.2	7.5	15.9	56.8	25,200	4,125	2,690	93	0.89	35	10.8	196	4.8	8.4	14.0	655	3.8	22.5	16.5	0.27
DSOR128S1	27,300	4.8	198	7,610	0.25	74.6	6.0	16.9	16.1	21,200	3,180	3,680	652	0.47	301	12.9	617	16.9	44.6	31.6	1,080	13.9	29.9	62.1	0.44
DSOR440S1[2]	30,500		324	4,090	0.65	76.1	20.4	19.6	46.9	31,800	2,710	3,260	735	3.10	123	43.4	773	24.6	36.1	12.5	1,190	13.7	39.6	68.0	1.10
DSOR456S1	21,100	79.2	143	3,300	0.14	76.7	10.7	20.8	27.4	25,500	4,960	4,930	440	0.54	160	18.9	575	12.8	27.8	13.6	1,190	3.0	33.6	49.6	0.22
DSOR458S1*	25,100		199	3,190	0.22	77.7	21.7	21.3	39.7	33,250	3,885	3,870	778		87	35.0	584	15.2	32.0	19.3	1,095	8.0	40.8	53.1	0.42
RZAH037S1	19,000	3.9	124	3,590	0.09	78.6	5.2	13.0	15.2	17,500	2,230	2,670	493	0.32	287	11.3	500	13.8	35.4	60.8	846	24.1	30.2	43.6	0.40
DSOR445S1	28,100	7.7	172	2,890	0.23	78.7	10.4	19.9	21.2	23,200	6,540	6,340	463	0.51	268	20.4	608	8.6	27.9	15.4	1,620	2.6	27.9	54.4	0.17
DSOR120S1	21,900	4.0	116	4,430	0.19	79.0	5.2	11.0	12.3	19,400	2,590	3,430	331	0.26	295	9.4	674	22.2	34.8	26.2	822	11.9	27.6	80.4	0.45
DSOR438S1[2]	33,900	44.4	144	9,620	0.22	79.7	17.5	28.8	43.2	37,400	4,230	6,010	829	1.50	210	33.1	754	16.1	38.7	12.9	1,220	3.5	42.4	72.9	0.27
DSOR451S1*	27,950	24.1	192	4,000	0.19	80.2	11.3	24.5	25.4	25,550	5,710	5,625	564	0.49	254	22.6	618	13.5	33.3	11.2	1,465	4.5	34.2	52.1	0.40
DSOR398S1	39,100	42.9	266	4,070	0.16	80.6	17.6	36.4	39.4	41,600	11,000	7,110	716	1.70	181	32.5	809	12.1	40.5	14.9	1,850	2.2	44.5	85.2	0.15
DSOR421S1	21,800	5.0	153	2,490	0.15	82.4	5.2	12.5	13.8	20,600	2,910	4,280	515	0.56	151	10.1	603	16.8	25.5	20.4	1,130	6.1	32.4	70.2	0.30
RZAH027S1	16,600	2.7	102	2,930	0.04	84.3	4.9	11.2	9.5	16,500	2,270	2,890	456	0.25	214	8.2	538	9.9	29.8	58.5	929	11.8	25.5	41.6	0.20
DSOR420S1	22,600	2.4	151	2,480	0.10	84.5	6.4	12.4	11.7	20,700	3,980	4,030	707	0.30	154	10.8	503	9.8	25.9	32.6	1,430	4.9	33.2	71.6	0.15
DSOR134S1*	17,400	5.3	105	3,260	0.23	85.0	4.8	12.1	13.8	19,400	3,020	3,985	433	0.31	180	9.2	463	17.2	26.4	23.9	970	9.4	28.7	98.1	0.40
DSOR416S1[1]	21,200	14.8	109	2,730	0.10	85.0	10.4	17.1	18.2	20,500	2,390	2,870	491	0.87	236	15.7	455	17.2	24.7	24.7	1,090	18.9	33.8	38.1	0.77
DSOR121S1	14,600	8.5	111	3,100	0.33	85.7	6.8	14.3	15.7	19,200	3,840	5,060	641	0.53	152	12.1	498	22.1	23.3	16.8	962	2.7	27.7	90.2	0.16
RZAH021S1*	20,600	39.8	111	3,675	0.08	87.5	14.9	21.1	32.4	25,850	3,225	4,205	619	0.54	141	18.0	422	14.4	24.9	11.7	1,420	1.8	46.5	38.1	0.15
06MM07.02	19,800	2.9	119	4,930	0.21	98.1	5.7	12.8	12.6	20,500	2,340	2,760	501	0.73	141	10.0	1,180	17.7	37.1	59.5	598	20.2	30.0	57.3	0.34
DSOR403S1	14,900	2.4	109	3,800	0.24	98.7	5.0	7.2	8.3	15,800	3,690	3,220	958	1.20	269	5.6	565	22.9	33.8	49.4	959	20.9	24.6	72.2	0.42
06MM07.01	17,200	3.3	130	5,630	0.65	102	6.4	15.3	12.0	17,700	2,190	2,510	554	0.83	156	12.1	1,100	17.7	42.4	63.3	507	21.2	25.7	56.4	0.33
06MM07.03	24,800	3.8	152	5,380	0.44	105	4.8	47.4	22.9	19,700	2,300	2,830	291	2.50	172	35.2	910	22.4	42.6	44.9	755	30.5	44.6	63.1	0.68
n =	59	56	59	59	59	59	59	59	59	59	59	59	59	57	59	59	59	59	59	59	59	57	59	59	57
Minimum	11,700	1.7	36.0	889	0.04	29.3	2.9	7.2	8.3	12,400	1,900	2,160	93.3	0.25	34.6	5.6	196	4.8	8.4	6.0	507	1.0	20.0	16.5	0.11
25th percentile	16,675	3.2	129	2,945	0.14	55.0	6.0	12.7	13.2	17,700	2,645	2,915	487	0.42	157	10.6	480	12.3	26.2	10.5	955	2.0	27.6	49.7	0.15
50th percentile	21,200	5.3	157	3,550	0.21	67.4	7.3	15.6	18.4	20,500	3,230	3,740	564	0.52	203	13.1	588	15.2	33.1	13.2	1,160	2.8	30.2	58.1	0.22
75th percentile	25,900	18.7	202	4,715	0.27	78.9	10.4	20.9	26.8	23,950	4,178	4,550	712	0.83	272	20.0	757	18.3	39.4	20.9	1,330	6.1	36.0	72.6	0.35
Maximum	44,100	79	432	19,400	0.65	105	21.7	47.4	56.8	41,600	11,000	9,170	1,230	3.1	684	43.4	1,330	30.1	56.7	63.3	1,910	31	59.8	126.0	1.10
Mean	22,415	13.0	182	4,408	0.23	67.3	8.8	17.7	21.7	21,695	3,673	4,129	602	0.73	236	16.4	657	15.7	33.5	18.7	1,173	5.9	32.7	62.1	0.28
Std. Dev.	7,158	15.8	80.6	3,006	0.14	16.6	4.3	7.6	11.2	6,157	1,685	1,661	206	0.59	120	8.5	253	5.0	9.0	14.3	312	6.7	8.2	19.3	0.19
UCL95																									
CV	32%	159%	44%	68%	60%	25%	49%	43%	52%	28%	46%	40%	34%	80%	51%	52%	38%	32%	27%	76%	27%	114%	25%	31%	66%
Geometric Mean	**21,375**	**7.5**	**166**	**3,858**	**0.20**	**65.2**	**7.9**	**16.4**	**19.3**	**20,963**	**3,413**	**3,865**	**564**	**0.60**	**212**	**14.6**	**614**	**14.9**	**32.2**	**15.4**	**1,131**	**3.7**	**31.8**	**59.2**	**0.24**
Skewness	0.86	2.31	1.16	3.32	1.56	0.05	1.54	1.79	1.10	1.46	2.59	1.50	0.71	2.74	1.81	1.38	1.02	0.41	0.22	1.99	0.38	2.00	1.31	0.85	2.18
Kurtosis	0.51	5.98	0.96	12.76	2.55	-0.27	1.81	4.27	0.58	2.33	8.60	1.86	1.46	7.93	4.14	1.29	0.66	0.28	0.47	3.23	-0.08	3.46	2.25	1.80	6.12

[1] Indicates sediment site from within the geochemical anomaly of the Spokane Mountain uranium deposit (Robbins, 1978).

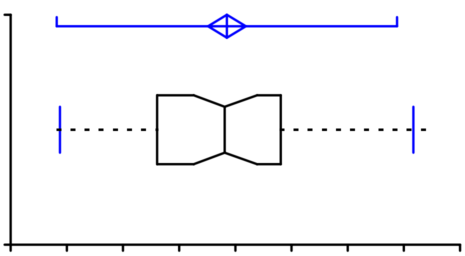
[2] Indicates sediment site from within the geochemical anomaly of the Midnite Mine uranium deposit.

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**		
Variable	Al		
Performed by		**Date**	8 August 2007

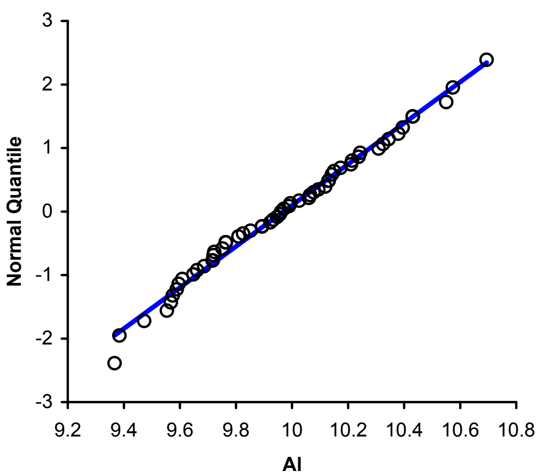


n	59
Mean	9.970
90% CI	9.903 to 10.037
Variance	0.0955
SD	0.3090
SE	0.0402
CV	3%



Median	9.962
93.3% CI	9.852 to 10.077
Range	1.326870941
IQR	0.440266413

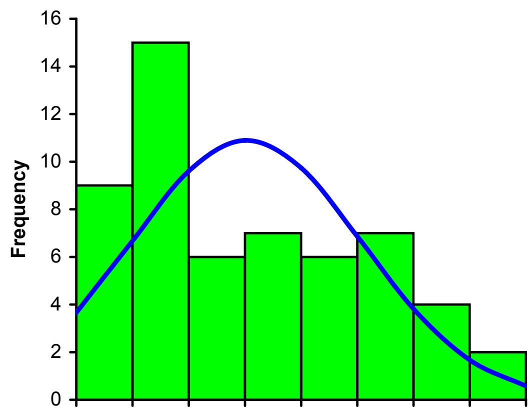
Percentile	
2.5th	9.376
25th	9.722
50th	9.962
75th	10.162
97.5th	10.634



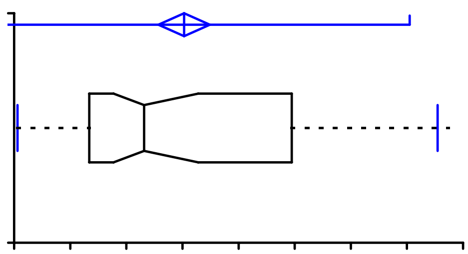
	Coefficient	p
Shapiro-Wilk	0.9863	0.7456
Skewness	0.1768	0.5543
Kurtosis	-0.5489	0.3173

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	As
Performed by	
Date	8 August 2007

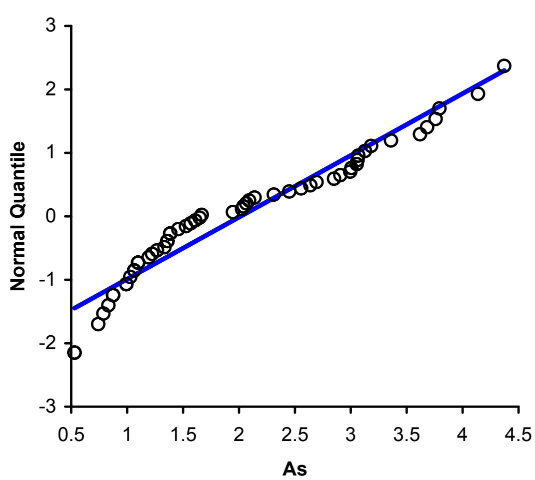


n	56 (cases excluded: 3 due to mis
Mean	2.015
90% CI	1.785 to 2.244
Variance	1.0516
SD	1.0255
SE	0.1370
CV	51%



Median	1.658
91.9% CI	1.386 to 2.140
Range	3.841348048
IQR	1.803429547

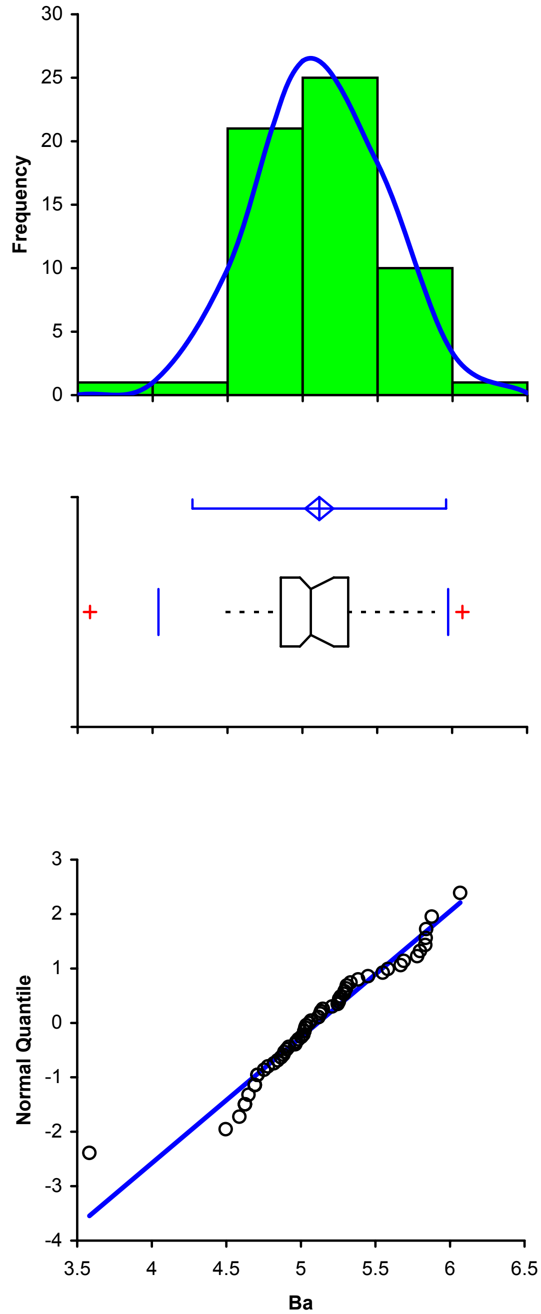
Percentile	
2.5th	0.531
25th	1.170
50th	1.658
75th	2.974
97.5th	4.273



	Coefficient	p
Shapiro-Wilk	0.9332	0.0040
Skewness	0.5288	0.0959
Kurtosis	-0.8388	0.0571

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Ba
Performed by	
Date	8 August 2007



n	59
Mean	5.113
90% CI	5.019 to 5.207
Variance	0.1865
SD	0.4319
SE	0.0562
CV	8%

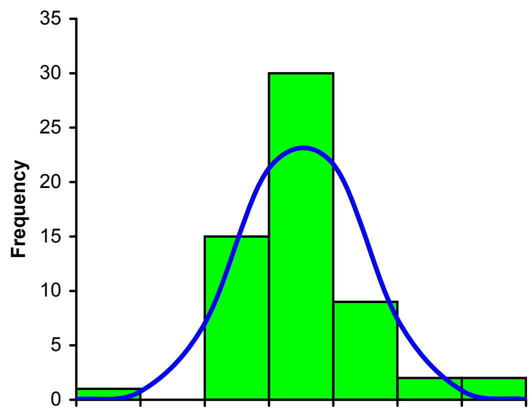
Median	5.056
93.3% CI	4.984 to 5.209
Range	2.486296504
IQR	0.449925534

Percentile	
2.5th	4.039
25th	4.856
50th	5.056
75th	5.306
97.5th	5.973

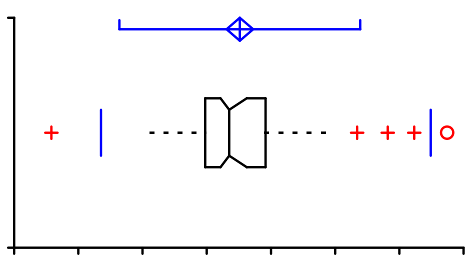
	Coefficient	**p**
Shapiro-Wilk	0.9509	0.0185
Skewness	-0.2471	0.4107
Kurtosis	1.6851	0.0369

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Ca
Performed by	
Date	8 August 2007

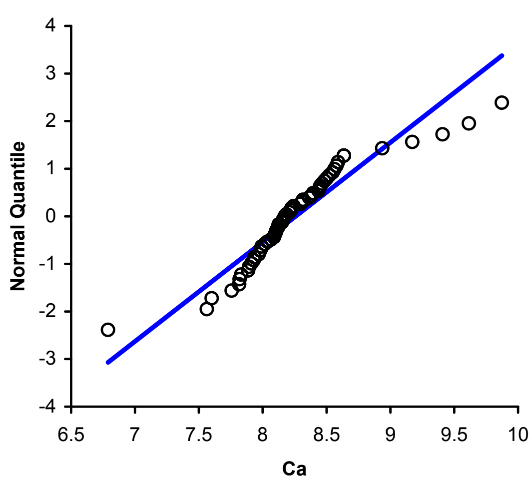


n	59
Mean	8.258
90% CI	8.154 to 8.362
Variance	0.2289
SD	0.4784
SE	0.0623
CV	6%



Median	8.175
93.3% CI	8.108 to 8.311
Range	3.083493697
IQR	0.470625518

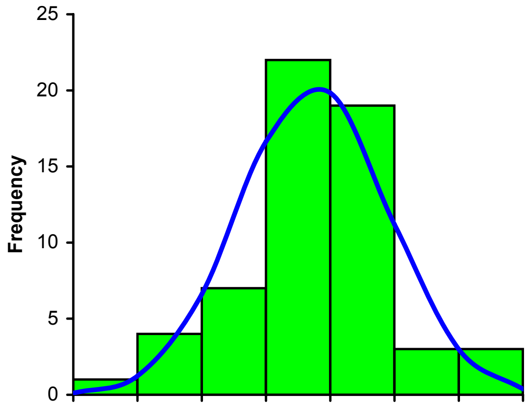
Percentile	
2.5th	7.176
25th	7.988
50th	8.175
75th	8.458
97.5th	9.744



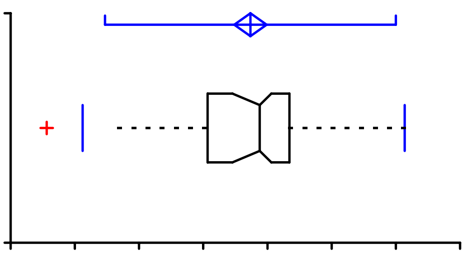
	Coefficient	**p**
Shapiro-Wilk	0.8999	0.0001
Skewness	0.8338	0.0108
Kurtosis	3.5221	0.0020

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Cd
Performed by	
Date	8 August 2007

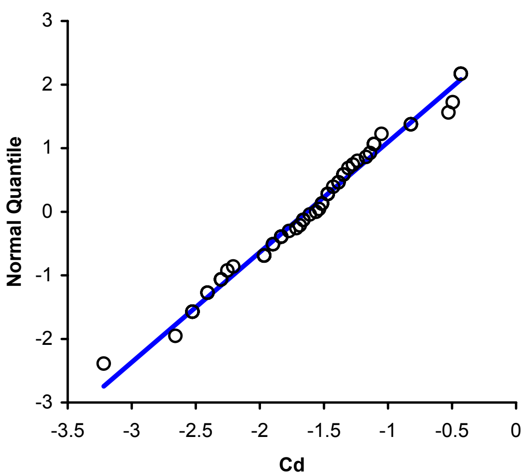


n	59
Mean	-1.633
90% CI	-1.758 to -1.507
Variance	0.3341
SD	0.5780
SE	0.0753
CV	-35%



Median	-1.561
93.3% CI	-1.772 to -1.470
Range	2.788092909
IQR	0.637909372

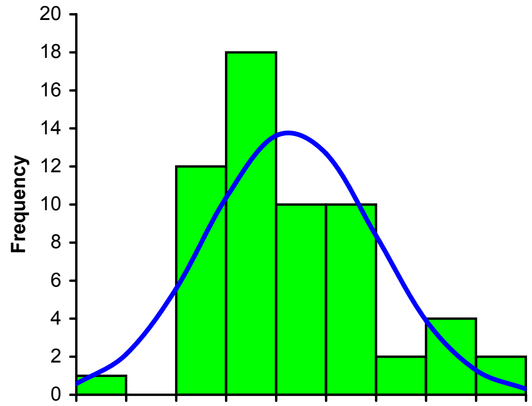
Percentile	
2.5th	-2.939
25th	-1.966
50th	-1.561
75th	-1.328
97.5th	-0.431



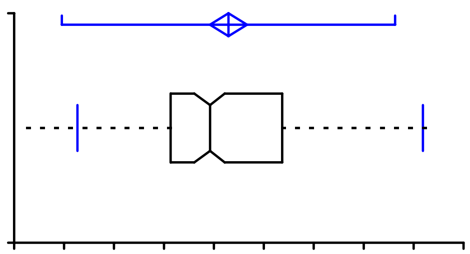
	Coefficient	p
Shapiro-Wilk	0.9815	0.5056
Skewness	-0.1147	0.7003
Kurtosis	0.2218	0.5679

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Co
Performed by	
Date	8 August 2007

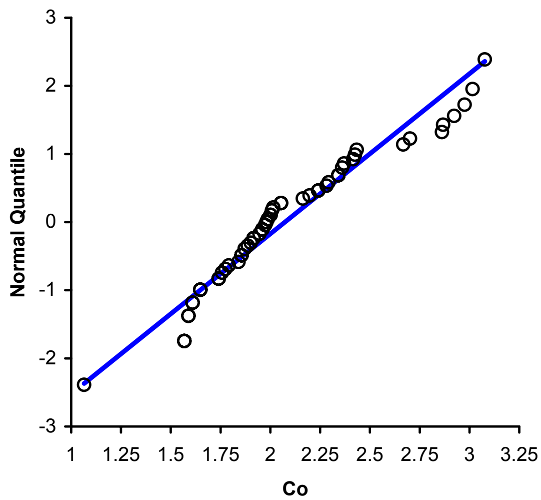


n	59
Mean	2.073
90% CI	1.980 to 2.166
Variance	0.1812
SD	0.4256
SE	0.0554
CV	21%



Median	1.981
93.3% CI	1.902 to 2.054
Range	2.012601524
IQR	0.558449896

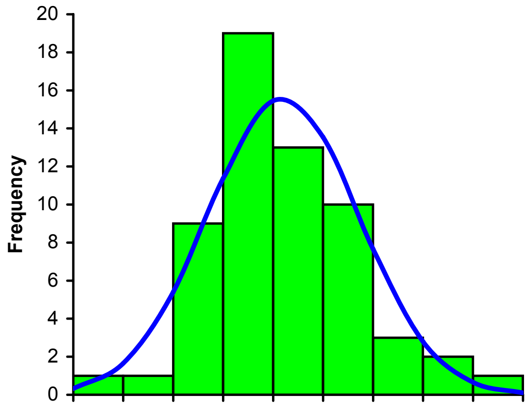
Percentile	
2.5th	1.317
25th	1.783
50th	1.981
75th	2.342
97.5th	3.046



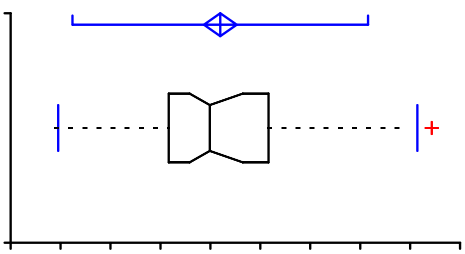
	Coefficient	p
Shapiro-Wilk	0.9441	0.0090
Skewness	0.6078	0.0531
Kurtosis	0.1785	0.6134

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Cr
Performed by	
Date	8 August 2007

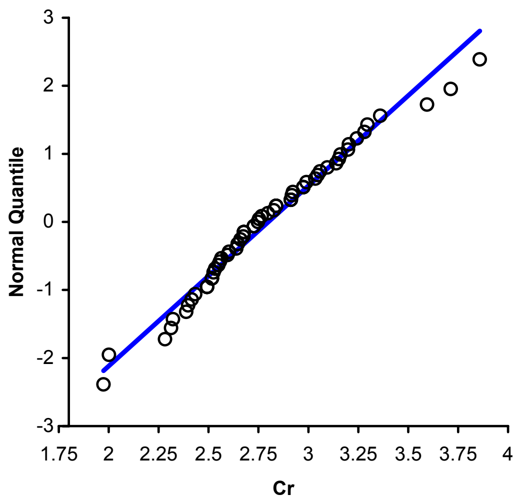


n	59
Mean	2.800
90% CI	2.717 to 2.882
Variance	0.1425
SD	0.3775
SE	0.0491
CV	13%



Median	2.747
93.3% CI	2.646 to 2.912
Range	1.884541203
IQR	0.499355781

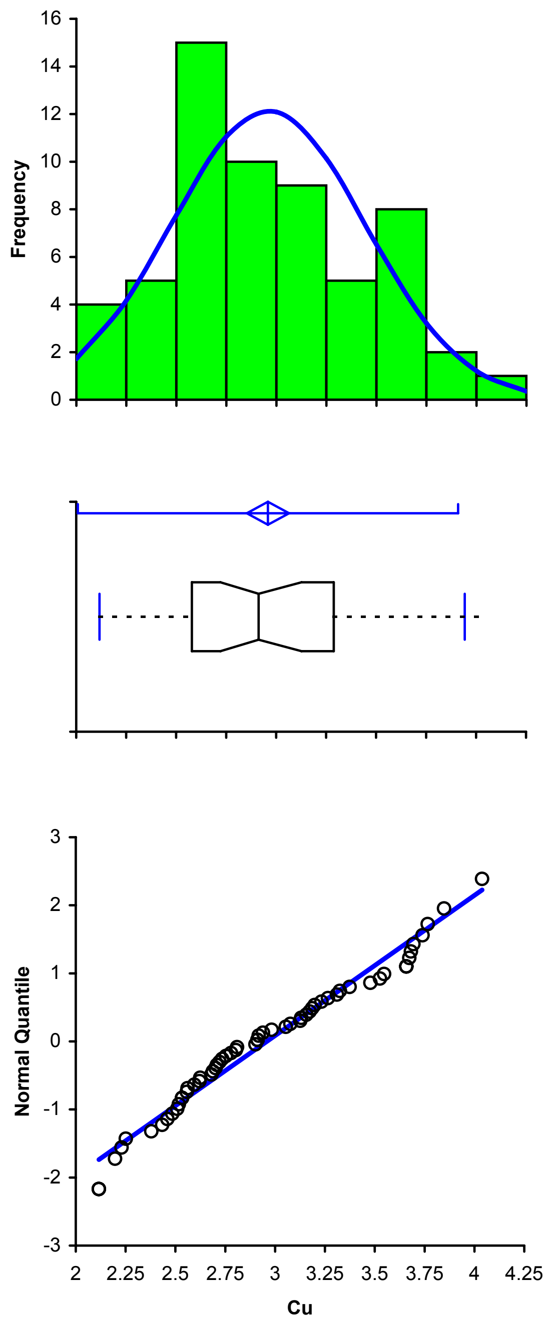
Percentile	
2.5th	1.988
25th	2.542
50th	2.747
75th	3.041
97.5th	3.786



	Coefficient	p
Shapiro-Wilk	0.9775	0.3444
Skewness	0.4690	0.1275
Kurtosis	0.5390	0.3158

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Cu
Performed by	
Date	8 August 2007



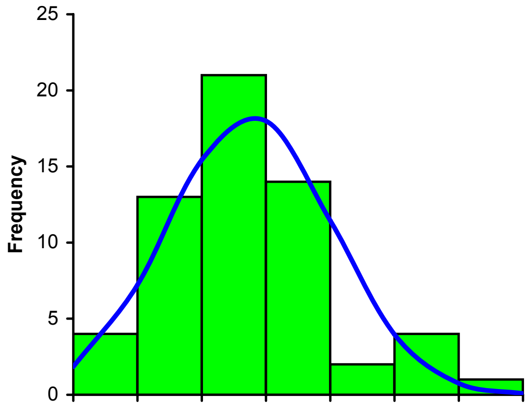
n	59
Mean	2.959
90% CI	2.854 to 3.065
Variance	0.2354
SD	0.4852
SE	0.0632
CV	16%
Median	2.912
93.3% CI	2.721 to 3.127
Range	1.922400142
IQR	0.709975965

Percentile	
2.5th	2.116
25th	2.578
50th	2.912
75th	3.288
97.5th	3.943

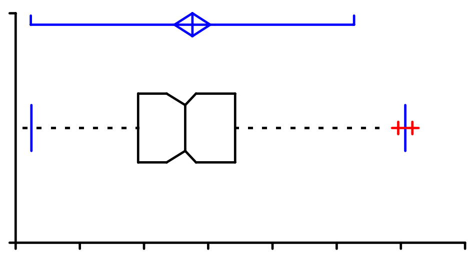
	Coefficient	**p**
Shapiro-Wilk	0.9678	0.1196
Skewness	0.2997	0.3206
Kurtosis	-0.7759	0.0841

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Fe
Performed by	
Date	8 August 2007

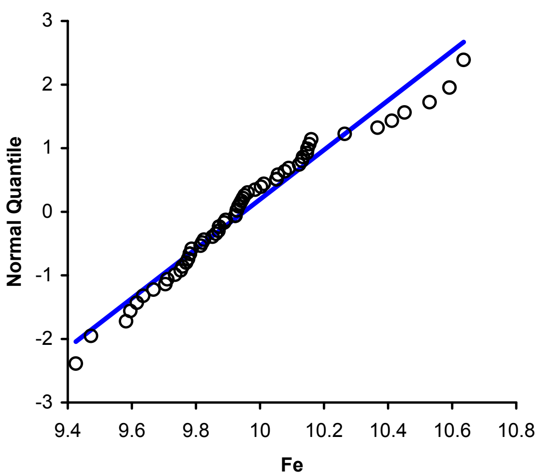


n	59
Mean	9.951
90% CI	9.895 to 10.006
Variance	0.0660
SD	0.2569
SE	0.0334
CV	3%



Median	9.928
93.3% CI	9.870 to 9.962
Range	1.210403695
IQR	0.302384071

Percentile	
2.5th	9.449
25th	9.781
50th	9.928
75th	10.084
97.5th	10.614

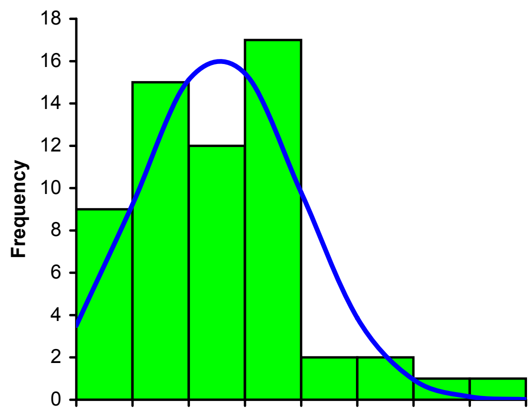


	Coefficient	p
Shapiro-Wilk	0.9603	0.0520
Skewness	0.6699	0.0349
Kurtosis	0.6563	0.2527

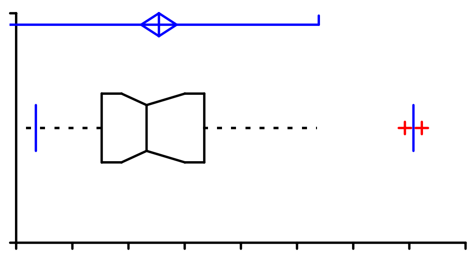
analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	K
Performed by	

Date 8 August 2007

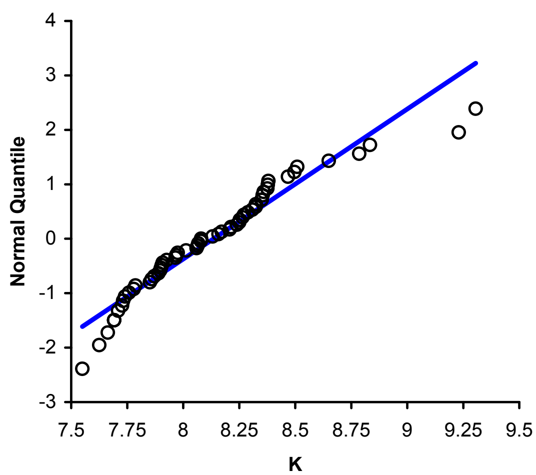


n	59
Mean	8.135
90% CI	8.056 to 8.214
Variance	0.1318
SD	0.3630
SE	0.0473
CV	4%



Median	8.080
93.3% CI	7.969 to 8.251
Range	1.756041387
IQR	0.457007611

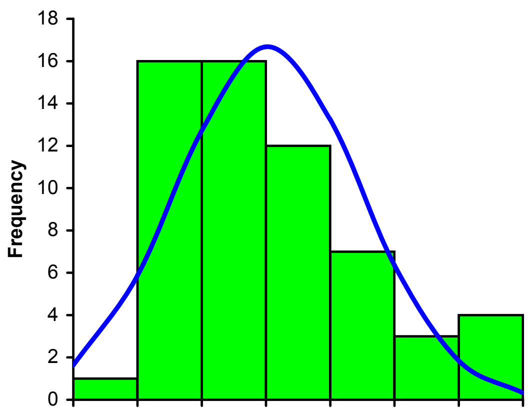
Percentile	
2.5th	7.588
25th	7.880
50th	8.080
75th	8.337
97.5th	9.268



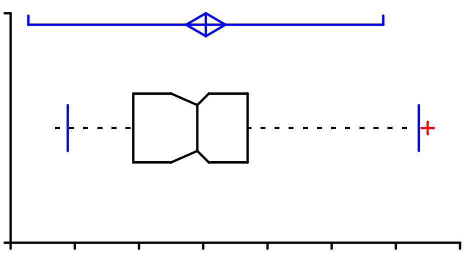
	Coefficient	p
Shapiro-Wilk	0.9305	0.0023
Skewness	1.0234	0.0026
Kurtosis	1.6665	0.0381

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Mg
Performed by	
Date	8 August 2007

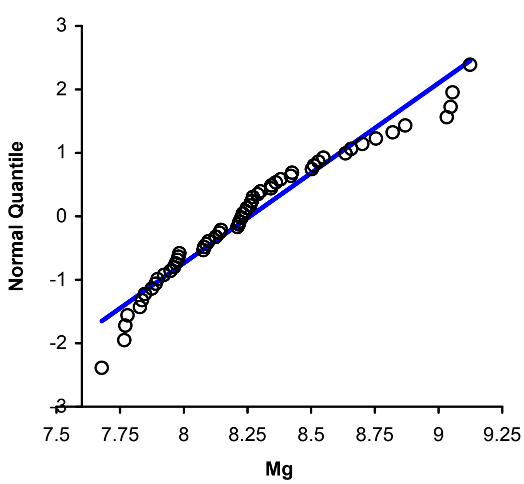


n	59
Mean	8.260
90% CI	8.183 to 8.337
Variance	0.1243
SD	0.3526
SE	0.0459
CV	4%



Median	8.227
93.3% CI	8.126 to 8.271
Range	1.445829065
IQR	0.445256469

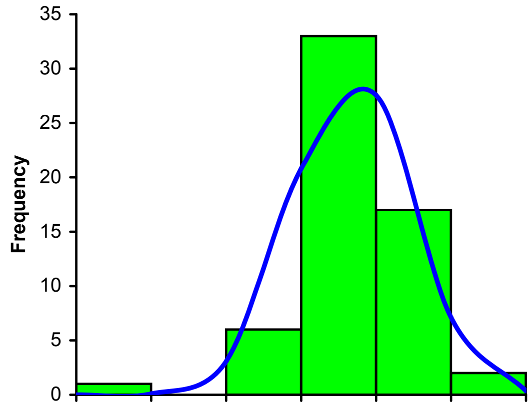
Percentile	
2.5th	7.722
25th	7.978
50th	8.227
75th	8.423
97.5th	9.089



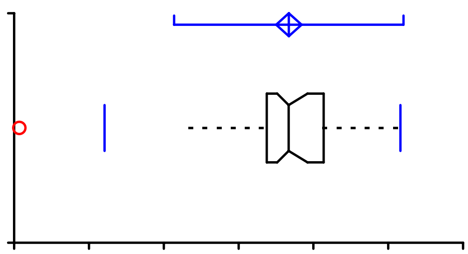
	Coefficient	p
Shapiro-Wilk	0.9466	0.0117
Skewness	0.7189	0.0248
Kurtosis	0.0515	0.7637

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Mn
Performed by	
Date	8 August 2007

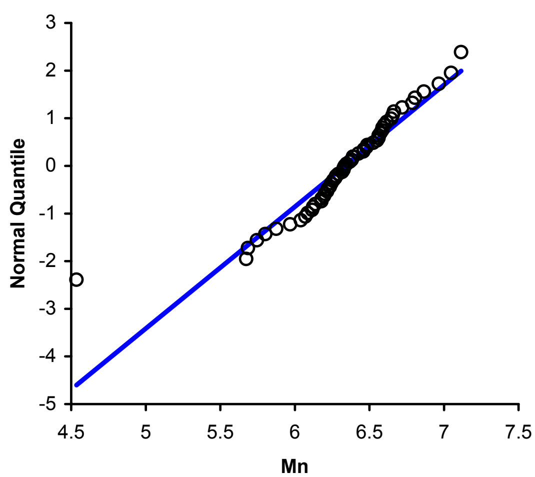


n	59
Mean	6.336
90% CI	6.251 to 6.421
Variance	0.1529
SD	0.3911
SE	0.0509
CV	6%



Median	6.335
93.3% CI	6.258 to 6.460
Range	2.578949341
IQR	0.37983174

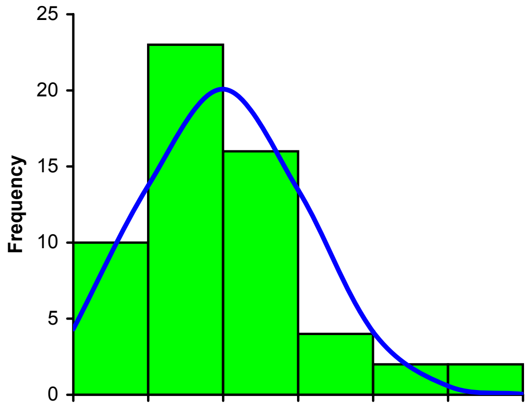
Percentile	
2.5th	5.105
25th	6.188
50th	6.335
75th	6.568
97.5th	7.081



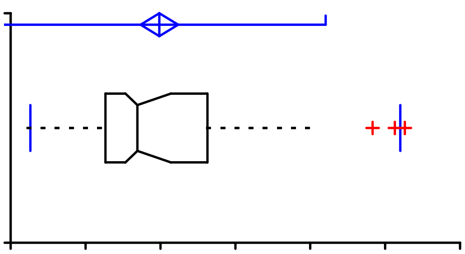
	Coefficient	p
Shapiro-Wilk	0.8920	<0.0001
Skewness	-1.5783	<0.0001
Kurtosis	6.8091	<0.0001

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Mo
Performed by	
Date	8 August 2007

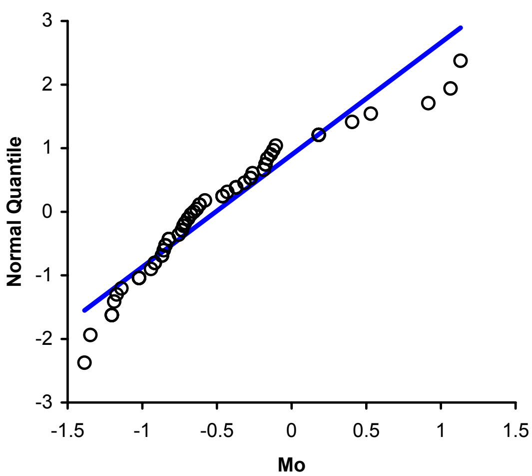


n	57 (cases excluded: 2 due to mis
Mean	-0.507
90% CI	-0.633 to -0.382
Variance	0.3206
SD	0.5662
SE	0.0750
CV	-112%



Median	-0.654
93.7% CI	-0.734 to -0.431
Range	2.517696473
IQR	0.68117099

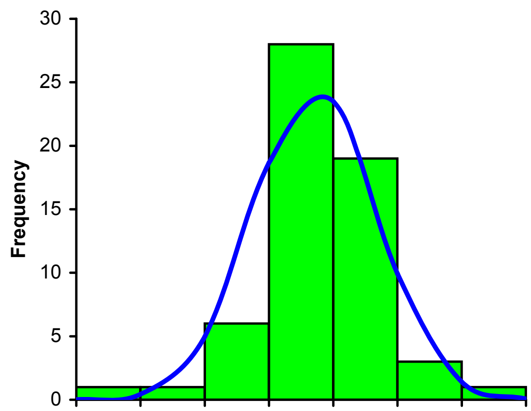
Percentile	
2.5th	-1.369
25th	-0.868
50th	-0.654
75th	-0.186
97.5th	1.101



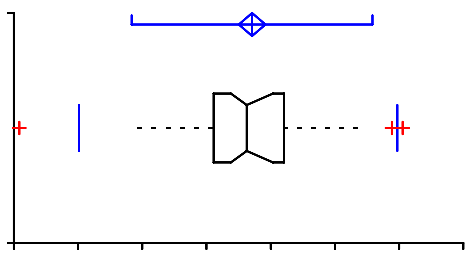
	Coefficient	p
Shapiro-Wilk	0.9210	0.0012
Skewness	1.0817	0.0019
Kurtosis	1.2090	0.0917

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Na
Performed by	
Date	8 August 2007

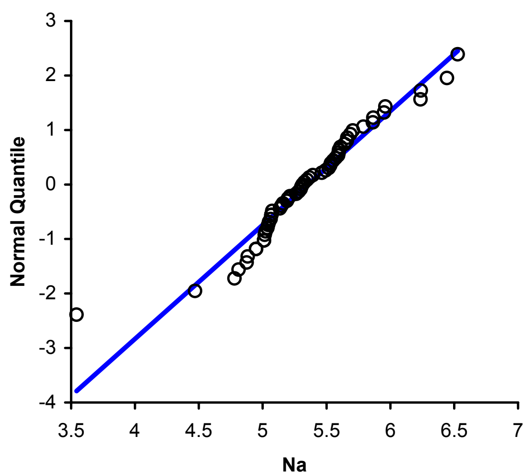


n	59
Mean	5.355
90% CI	5.251 to 5.459
Variance	0.2290
SD	0.4785
SE	0.0623
CV	9%



Median	5.313
93.3% CI	5.190 to 5.517
Range	2.985550367
IQR	0.547721357

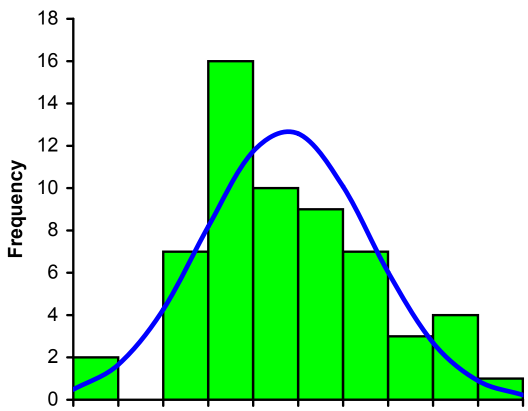
Percentile	
2.5th	4.006
25th	5.056
50th	5.313
75th	5.604
97.5th	6.486



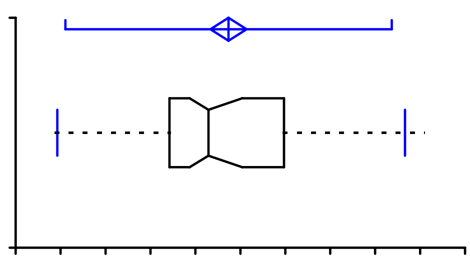
	Coefficient	**p**
Shapiro-Wilk	0.9420	0.0073
Skewness	-0.3948	0.1953
Kurtosis	3.0010	0.0042

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Ni
Performed by	
Date	8 August 2007

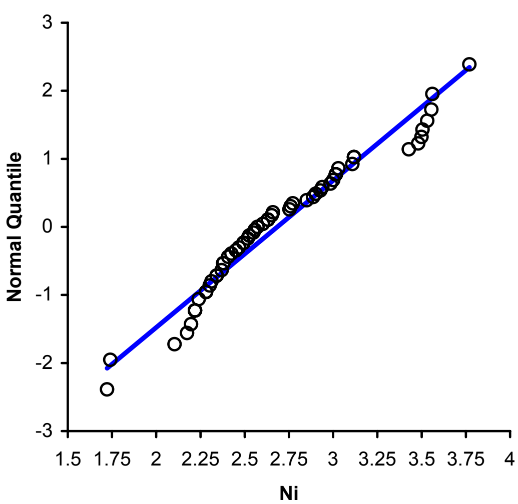


n	59
Mean	2.684
90% CI	2.583 to 2.785
Variance	0.2145
SD	0.4632
SE	0.0603
CV	17%



Median	2.573
93.3% CI	2.468 to 2.760
Range	2.047692843
IQR	0.637176103

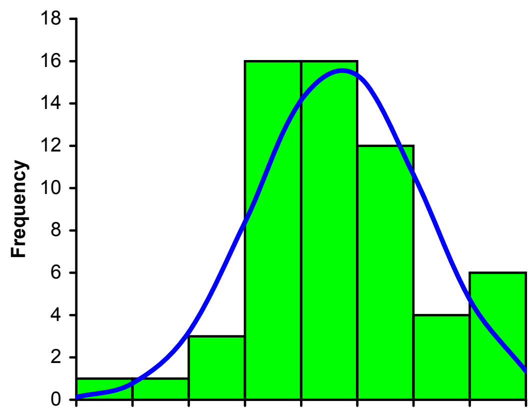
Percentile	
2.5th	1.732
25th	2.356
50th	2.573
75th	2.993
97.5th	3.666



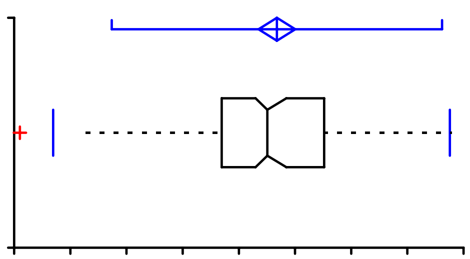
	Coefficient	p
Shapiro-Wilk	0.9539	0.0258
Skewness	0.4712	0.1259
Kurtosis	-0.2146	0.8450

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**		
Variable	P		
Performed by		**Date**	8 August 2007

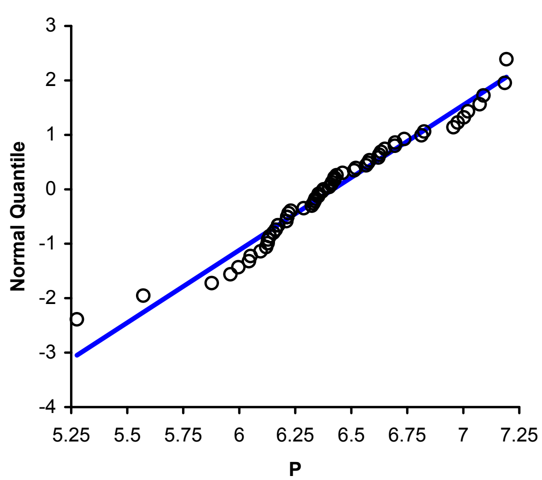


n	59
Mean	6.419
90% CI	6.338 to 6.501
Variance	0.1407
SD	0.3751
SE	0.0488
CV	6%



Median	6.377
93.3% CI	6.324 to 6.461
Range	1.917373842
IQR	0.455569297

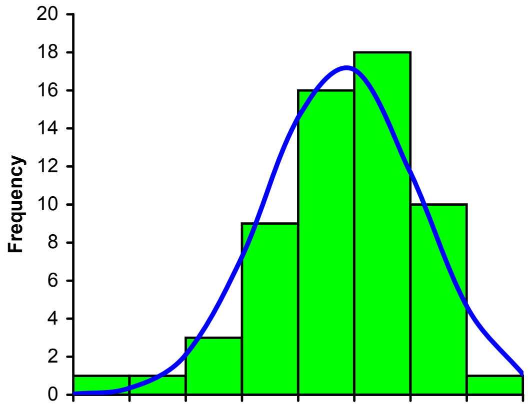
Percentile	
2.5th	5.424
25th	6.174
50th	6.377
75th	6.629
97.5th	7.189



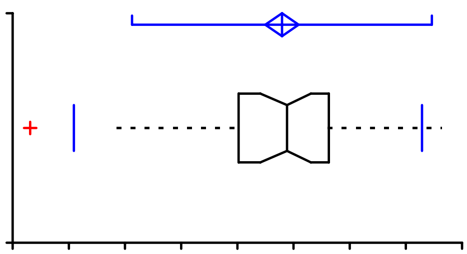
	Coefficient	p
Shapiro-Wilk	0.9680	0.1228
Skewness	-0.0982	0.7416
Kurtosis	0.7873	0.1968

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Pb
Performed by	
Date	8 August 2007

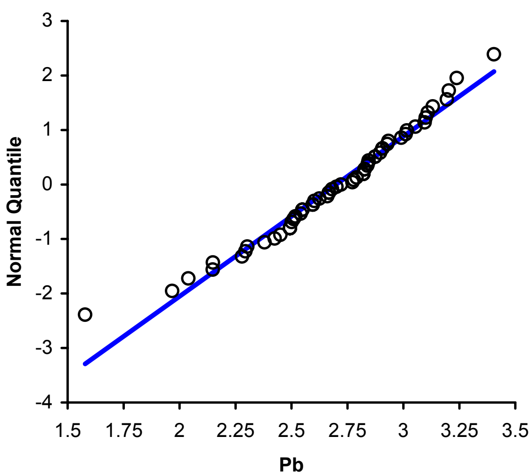


n	59
Mean	2.698
90% CI	2.624 to 2.773
Variance	0.1159
SD	0.3404
SE	0.0443
CV	13%



Median	2.721
93.3% CI	2.603 to 2.827
Range	1.826577926
IQR	0.401383453

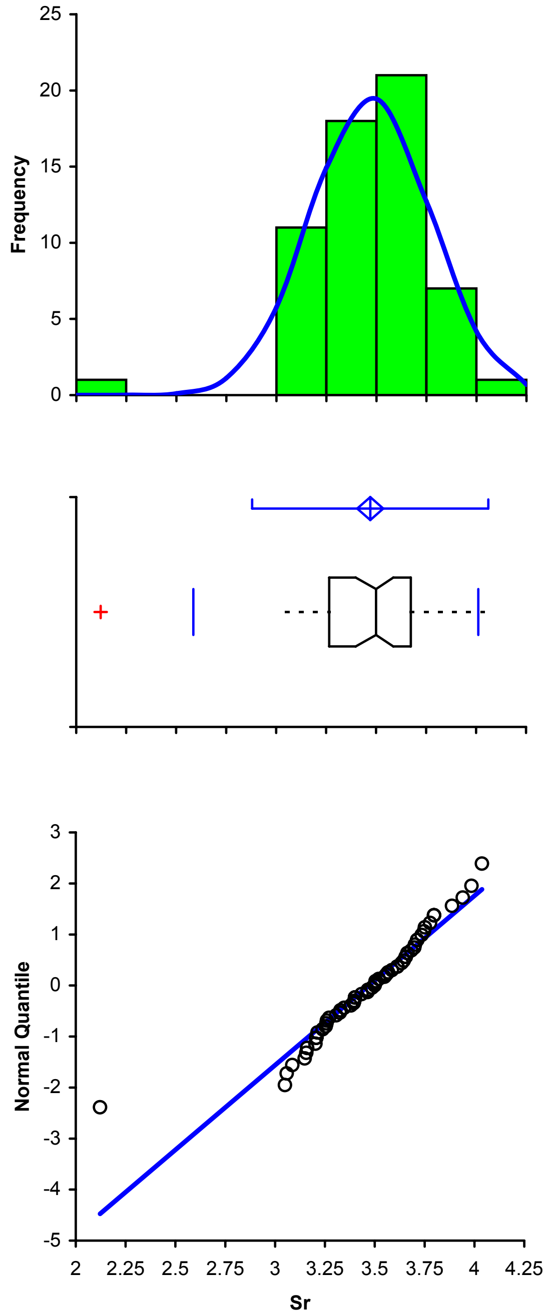
Percentile	
2.5th	1.773
25th	2.506
50th	2.721
75th	2.907
97.5th	3.322



	Coefficient	p
Shapiro-Wilk	0.9726	0.2041
Skewness	-0.6771	0.0332
Kurtosis	1.0785	0.1130

analysed with: Analyse-it + General 1.73

Test	Continuous summary descriptives		
Variable	Sr		
Performed by		Date	8 August 2007



n	59
Mean	3.471
90% CI	3.405 to 3.536
Variance	0.0907
SD	0.3012
SE	0.0392
CV	9%

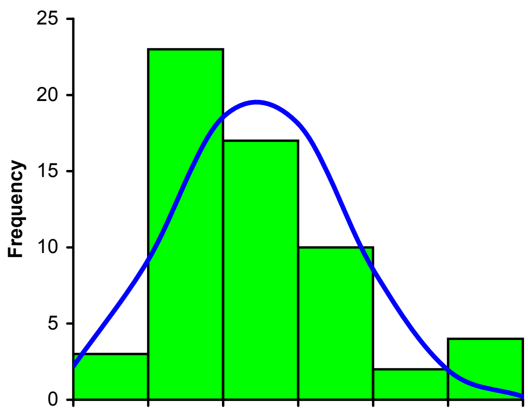
Median	3.500
93.3% CI	3.398 to 3.586
Range	1.915512672
IQR	0.407971258

Percentile	
2.5th	2.586
25th	3.266
50th	3.500
75th	3.674
97.5th	4.012

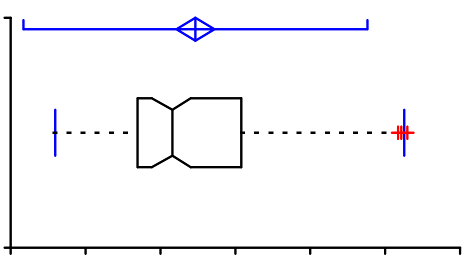
	Coefficient	p
Shapiro-Wilk	0.9065	0.0003
Skewness	-1.3881	0.0001
Kurtosis	5.5987	0.0002

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Th
Performed by	
Date	8 August 2007

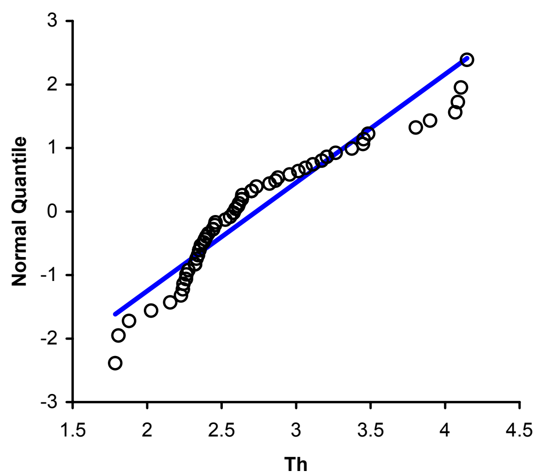


n	59
Mean	2.734
90% CI	2.606 to 2.861
Variance	0.3433
SD	0.5859
SE	0.0763
CV	21%



Median	2.580
93.3% CI	2.442 to 2.701
Range	2.361138402
IQR	0.69287238

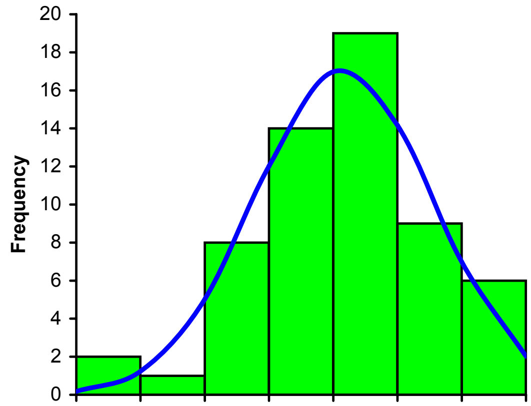
Percentile	
2.5th	1.798
25th	2.347
50th	2.580
75th	3.039
97.5th	4.128



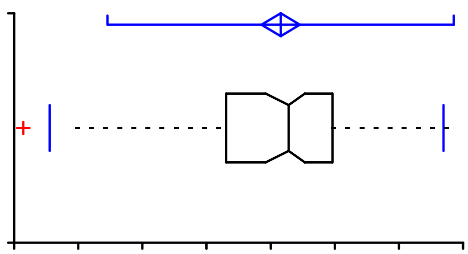
	Coefficient	**p**
Shapiro-Wilk	0.9046	0.0002
Skewness	0.9587	0.0042
Kurtosis	0.3251	0.4708

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Ti
Performed by	
Date	8 August 2007

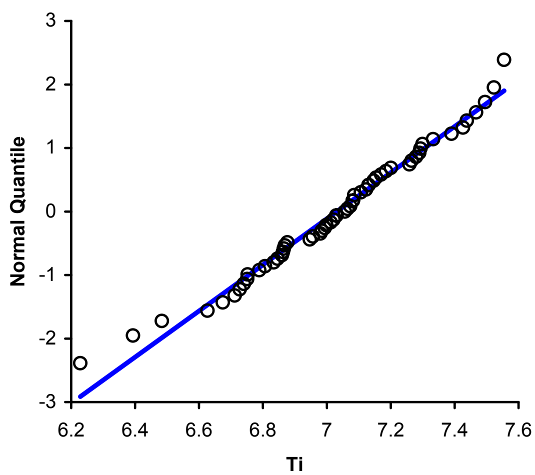


n	59
Mean	7.031
90% CI	6.971 to 7.091
Variance	0.0759
SD	0.2755
SE	0.0359
CV	4%



Median	7.056
93.3% CI	6.985 to 7.107
Range	1.326347517
IQR	0.331719546

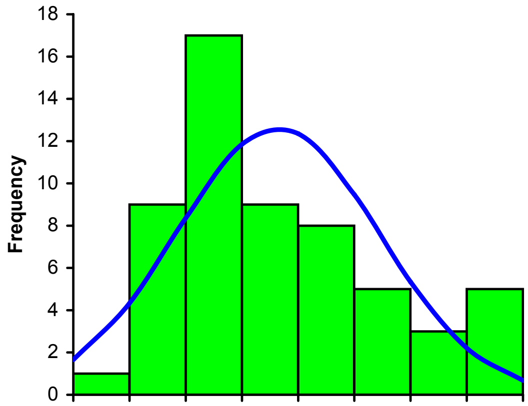
Percentile	
2.5th	6.311
25th	6.861
50th	7.056
75th	7.193
97.5th	7.539



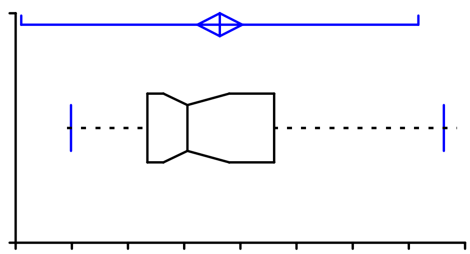
	Coefficient	**p**
Shapiro-Wilk	0.9810	0.4836
Skewness	-0.4120	0.1775
Kurtosis	0.4344	0.3844

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	U
Performed by	
Date	8 August 2007

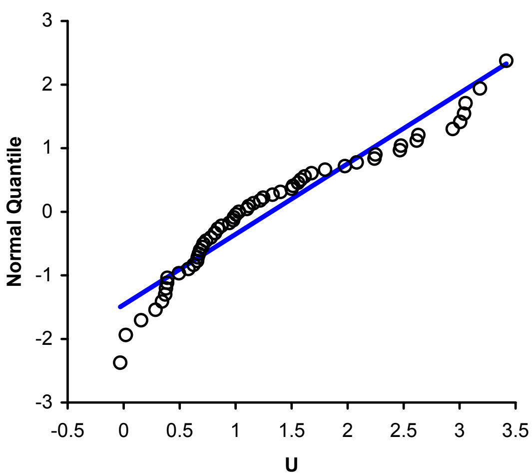


n	57 (cases excluded: 2 due to mis
Mean	1.318
90% CI	1.118 to 1.518
Variance	0.8132
SD	0.9018
SE	0.1194
CV	68%



Median	1.030
93.7% CI	0.815 to 1.401
Range	3.448185891
IQR	1.127113799

Percentile	
2.5th	-0.008
25th	0.673
50th	1.030
75th	1.800
97.5th	3.312

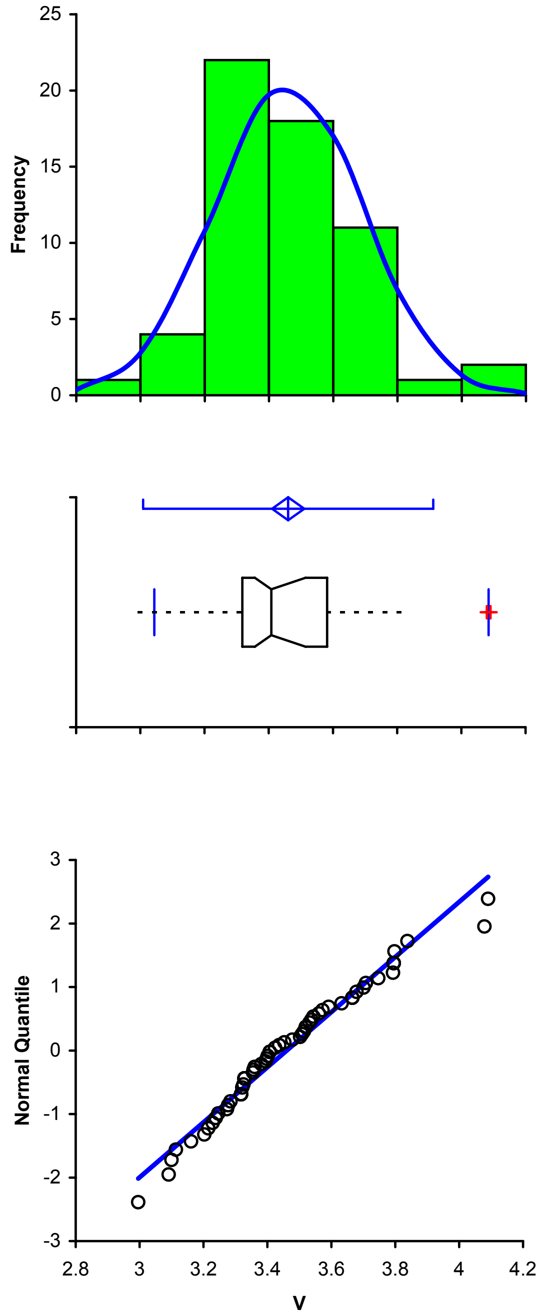


	Coefficient	p
Shapiro-Wilk	0.9218	0.0013
Skewness	0.7546	0.0210
Kurtosis	-0.4197	0.5201

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	V
Performed by	

Date	8 August 2007



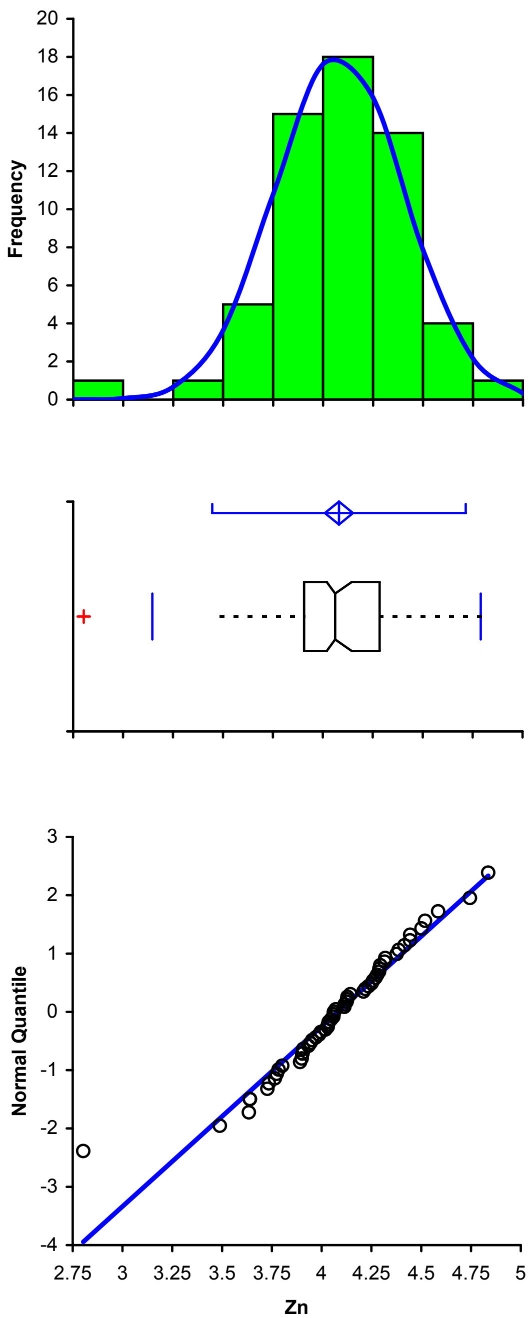
n	59
Mean	3.460
90% CI	3.410 to 3.511
Variance	0.0532
SD	0.2306
SE	0.0300
CV	7%
Median	3.408
93.3% CI	3.357 to 3.515
Range	1.095273387
IQR	0.264265917

Percentile	
2.5th	3.043
25th	3.318
50th	3.408
75th	3.582
97.5th	4.085

	Coefficient	**p**
Shapiro-Wilk	0.9694	0.1431
Skewness	0.5964	0.0572
Kurtosis	0.3796	0.4258

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Zn
Performed by	
Date	8 August 2007



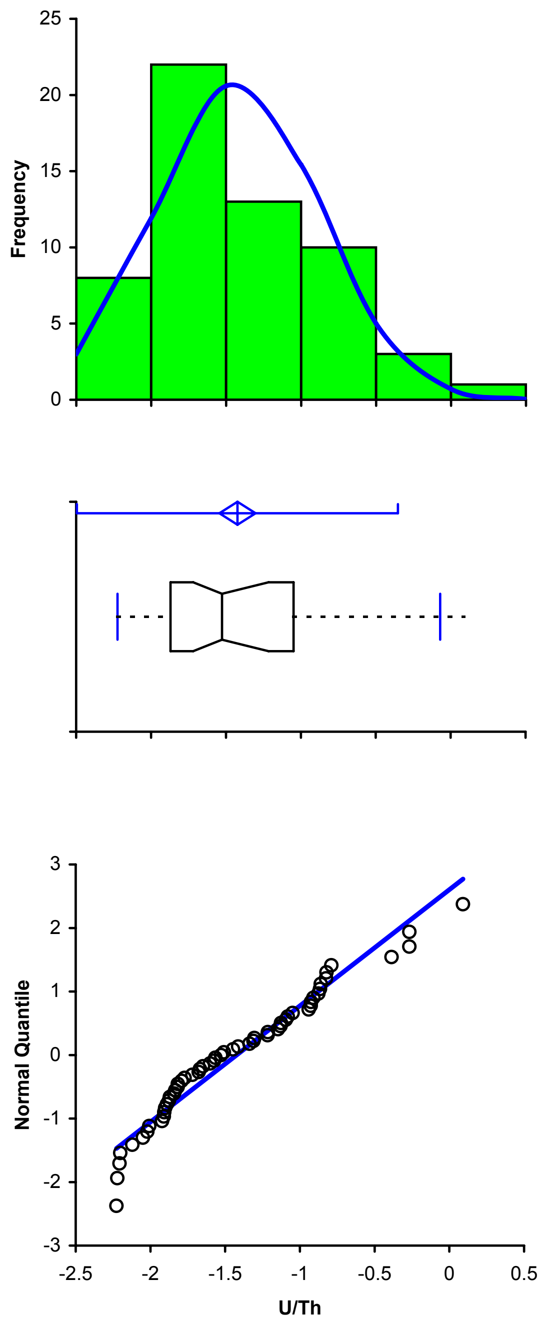
n	59
Mean	4.081
90% CI	4.010 to 4.151
Variance	0.1048
SD	0.3238
SE	0.0422
CV	8%
Median	4.062
93.3% CI	4.020 to 4.145
Range	2.032921526
IQR	0.378261434

Percentile	
2.5th	3.146
25th	3.906
50th	4.062
75th	4.284
97.5th	4.791

	Coefficient	**p**
Shapiro-Wilk	0.9512	0.0191
Skewness	-0.7853	0.0154
Kurtosis	3.2852	0.0028

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	U/Th
Performed by	
Date	8 August 2007



n	57 (cases excluded: 2 due to mis
Mean	-1.423
90% CI	-1.544 to -1.302
Variance	0.2989
SD	0.5467
SE	0.0724
CV	-38%
Median	-1.527
93.7% CI	-1.719 to -1.215
Range	2.318534108
IQR	0.821560094

Percentile	
2.5th	-2.224
25th	-1.870
50th	-1.527
75th	-1.049
97.5th	-0.070

	Coefficient	**p**
Shapiro-Wilk	0.9494	0.0185
Skewness	0.6155	0.0539
Kurtosis	-0.1126	0.9910

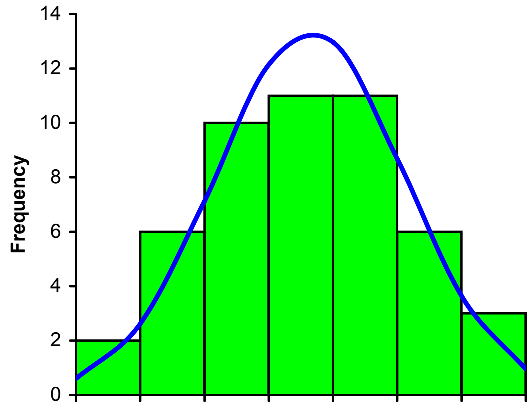
Table A21. Geochemical background statistical data and calculations, Case II.

[Concentrations are reported in parts per million (ppm); Std. Dev, Standard Deviation; CV, coefficient of variation; UCL_{95}, 95th upper confidence limit of the mean calculated from log-transformed data; samples indicated by S1* are the mean value of duplicate analyses; blanks in data set indicate outliers rejected for the statistical calculations. Statistical descriptions are shown in graphic form for each element following the table]

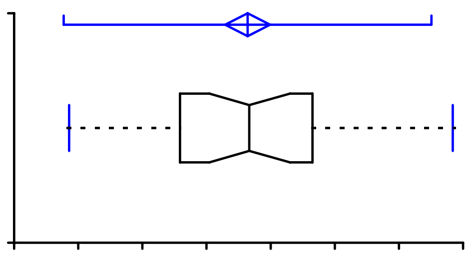
Sample No.	Al ppm	As ppm	Ba ppm	Ca ppm	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe ppm	K ppm	Mg ppm	Mn ppm	Mo ppm	Na ppm	Ni ppm	P ppm	Pb ppm	Sr ppm	Th ppm	Ti ppm	U ppm	V ppm	Zn ppm	U/Th
DSOR315S1	27,200	11.6	169	3,320	0.16	10.4	23.1	29.2	23,200	4,270	3,890	560	0.90	206	18.7	470	12.4	29.4	10.3	1,340	3.1	39.1	49.6	0.30
DSOR378S1	25,100	21.5	127	3,520	0.09	9.0	23.4	38.8	24,100	4,120	4,970	483	0.36	201	18.2	388	16.0	30.0	10.2	1,530	2.4	44.5	51.1	0.24
DSOR379S1	26,200	17.3	330	5,030	0.26	9.4	18.5	38.8	20,900	3,540	6,770	522	0.42	384	16.0	567	20.4	24.6	6.6	1,480	1.0	33.4	49.8	0.15
DSOR395S1	17,400	8.1	146	2,340	0.08	7.0	18.4	18.4	20,400	4,340	4,560	313	0.40	132	15.8	459	11.6	21.3	10.5	1,050	1.4	28.8	51.6	0.13
DSOR455S1*	16,650	21.4	109	1,925	0.08	7.3	14.6	19.8	19,350	4,350	3,450	295	0.43	184	13.9	425	7.7	21.9	9.6	1,075	1.5	25.3	32.8	0.15
RZAH021S1*	20,600	39.8	111	3,675	0.08	14.9	21.1	32.4	25,850	3,225	4,205	619	0.54	141	18.0	422	14.4	24.9	11.7	1,420	1.8	46.5	38.1	0.15
06MM07.01	17,200	3.3	130	5,630	0.65	6.4	15.3	12.0	17,700	2,190	2,510	554	0.83	156	12.1	1,100	17.7	42.4	63.3	507	21.2	25.7	56.4	0.33
06MM07.02	19,800	2.9	119	4,930	0.21	5.7	12.8	12.6	20,500	2,340	2,760	501	0.73	141	10.0	1,180	17.7	37.1	59.5	598	20.2	30.0	57.3	0.34
06MM07.03	24,800	3.8	152	5,380	0.44	4.8	47.4	22.9	19,700	2,300	2,830	291	2.50	172	35.2	910	22.4	42.6	44.9	755	30.5	44.6	63.1	0.68
DSOR100S1*	18,200	3.6	154	2,780	0.31	7.3	14.6	13.0	17,600	3,165	3,285	683	0.48	174	12.5	480	18.1	26.1	14.0	1,195	1.5	31.1	61.9	0.11
DSOR101S1	18,500	3.0	190	3,470	0.14	8.7	15.7	15.0	18,300	3,670	3,380	747	0.50	170	14.3	475	13.4	30.0	13.2	1,170	1.5	31.6	56.6	0.11
DSOR118S1	15,700	7.9	133	2,660	0.16	6.8	17.1	16.6	19,800	4,250	4,360	391	1.20	150	14.2	480	14.6	23.6	10.9	1,040	2.3	30.7	58.6	0.21
DSOR119S1	16,700	3.0	132	3,360	0.11	5.9	10.2	11.4	14,500	2,700	2,920	559	0.43	352	8.8	458	12.2	33.2	11.5	855	5.0	22.0	49.4	0.44
DSOR120S1	21,900	4.0	116	4,430	0.19	5.2	11.0	12.3	19,400	2,590	3,430	331	0.26	295	9.4	674	22.2	34.8	26.2	822	11.9	27.6	80.4	0.45
DSOR121S1	14,600	8.5	111	3,100	0.33	6.8	14.3	15.7	19,200	3,840	5,060	641	0.53	152	12.1	498	22.1	23.3	16.8	962	2.7	27.7	90.2	0.16
DSOR126S1	25,400	3.9	194	3,280	0.26	5.0	10.1	21.7	15,000	3,230	2,360	639	0.44	511	9.2	679	14.4	33.1	6.0	1,120	1.9	22.2	73.0	0.32
DSOR127S1	15,500	4.6	167	4,840	0.35	6.5	12.6	12.4	17,700	3,790	3,910	903	0.76	203	10.7	611	21.2	40.4	17.5	956	2.3	27.8	82.8	0.13
DSOR128S1	27,300	4.8	198	7,610	0.25	6.0	16.9	16.1	21,200	3,180	3,680	652	0.47	301	12.9	617	16.9	44.6	31.6	1,080	13.9	29.9	62.1	0.44
DSOR133S1	14,400	5.2	90	3,380	0.14	4.9	12.1	14.6	16,400	2,890	3,230	420	0.76	263	9.0	444	12.3	27.3	21.4	835	3.4	26.7	58.1	0.16
DSOR134S1*	17,400	5.3	105	3,260	0.23	4.8	12.1	13.8	19,400	3,020	3,985	433	0.31	180	9.2	463	17.2	26.4	23.9	970	9.4	28.7	98.1	0.40
DSOR403S1	14,900	2.4	109	3,800	0.24	5.0	7.2	8.3	15,800	3,690	3,220	958	1.20	269	5.6	565	22.9	33.8	49.4	959	20.9	24.6	72.2	0.42
DSOR404S1	14,700	2.3	170	2,520	0.19	2.9	7.4	8.3	12,400	2,190	2,160	529	0.44	388	5.7	623	12.7	26.0	14.9	940	1.6	20.0	115	0.11
DSOR419S1	11,900	1.7	135	2,000	0.10	5.8	13.5	9.3	13,000	2,130	2,370	583	0.30	119	11.1	263	7.2	21.1	13.2	1,160	2.0	27.9	37.9	0.15
DSOR420S1	22,600	2.4	151	2,480	0.10	6.4	12.4	11.7	20,700	3,980	4,030	707	0.30	154	10.8	503	9.8	25.9	32.6	1,430	4.9	33.2	71.6	0.15
DSOR421S1	21,800	5.0	153	2,490	0.15	5.2	12.5	13.8	20,600	2,910	4,280	515	0.56	151	10.1	603	16.8	25.5	20.4	1,130	6.1	32.4	70.2	0.30
DSOR422S1	25,600	2.2	167	4,370	0.26	4.8	11.4	14.7	15,300	2,670	2,630	503	0.31	629	9.8	402	12.8	48.8	14.0	1,130	4.5	23.6	55.7	0.32
DSOR423S1	23,800	2.7	201	3,720	0.23	7.2	14.1	14.9	18,400	4,060	3,800	726	0.63	258	10.4	722	12.1	37.9	22.5	1,250	9.5	29.8	61.3	0.42
DSOR425S1	23,500	3.4	218	3,550	0.44	7.5	15.3	15.4	18,500	3,400	3,380	596	0.65	220	11.8	640	13.4	39.8	10.5	1,250	2.0	29.4	62.2	0.19
DSOR426S1	20,400	1.7	183	2,680	0.17	5.7	13.4	10.8	16,900	3,190	3,740	725	0.36	270	11.6	357	10.0	35.1	29.2	1,280	4.8	27.9	53.9	0.16
RZAH027S1	16,600	2.7	102	2,930	0.04	4.9	11.2	9.5	16,500	2,270	2,890	456	0.25	214	8.2	538	9.9	29.8	58.5	929	11.8	25.5	41.6	0.20
DSOR135S1	13,000	21.2	102	12,200	0.27	7.4	16.4	18.4	21,700	2,720	8,500	482	0.49	150	13.5	711	18.8	28.4	13.4	888	2.8	27.6	67.4	0.21
DSOR388S1	21,400	4.3	152	3,740	0.07	7.8	14.1	13.4	21,000	2,620	3,700	532	0.77	200	10.8	562	12.1	38.3	10.6	1,270	2.0	40.5	43.2	0.19
DSOR389S1	16,100	14.0	159	3,360	0.22	6.7	10.9	18.9	19,000	2,690	2,930	591		252	9.2	558	24.4	23.5	17.8	1,110	3.2	36.3	49.0	0.18
DSOR398S1	39,100	42.9	266	4,070	0.16	17.6	36.4	39.4	41,600	11,000	7,110	716	1.70	181	32.5	809	12.1	40.5	14.9	1,850	2.2	44.5	85.2	0.15
DSOR399S1	30,000	7.6	344	5,230	0.28	11.4	22.1	24.2	25,100	4,230	3,890	887	0.85	249	19.8	751	17.1	56.7	9.6	1,700	2.1	39.1	74.9	0.22
DSOR443S1	19,800	3.9	202	5,630	0.33	7.4	18.4	16.5	17,200	3,490	3,740	515	0.40	197	13.1	574	18.3	41.9	7.6	1,190	2.7	30.2	56.3	0.35
DSOR376S1	23,400	22.8	149	2,800	0.15	9.4	25.6	24.5	23,300	4,760	5,160	356	0.39	243	22.4	588	8.6	24.7	10.8	1,300	2.0	34.6	44.8	0.19
DSOR400S1	24,200	28.8	233	4,750	0.33	11.2	23.6	34.0	22,300	4,360	3,820	769	0.84	282	20.1	808	25.5	41.0	10.2	1,470	2.7	35.6	70.7	0.26
DSOR445S1	28,100	7.7	172	2,890	0.23	10.4	19.9	21.2	23,200	6,540	6,340	463	0.51	268	20.4	608	8.6	27.9	15.4	1,620	2.6	27.9	54.4	0.17
DSOR446S1	31,100	7.0	343	2,930	0.19	10.6	24.6	23.5	25,700	4,900	4,540	571	0.43	353	20.7	1,120	10.8	29.9	9.8	1,800	1.2	37.8	73.3	0.12
DSOR450S1	38,200		207	4,650	0.14	19.6	41.0	40.2	39,800	10,200	8,370	784	0.63	155	34.2	1,200	11.3	39.0	11.5	1,750	1.5	59.1	61.2	0.13
DSOR451S1*	27,950	24.1	192	4,000	0.19	11.3	24.5	25.4	25,550	5,710	5,625	564	0.49	254	22.6	618	13.5	33.3	11.2	1,465	4.5	34.2	52.1	0.40
DSOR452S1	33,900	62.7	357	5,160	0.61	18.6	27.0	42.1	34,600	6,860	5,750	1,060	0.69	273	30.8	1,320	30.1	51.5	8.6	1,910	1.3	59.8	91.8	0.15
DSOR456S1	21,100	79.2	143	3,300	0.14	10.7	20.8	27.4	25,500	4,960	4,930	440	0.54	160	18.9	575	12.8	27.8	13.6	1,190	3.0	33.6	49.6	0.22
DSOR457S1*	14,300	12.9	36	889	0.11	7.5	15.9	56.8	25,200	4,125	2,690	93	0.89	35	10.8	196	4.8	8.4	14.0	655	3.8	22.5	16.5	0.27
DSOR458S1*	25,100		199	3,190	0.22	21.7	21.3	39.7	33,250	3,885	3,870	778		87	35.0	584	15.2	32.0	19.3	1,095	8.0	40.8	53.1	0.42
DSOR340S1	14,100	20.2	137	19,400	0.23	9.8	19.6	22.8	24,900	2,880	9,170	540	0.50	159	17.3	760	20.3	41.0	11.7	953	1.9	34.4	69.1	0.16
DSOR341S1	11,700	20.0	98	15,000	0.18	7.1	15.6	18.5	20,400	2,570	8,560	453	0.42	131	12.8	717	16.8	32.0	9.4	792	1.0	26.4	58.0	0.11
RZAH037S1	19,000	3.9	124	3,590	0.09	5.2	13.0	15.2	17,500	2,230	2,670	493	0.32	287	11.3	500	13.8	35.4	60.8	846	24.1	30.2	43.6	0.40
n =	49	47	49	49	49	49	49	49	49	49	49	49	47	49	49	49	49	49	49	49	49	49	49	49
Minimum	11,700	1.7	36.0	889	0.04	2.9	7.2	8.3	12,400	2,130	2,160	93.3	0.25	34.6	5.6	196	4.8	8.4	6.0	507	1.0	20.0	16.5	0.11
25th Percentile	16,600	3.4	124	2,930	0.14	5.7	12.6	13.4	17,700	2,700	3,220	463	0.41	155	10.4	475	12.1	26.0	10.5	953	1.9	27.6	49.8	0.15
50th Percentile	20,600	5.2	152	3,520	0.19	7.2	15.6	16.6	20,400	3,490	3,820	554	0.50	201	12.8	575	14.4	32.0	13.6	1,130	2.7	30.2	58.0	0.20
75th Percentile	25,100	18.7	194	4,750	0.26	9.8	21.1	24.5	23,300	4,250	4,930	683	0.75	269	18.7	711	18.1	39.0	21.4	1,340	5.0	35.6	70.7	0.33
Maximum	39,100	79.2	357	19,400	0.65	21.7	47.4	56.8	41,600	11,000	9,170	1,060	2.5	629	35.2	1,320	30.1	56.7	63.3	1,910	30.5	59.8	115	0.68
Mean	21,386	12.6	167	4,393	0.22	8.4	17.8	20.9	21,329	3,841	4,274	570	0.62	226	15.3	624	15.3	32.5	19.7	1,165	5.7	32.5	60.7	0.25
Std. Dev.	6,423	16.0	67.6	3,189	0.13	4.1	7.9	10.8	5,959	1,769	1,727	183	0.4	104	7.5	236	5.2	8.9	15.2	326	6.8	8.5	17.6	0.13
UCL_{95}	22,000	9.3	171	4,280	0.21	8.4	18.0	20.9	21,900	3,890	4,360	588	0.6	229	15.4	638	15.7	33.6	18.5	1,200	4.4	33.4	62.7	0.25
CV	30%	127%	40%	73%	58%	49%	44%	52%	28%	46%	40%	32%	64%	46%	49%	38%	34%	27%	77%	28%	120%	26%	29%	51%
Geometric Mean	**20,500**	**7.3**	**155**	**3,794**	**0.18**	**7.6**	**16.4**	**18.7**	**20,645**	**3,567**	**3,995**	**536**	**0.54**	**205**	**13.9**	**585**	**14.4**	**31.2**	**16.0**	**1,120**	**3.5**	**31.6**	**58.1**	**0.22**
Skewness	0.80	2.55	1.31	3.31	1.58	1.74	1.85	1.30	1.66	2.50	1.40	0.29	2.95	1.64	1.41	1.25	0.56	0.29	1.85	0.42	2.13	1.44	0.59	1.14
Kurtosis	0.50	7.32	1.93	12.22	3.31	2.91	4.40	1.35	3.52	7.60	1.44	0.76	11.25	4.31	1.45	1.66	0.25	0.67	2.46	-0.14	3.98	2.58	1.40	1.22

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**		
Variable	Table A21. Log-transformed data, case II - Al		
Performed by		**Date**	8 August 2007

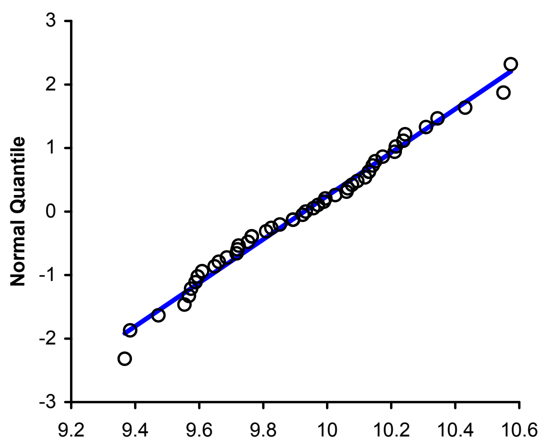


n	49
Mean	9.928
90% CI	9.858 to 9.998
Variance	0.0856
SD	0.2926
SE	0.0418
CV	3%



Median	9.933
91.5% CI	9.809 to 10.060
Range	1.206533625
IQR	0.413465151

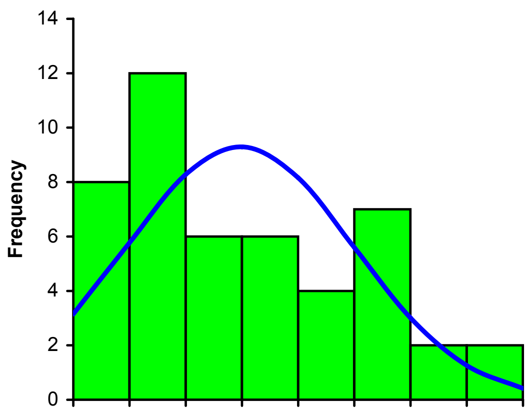
Percentile	
2.5th	9.372
25th	9.717
50th	9.933
75th	10.131
97.5th	10.568



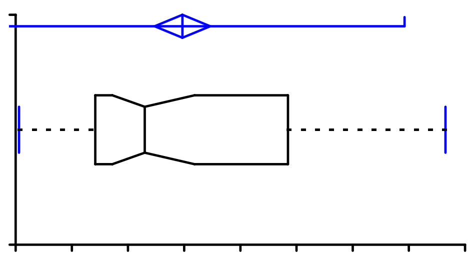
	Coefficient	p
Shapiro-Wilk	0.9833	0.7093
Skewness	0.1414	0.6628
Kurtosis	-0.5337	0.3972

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**		
Variable	Table A21. Log-transformed data, case II - As		
Performed by		**Date**	8 August 2007

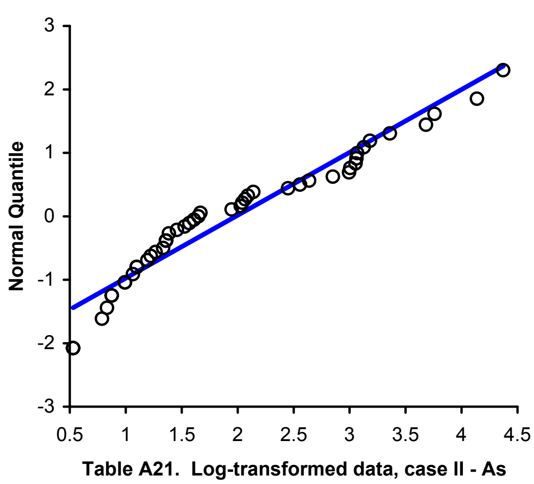


n	47 (cases excluded: 2 due to mis
Mean	1.984
90% CI	1.737 to 2.231
Variance	1.0179
SD	1.0089
SE	0.1472
CV	51%



Median	1.649
92.1% CI	1.361 to 2.092
Range	3.841348048
IQR	1.714370437

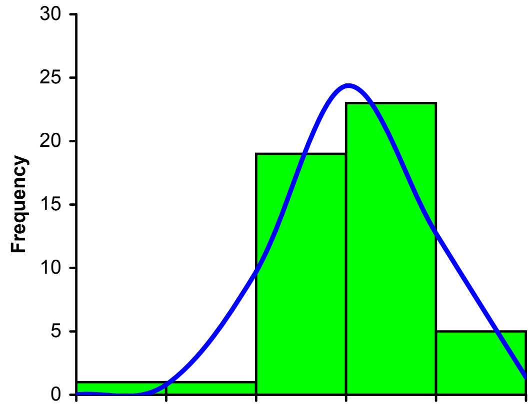
Percentile	
2.5th	0.531
25th	1.209
50th	1.649
75th	2.923
97.5th	4.325



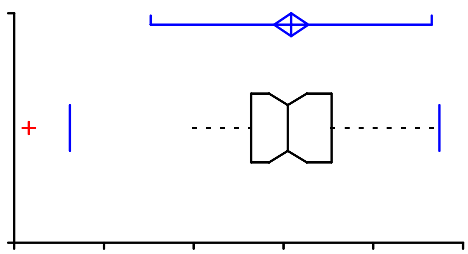
	Coefficient	**p**
Shapiro-Wilk	0.9328	0.0096
Skewness	0.6145	0.0765
Kurtosis	-0.6182	0.2994

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - Ba
Performed by	
Date	8 August 2007

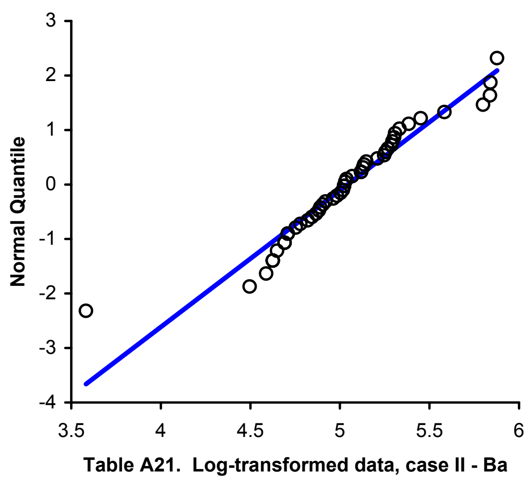


n	49
Mean	5.043
90% CI	4.947 to 5.139
Variance	0.1592
SD	0.3991
SE	0.0570
CV	8%



Median	5.024
91.5% CI	4.920 to 5.130
Range	2.295606698
IQR	0.447576593

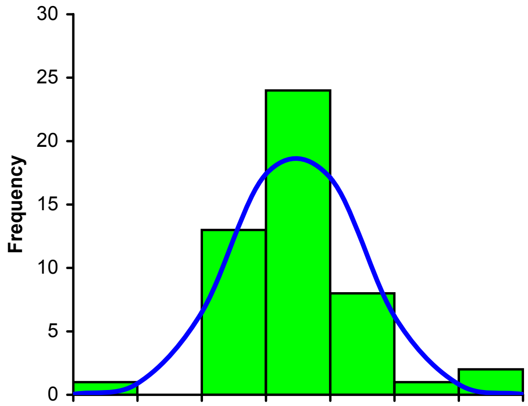
Percentile	
2.5th	3.811
25th	4.820
50th	5.024
75th	5.268
97.5th	5.868



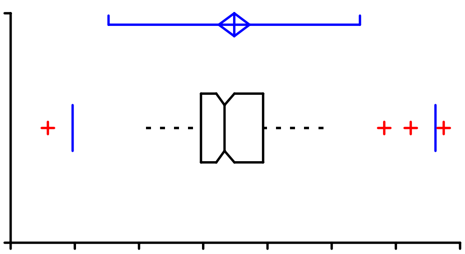
	Coefficient	p
Shapiro-Wilk	0.9337	0.0085
Skewness	-0.4811	0.1502
Kurtosis	2.9663	0.0069

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - Ca
Performed by	
Date	8 August 2007

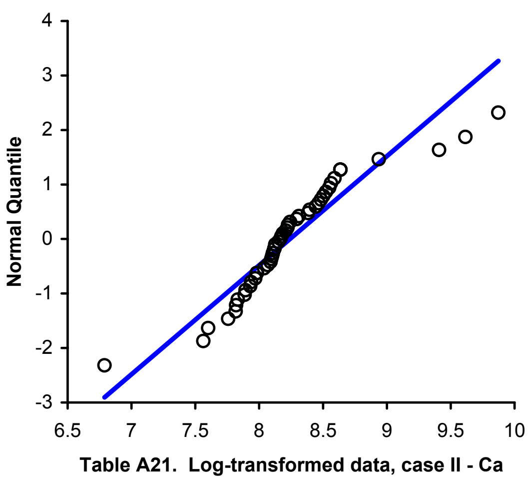


n	49
Mean	8.241
90% CI	8.122 to 8.361
Variance	0.2496
SD	0.4996
SE	0.0714
CV	6%



Median	8.166
91.5% CI	8.102 to 8.243
Range	3.083493697
IQR	0.483142195

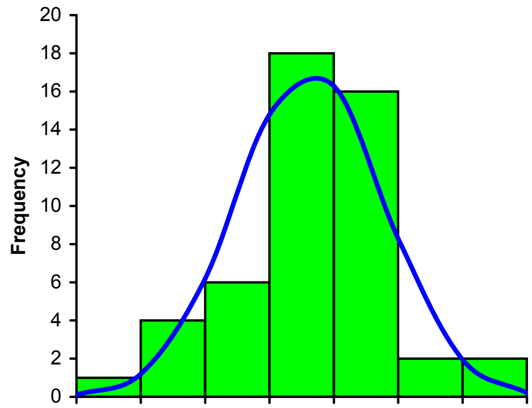
Percentile	
2.5th	6.983
25th	7.983
50th	8.166
75th	8.466
97.5th	9.809



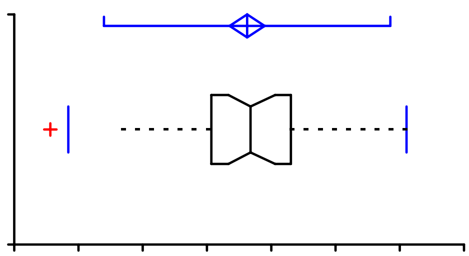
	Coefficient	**p**
Shapiro-Wilk	0.8924	0.0003
Skewness	0.8678	0.0147
Kurtosis	3.5832	0.0030

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - Cd
Performed by	
Date	8 August 2007

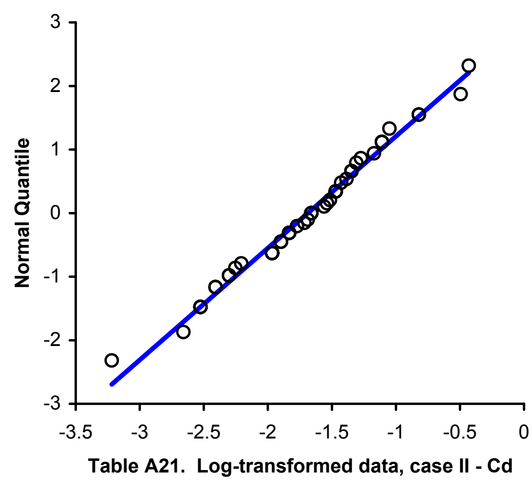


n	49
Mean	-1.688
90% CI	-1.824 to -1.551
Variance	0.3233
SD	0.5686
SE	0.0812
CV	-34%



Median	-1.661
91.5% CI	-1.833 to -1.470
Range	2.788092909
IQR	0.619039208

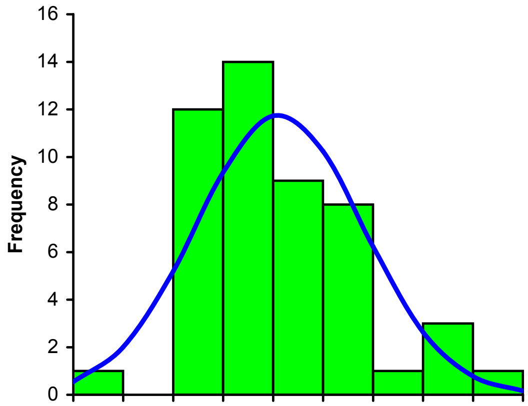
Percentile	
2.5th	-3.079
25th	-1.966
50th	-1.661
75th	-1.347
97.5th	-0.447



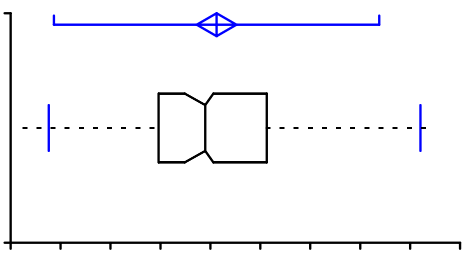
	Coefficient	p
Shapiro-Wilk	0.9857	0.8104
Skewness	-0.1911	0.5566
Kurtosis	0.2453	0.5590

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - Co
Performed by	
Date	8 August 2007

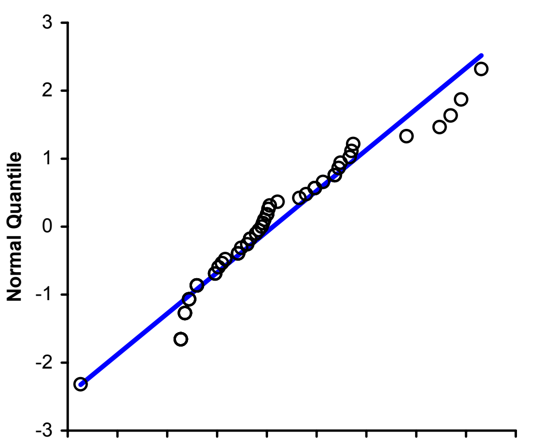


n	49
Mean	2.031
90% CI	1.932 to 2.131
Variance	0.1727
SD	0.4156
SE	0.0594
CV	20%



Median	1.974
91.5% CI	1.872 to 2.015
Range	2.012601524
IQR	0.541916211

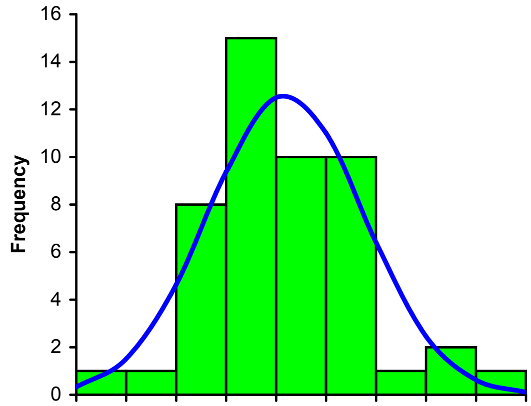
Percentile	
2.5th	1.191
25th	1.740
50th	1.974
75th	2.282
97.5th	3.052



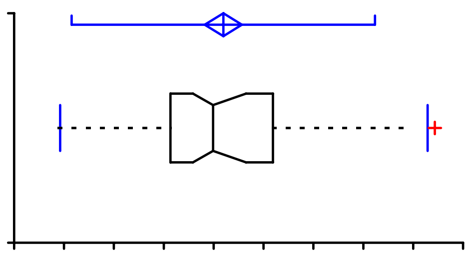
	Coefficient	p
Shapiro-Wilk	0.9455	0.0243
Skewness	0.6450	0.0596
Kurtosis	0.5136	0.3550

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - Cr
Performed by	
Date	8 August 2007

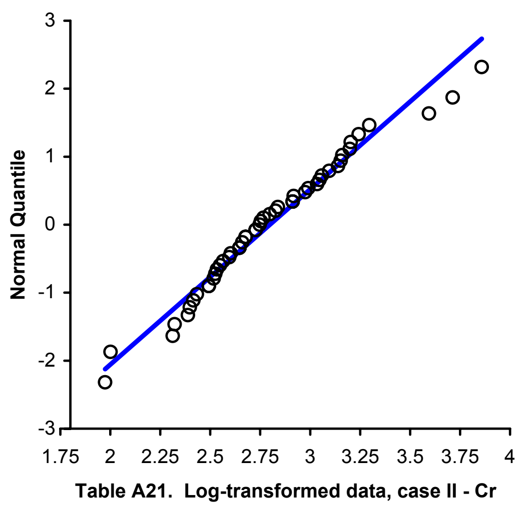


n	49
Mean	2.798
90% CI	2.705 to 2.891
Variance	0.1505
SD	0.3879
SE	0.0554
CV	14%



Median	2.747
91.5% CI	2.646 to 2.912
Range	1.884541203
IQR	0.513203746

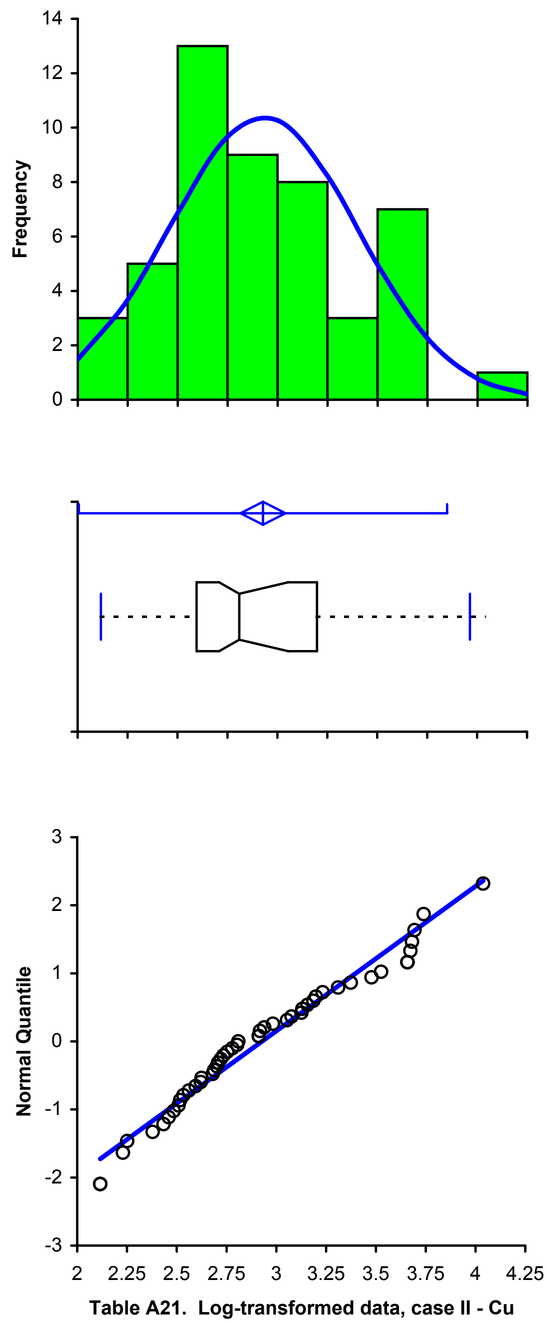
Percentile	
2.5th	1.981
25th	2.534
50th	2.747
75th	3.047
97.5th	3.822



	Coefficient	p
Shapiro-Wilk	0.9723	0.2982
Skewness	0.4924	0.1415
Kurtosis	0.6596	0.2757

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - Cu
Performed by	
Date	8 August 2007



n	49
Mean	2.928
90% CI	2.815 to 3.041
Variance	0.2212
SD	0.4704
SE	0.0672
CV	16%

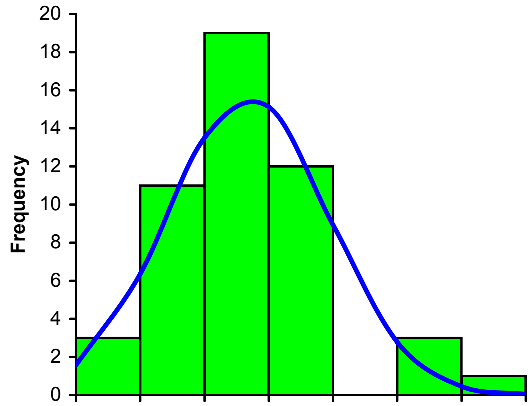
Median	2.809
91.5% CI	2.708 to 3.054
Range	1.922400142
IQR	0.603418411

Percentile	
2.5th	2.116
25th	2.595
50th	2.809
75th	3.199
97.5th	3.964

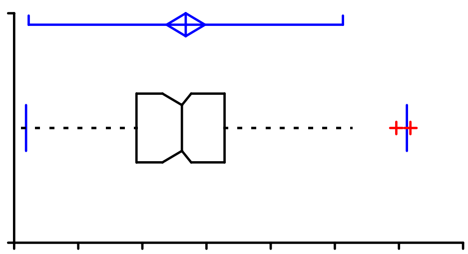
	Coefficient	p
Shapiro-Wilk	0.9651	0.1541
Skewness	0.4126	0.2133
Kurtosis	-0.5410	0.3871

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - Fe
Performed by	
Date	8 August 2007



n	49
Mean	9.935
90% CI	9.875 to 9.995
Variance	0.0625
SD	0.2500
SE	0.0357
CV	3%



Median	9.923
91.5% CI	9.863 to 9.952
Range	1.210403695
IQR	0.274888721

Percentile	
2.5th	9.437
25th	9.781
50th	9.923
75th	10.056
97.5th	10.625

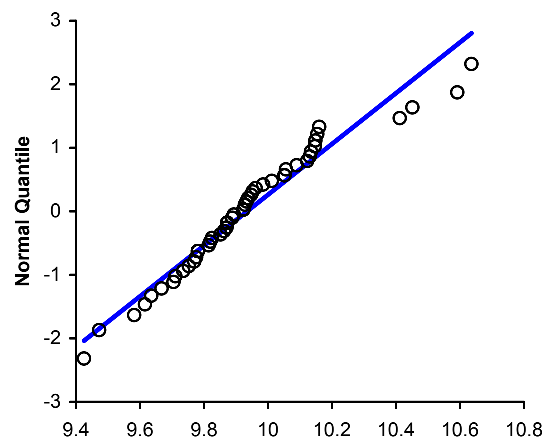
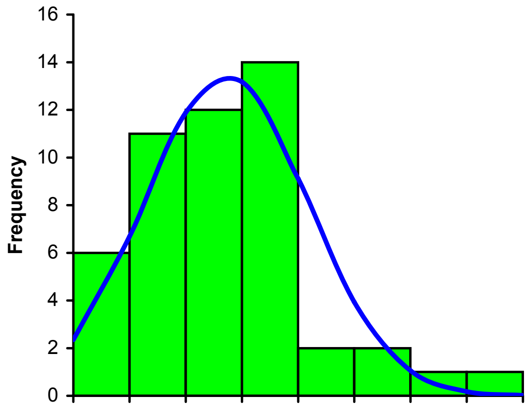


Table A21. Log-transformed data, case II - Fe

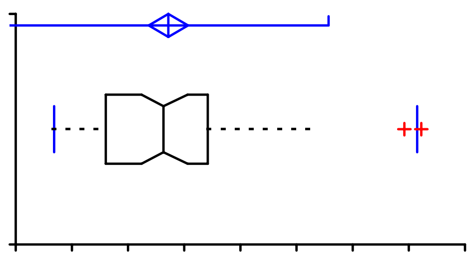
	Coefficient	p
Shapiro-Wilk	0.9523	0.0457
Skewness	0.7378	0.0338
Kurtosis	1.2003	0.1081

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - K
Performed by	
Date	8 August 2007

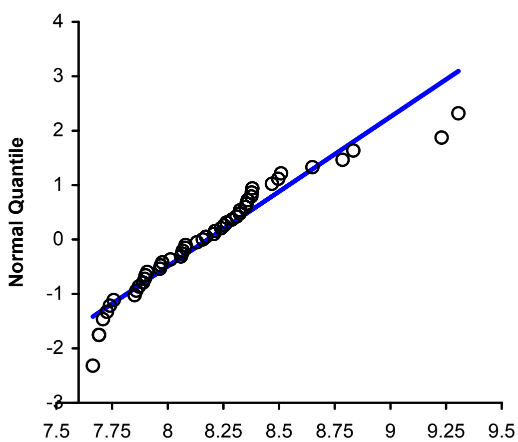


n	49
Mean	8.180
90% CI	8.092 to 8.267
Variance	0.1325
SD	0.3640
SE	0.0520
CV	4%



Median	8.158
91.5% CI	8.060 to 8.265
Range	1.641773293
IQR	0.45366721

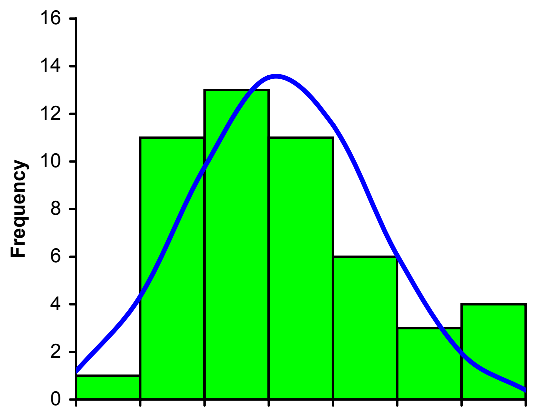
Percentile	
2.5th	7.671
25th	7.901
50th	8.158
75th	8.355
97.5th	9.287



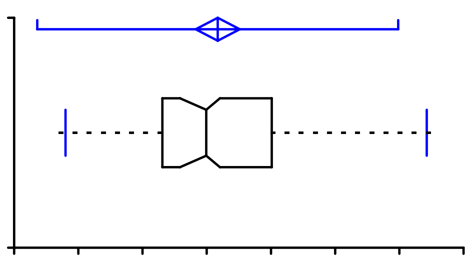
	Coefficient	p
Shapiro-Wilk	0.9226	0.0033
Skewness	1.0745	0.0037
Kurtosis	1.6946	0.0473

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**		
Variable	Table A21. Log-transformed data, case II - Mg		
Performed by		**Date**	8 August 2007

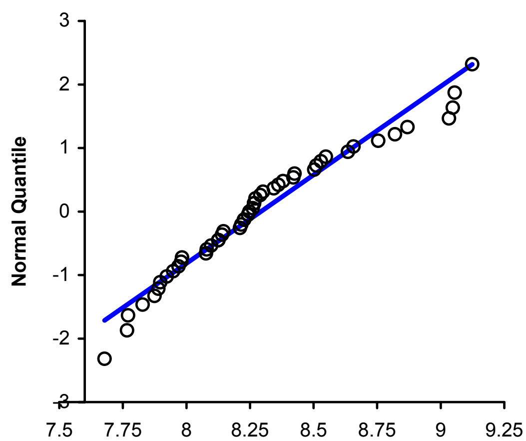


n	49
Mean	8.293
90% CI	8.207 to 8.379
Variance	0.1287
SD	0.3587
SE	0.0512
CV	4%



Median	8.248
91.5% CI	8.146 to 8.302
Range	1.445829065
IQR	0.425957628

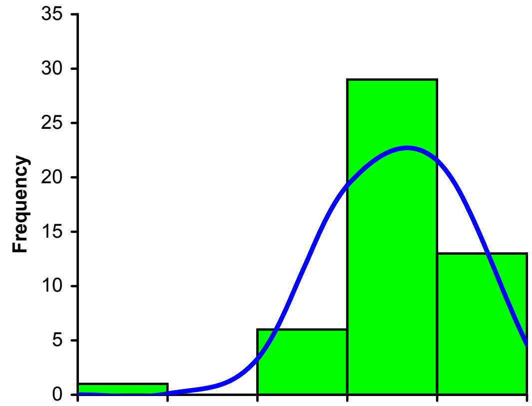
Percentile	
2.5th	7.700
25th	8.077
50th	8.248
75th	8.503
97.5th	9.106



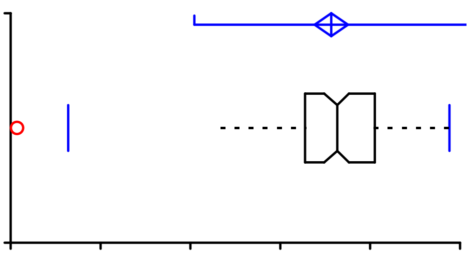
	Coefficient	p
Shapiro-Wilk	0.9513	0.0418
Skewness	0.6493	0.0581
Kurtosis	-0.0473	0.8871

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - Mn
Performed by	
Date	8 August 2007

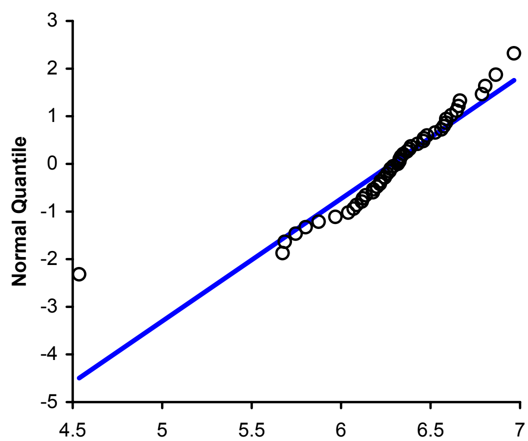


n	49
Mean	6.284
90% CI	6.191 to 6.377
Variance	0.1511
SD	0.3887
SE	0.0555
CV	6%



Median	6.317
91.5% CI	6.244 to 6.382
Range	2.430204079
IQR	0.388035473

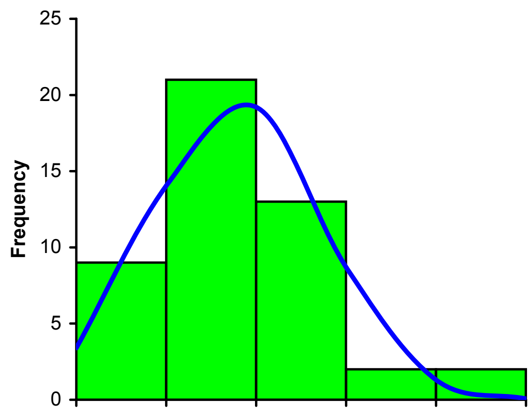
Percentile	
2.5th	4.820
25th	6.138
50th	6.317
75th	6.526
97.5th	6.941

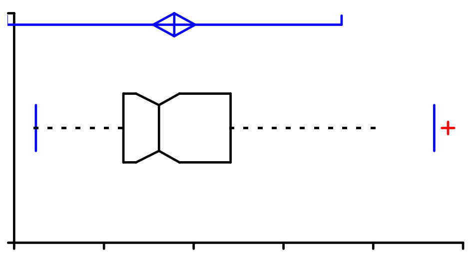


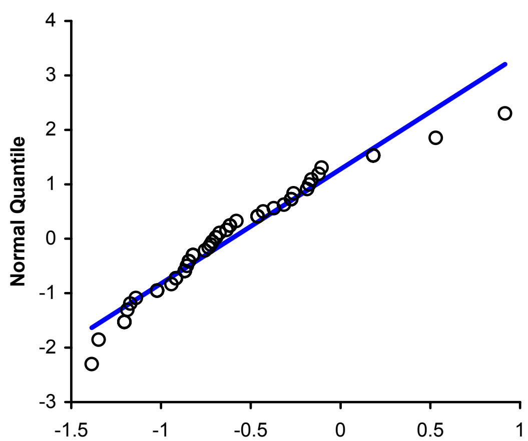
	Coefficient	p
Shapiro-Wilk	0.8684	<0.0001
Skewness	-1.8790	<0.0001
Kurtosis	7.5178	<0.0001

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - Mo
Performed by	
Date	8 August 2007







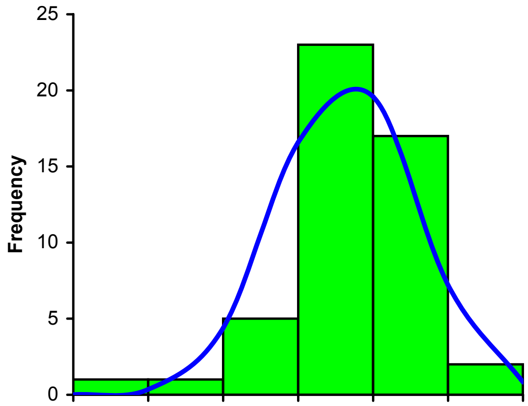
n	47 (cases excluded: 2 due to mis
Mean	-0.609
90% CI	-0.725 to -0.492
Variance	0.2261
SD	0.4755
SE	0.0694
CV	-78%
Median	-0.693
92.1% CI	-0.821 to -0.580
Range	2.302585093
IQR	0.597321855

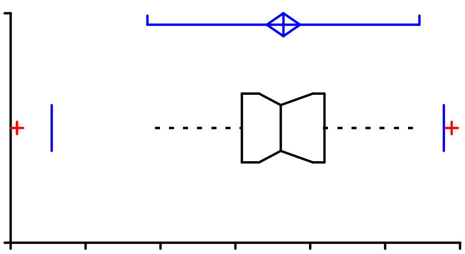
Percentile	
2.5th	-1.378
25th	-0.892
50th	-0.693
75th	-0.295
97.5th	0.839

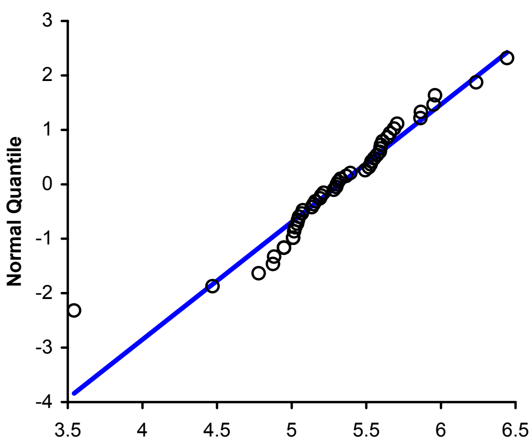
	Coefficient	**p**
Shapiro-Wilk	0.9452	0.0281
Skewness	0.9521	0.0096
Kurtosis	1.3807	0.0832

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - Na
Performed by	
Date	8 August 2007







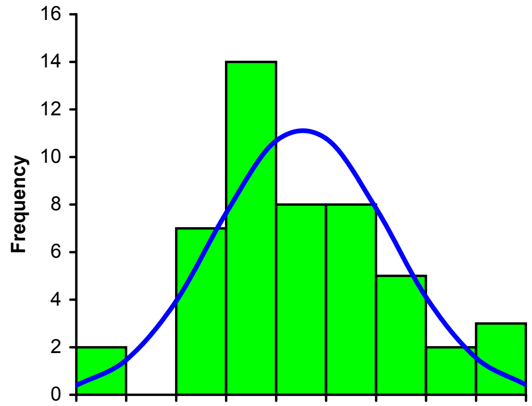
n	49
Mean	5.321
90% CI	5.210 to 5.432
Variance	0.2146
SD	0.4632
SE	0.0662
CV	9%
Median	5.303
91.5% CI	5.159 to 5.517
Range	2.901723706
IQR	0.551286263

Percentile	
2.5th	3.774
25th	5.043
50th	5.303
75th	5.595
97.5th	6.392

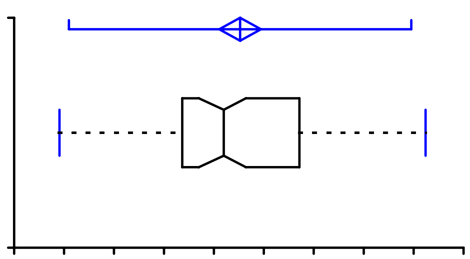
	Coefficient	**p**
Shapiro-Wilk	0.9307	0.0065
Skewness	-0.7787	0.0261
Kurtosis	3.8205	0.0022

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - Ni
Performed by	
Date	8 August 2007

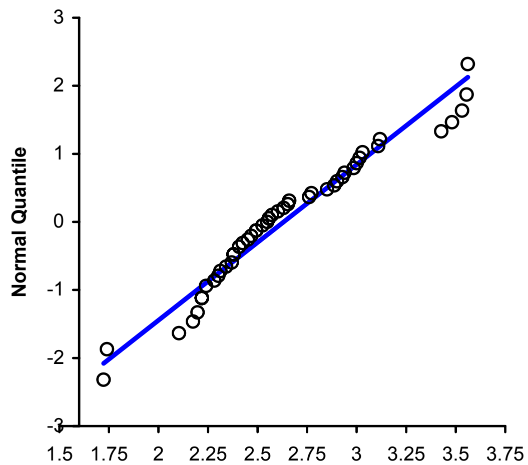


n	49
Mean	2.631
90% CI	2.527 to 2.736
Variance	0.1911
SD	0.4372
SE	0.0625
CV	17%



Median	2.549
91.5% CI	2.425 to 2.660
Range	1.838279485
IQR	0.586717718

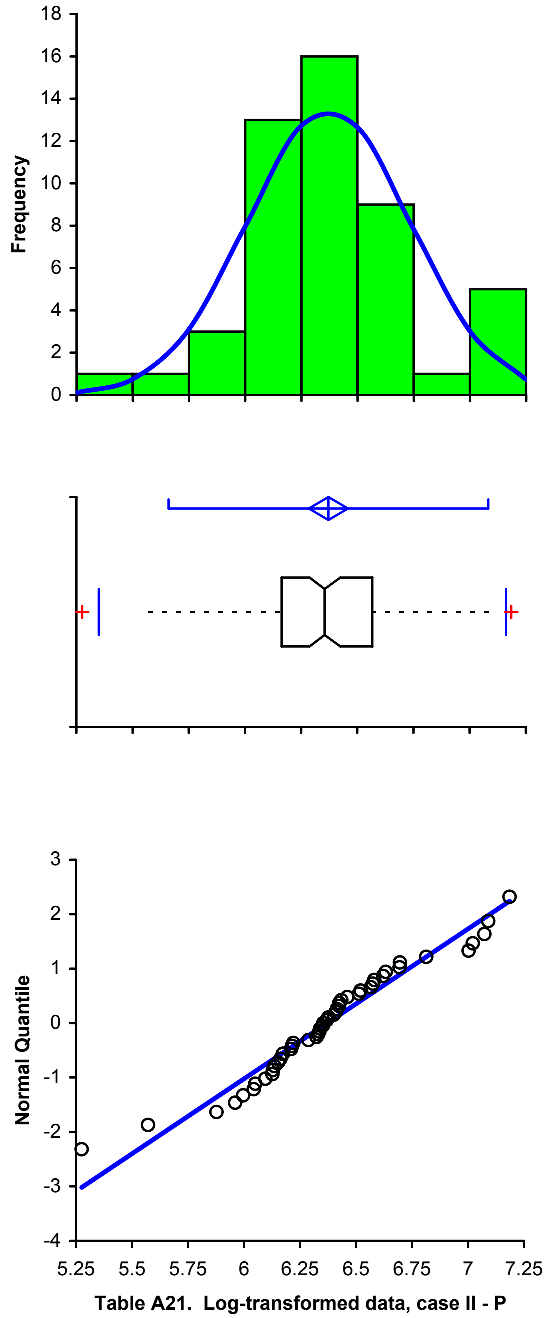
Percentile	
2.5th	1.727
25th	2.342
50th	2.549
75th	2.929
97.5th	3.560



	Coefficient	p
Shapiro-Wilk	0.9548	0.0578
Skewness	0.4424	0.1837
Kurtosis	-0.0162	0.8468

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - P
Performed by	
Date	8 August 2007



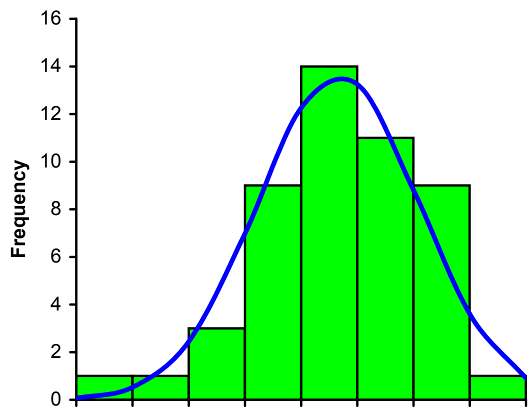
n	49
Mean	6.372
90% CI	6.285 to 6.459
Variance	0.1318
SD	0.3630
SE	0.0519
CV	6%
Median	6.354
91.5% CI	6.288 to 6.425
Range	1.909826636
IQR	0.403357626

Percentile	
2.5th	5.350
25th	6.163
50th	6.354
75th	6.567
97.5th	7.162

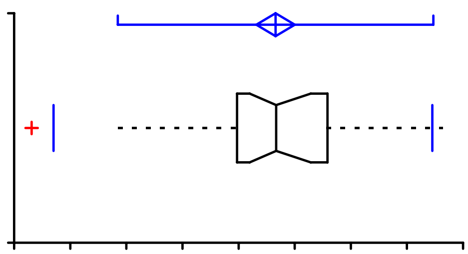
	Coefficient	**p**
Shapiro-Wilk	0.9585	0.0823
Skewness	-0.1130	0.7273
Kurtosis	1.3783	0.0799

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**		
Variable	Table A21. Log-transformed data, case II - Pb		
Performed by		**Date**	8 August 2007

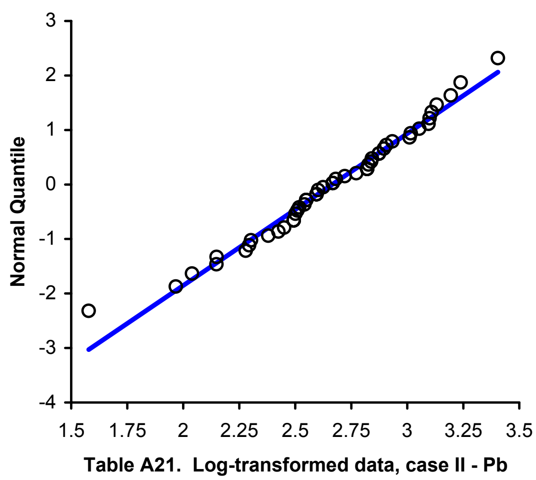


n	49
Mean	2.665
90% CI	2.579 to 2.751
Variance	0.1287
SD	0.3587
SE	0.0512
CV	13%



Median	2.667
91.5% CI	2.549 to 2.821
Range	1.826577926
IQR	0.402706486

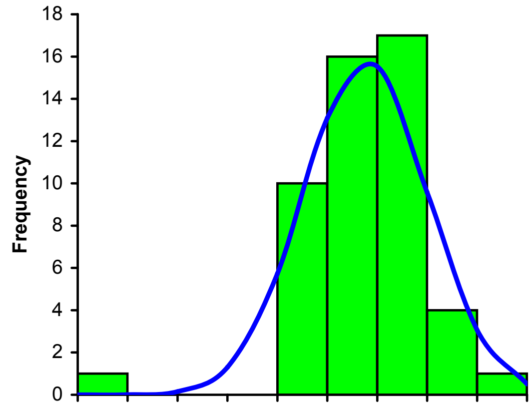
Percentile	
2.5th	1.675
25th	2.493
50th	2.667
75th	2.896
97.5th	3.363



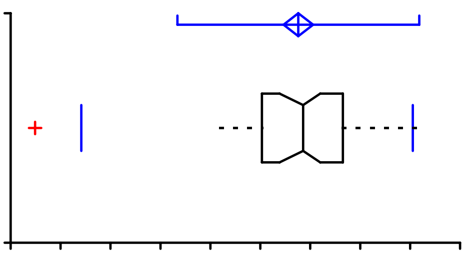
	Coefficient	p
Shapiro-Wilk	0.9797	0.5531
Skewness	-0.4956	0.1391
Kurtosis	0.6782	0.2670

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - Sr
Performed by	
Date	8 August 2007

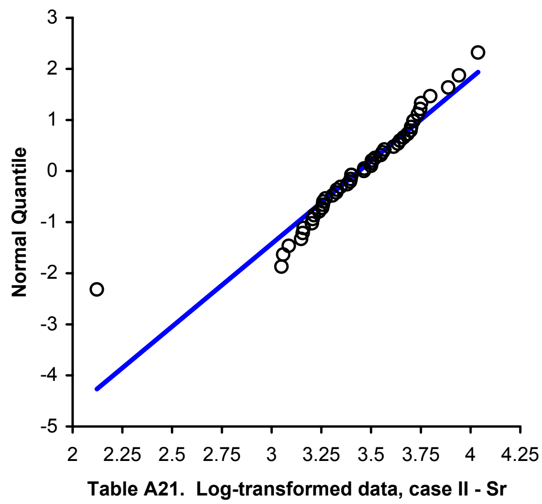


n	49
Mean	3.440
90% CI	3.366 to 3.514
Variance	0.0954
SD	0.3088
SE	0.0441
CV	9%



Median	3.464
91.5% CI	3.346 to 3.550
Range	1.915512672
IQR	0.405465108

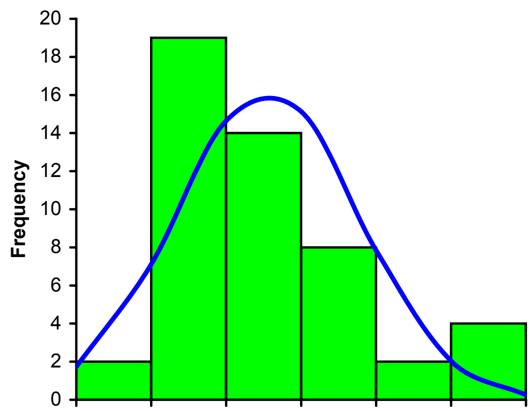
Percentile	
2.5th	2.354
25th	3.258
50th	3.464
75th	3.664
97.5th	4.014



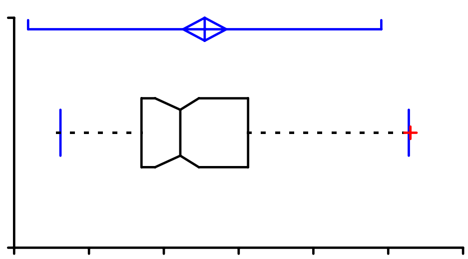
	Coefficient	p
Shapiro-Wilk	0.8997	0.0005
Skewness	-1.4048	0.0004
Kurtosis	5.6697	0.0003

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - Th
Performed by	
Date	8 August 2007



n	49
Mean	2.774
90% CI	2.629 to 2.918
Variance	0.3623
SD	0.6019
SE	0.0860
CV	22%



Median	2.610
91.5% CI	2.442 to 2.734
Range	2.361138402
IQR	0.712015665

Percentile	
2.5th	1.810
25th	2.351
50th	2.610
75th	3.063
97.5th	4.138

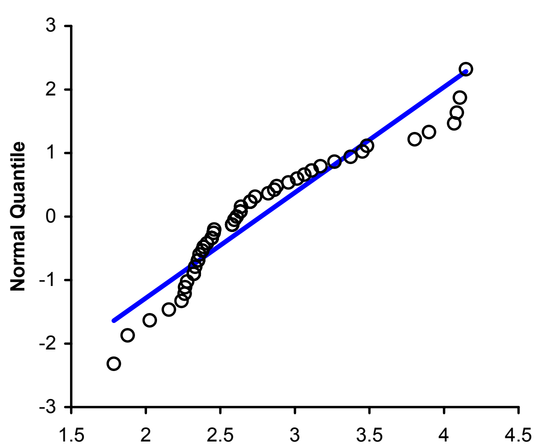
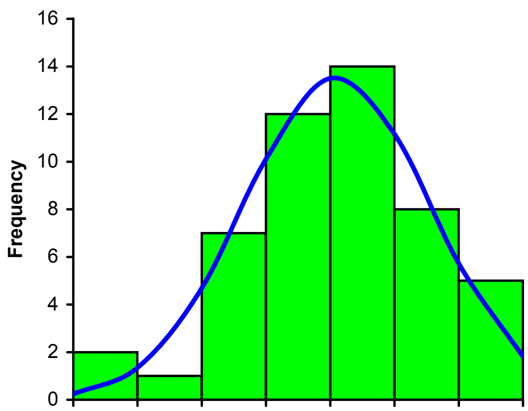


Table A21. Log-transformed data, case II - Th

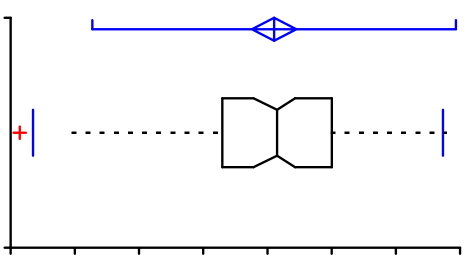
	Coefficient	p
Shapiro-Wilk	0.9022	0.0007
Skewness	0.9359	0.0094
Kurtosis	0.1507	0.6523

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - Ti
Performed by	
Date	8 August 2007

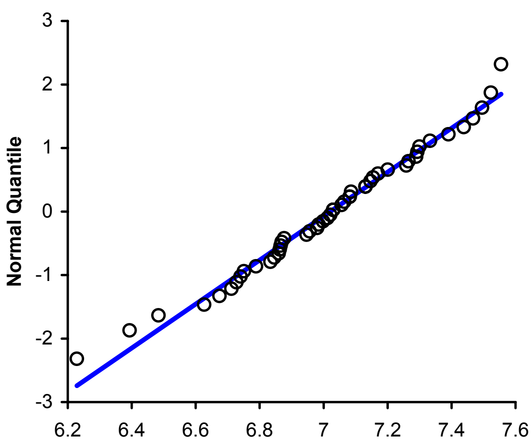


n	49
Mean	7.021
90% CI	6.951 to 7.090
Variance	0.0835
SD	0.2889
SE	0.0413
CV	4%



Median	7.030
91.5% CI	6.957 to 7.086
Range	1.326347517
IQR	0.340809989

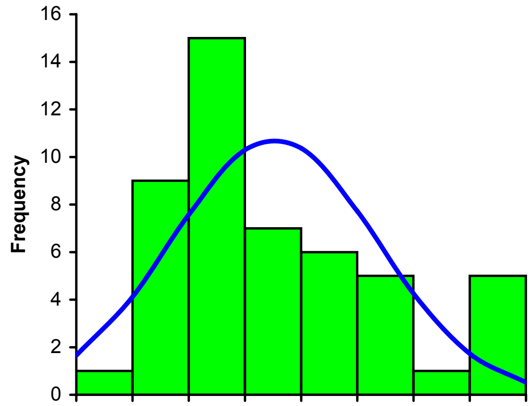
Percentile	
2.5th	6.270
25th	6.860
50th	7.030
75th	7.200
97.5th	7.547



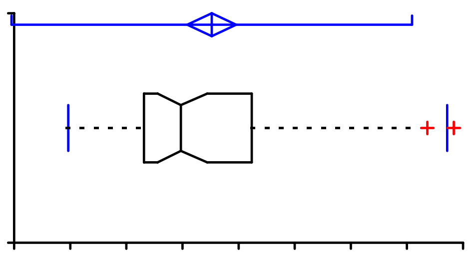
	Coefficient	p
Shapiro-Wilk	0.9822	0.6611
Skewness	-0.3647	0.2688
Kurtosis	0.2792	0.5284

analysed with: Analyse-it + General 1.73

Test	Continuous summary descriptives		
Variable	Table A21. Log-transformed data, case II - U		
Performed by		Date	8 August 2007

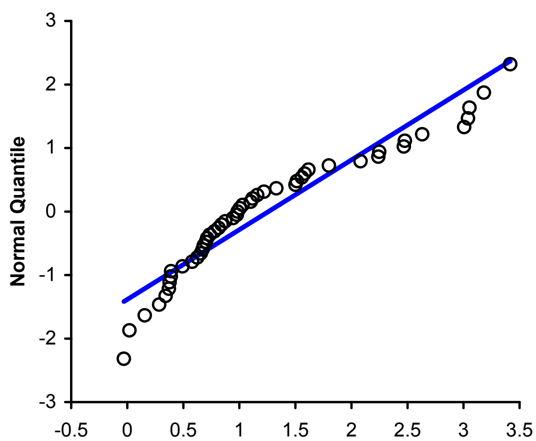


n	49
Mean	1.261
90% CI	1.043 to 1.479
Variance	0.8292
SD	0.9106
SE	0.1301
CV	72%



Median	0.986
91.5% CI	0.779 to 1.221
Range	3.448185891
IQR	0.959886079

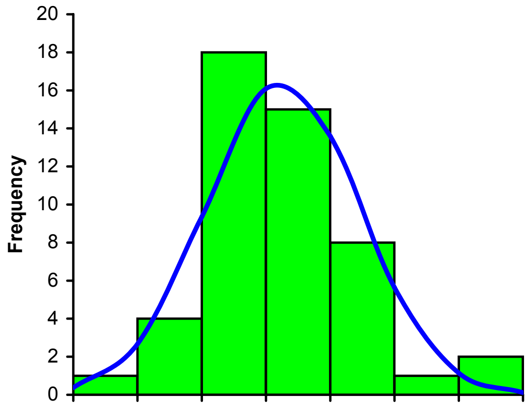
Percentile	
2.5th	-0.018
25th	0.658
50th	0.986
75th	1.617
97.5th	3.359



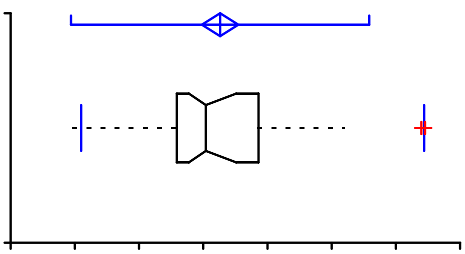
	Coefficient	p
Shapiro-Wilk	0.9074	0.0010
Skewness	0.8727	0.0142
Kurtosis	-0.1980	0.9014

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - V
Performed by	
Date	8 August 2007

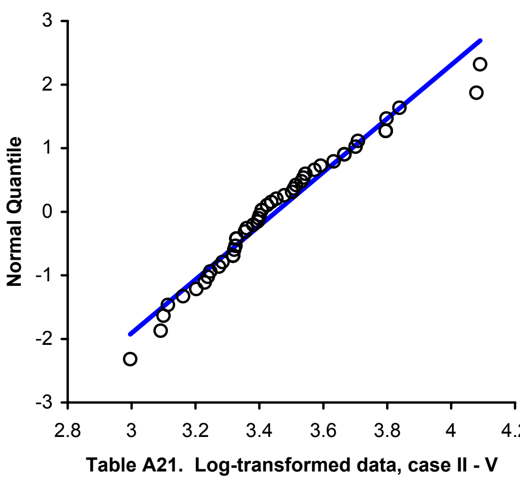


n	49
Mean	3.453
90% CI	3.396 to 3.509
Variance	0.0562
SD	0.2371
SE	0.0339
CV	7%



Median	3.408
91.5% CI	3.355 to 3.503
Range	1.095273387
IQR	0.254529865

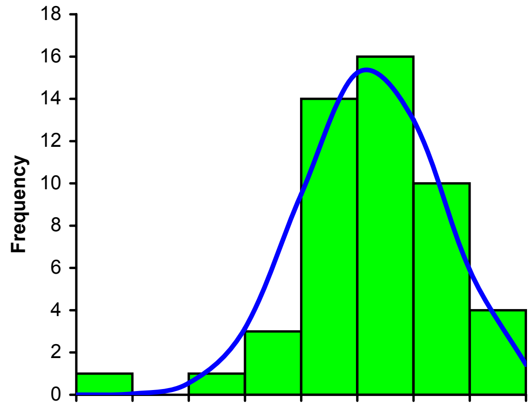
Percentile	
2.5th	3.020
25th	3.318
50th	3.408
75th	3.572
97.5th	4.088



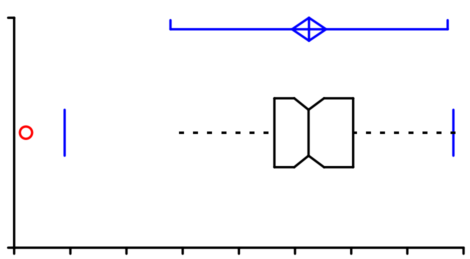
	Coefficient	p
Shapiro-Wilk	0.9622	0.1165
Skewness	0.6940	0.0443
Kurtosis	0.6081	0.3015

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - Zn
Performed by	
Date	8 August 2007

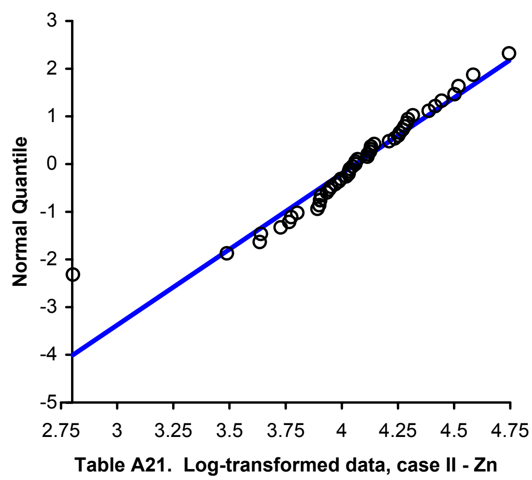


n	49
Mean	4.062
90% CI	3.987 to 4.138
Variance	0.0990
SD	0.3146
SE	0.0449
CV	8%



Median	4.060
91.5% CI	3.996 to 4.129
Range	1.941571747
IQR	0.350430589

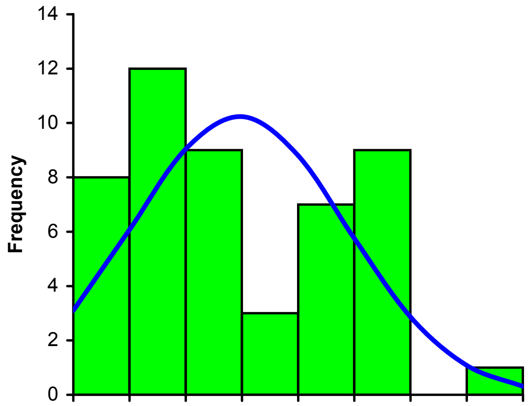
Percentile	
2.5th	2.975
25th	3.908
50th	4.060
75th	4.258
97.5th	4.705



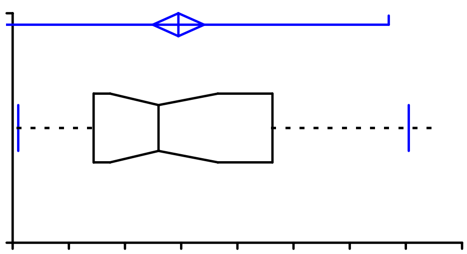
	Coefficient	**p**
Shapiro-Wilk	0.9269	0.0047
Skewness	-1.1230	0.0026
Kurtosis	4.4203	0.0011

analysed with: Analyse-it + General 1.73

Test	**Continuous summary descriptives**
Variable	Table A21. Log-transformed data, case II - U/Th
Performed by	
Date	8 August 2007

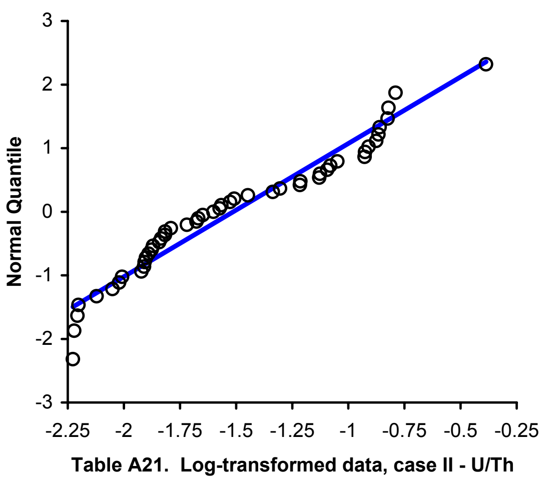


n	49
Mean	-1.512
90% CI	-1.627 to -1.398
Variance	0.2279
SD	0.4774
SE	0.0682
CV	-32%



Median	-1.601
91.5% CI	-1.816 to -1.337
Range	1.840155809
IQR	0.795794426

Percentile	
2.5th	-2.225
25th	-1.890
50th	-1.601
75th	-1.094
97.5th	-0.487



	Coefficient	p
Shapiro-Wilk	0.9421	0.0179
Skewness	0.3461	0.2930
Kurtosis	-0.9631	0.0269

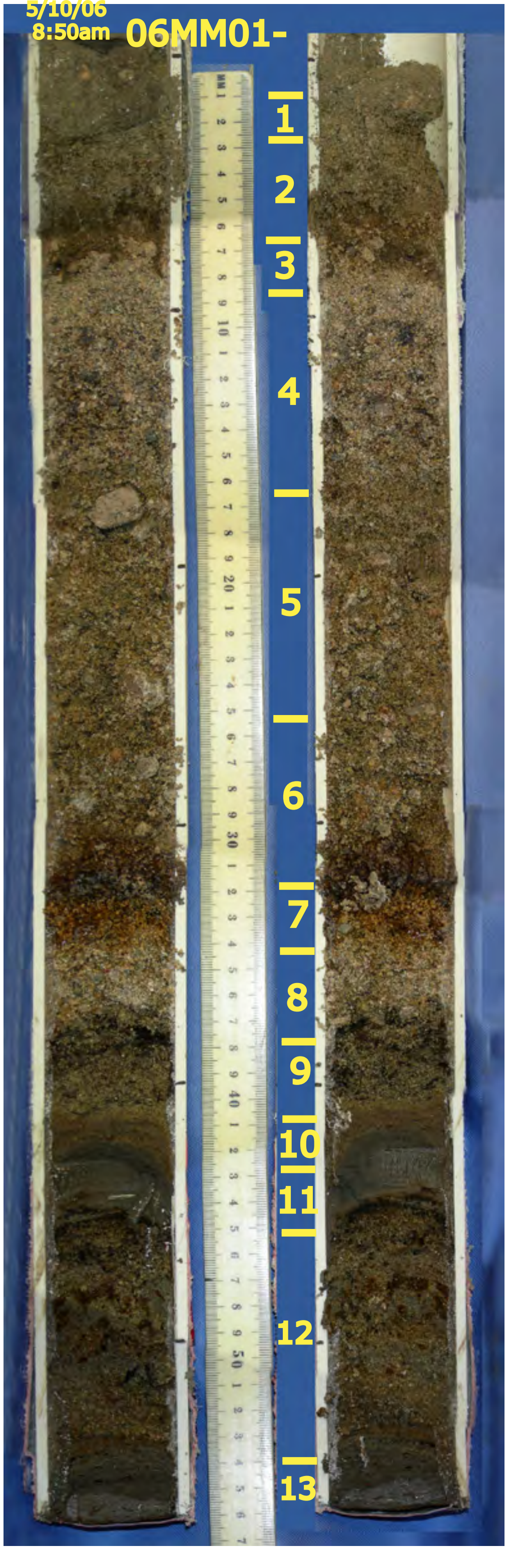
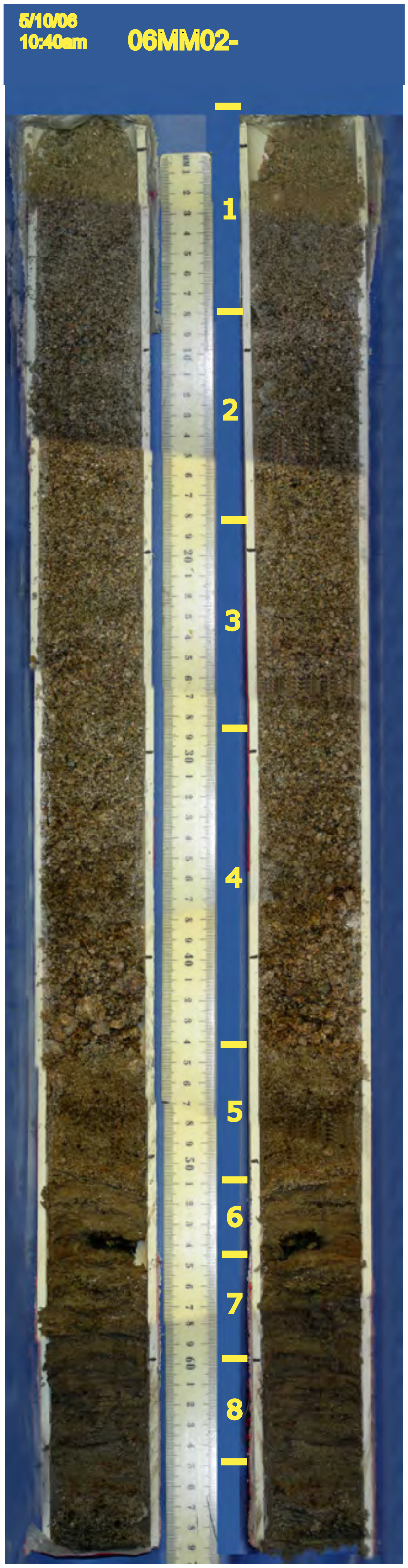


Figure A1A. Photograph of core 06MM01 showing sample intervals 1–13 (0–56 cm). Scale is in centimeters.

Figure A1B. Photograph of core 06MM01 showing sample intervals 13–25 (56–127 cm). Scale is in centimeters.



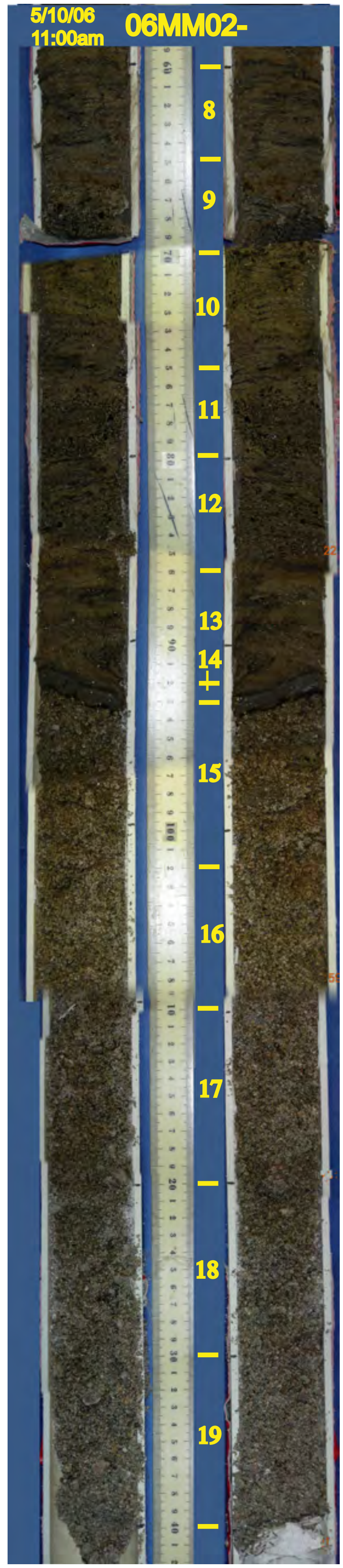


Figure A2A. Photograph of core 06MM02 showing sample intervals 1–8 (0–69 cm). Scale is in centimeters.

Figure A2B. Photograph of core 06MM02 showing sample intervals 8–19 (60–140 cm). The meter stick was off by 10 cm between what is now labeled 70 cm to the bottom of the meter stick (100 cm). The photo has been corrected to reflect the written record (table A2). Scale is in centimeters.

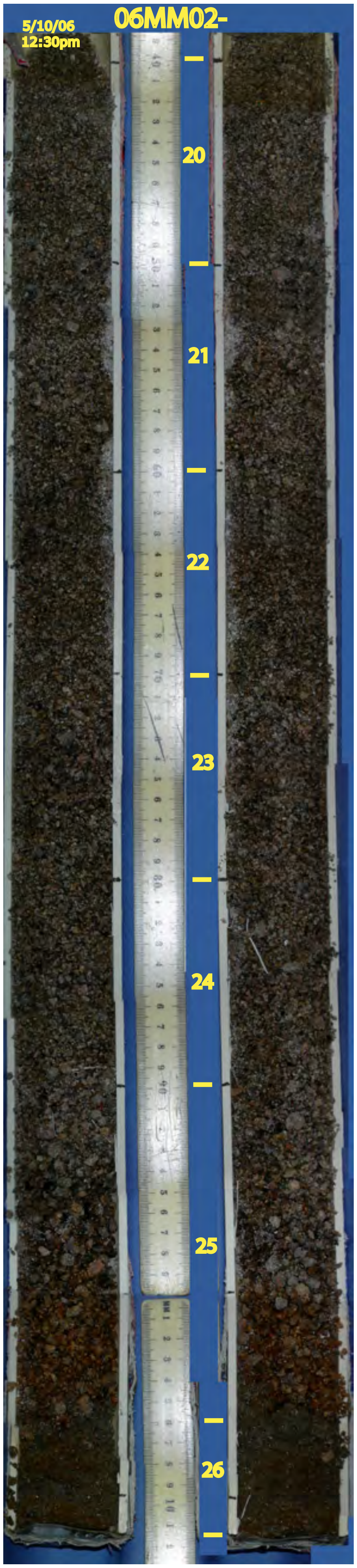


Figure A2C. Photograph of core 06MM02 showing sample intervals 20–26 (140–211 cm). Scale is in centimeters.

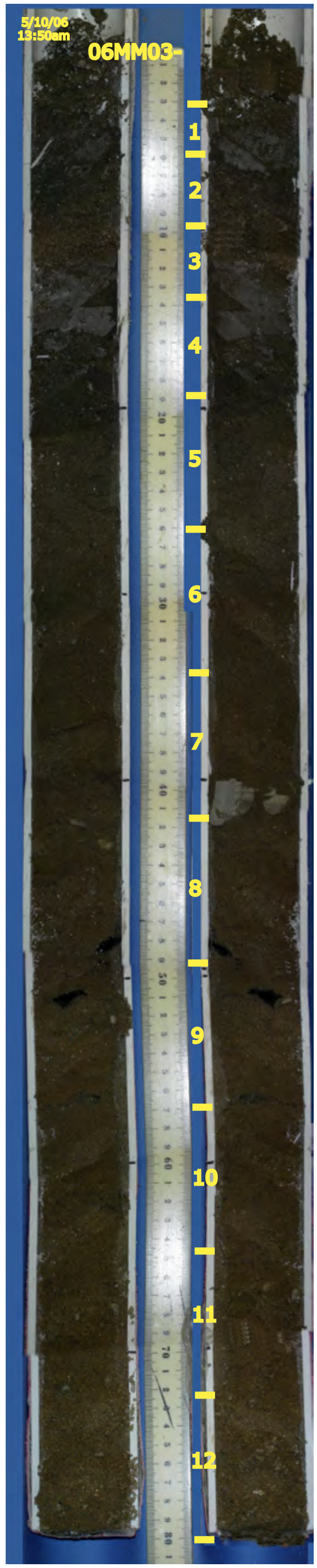


Figure A3A. Photograph of core 06MM03 showing sample intervals 1–12 (0–80 cm). Scale is in centimeters.

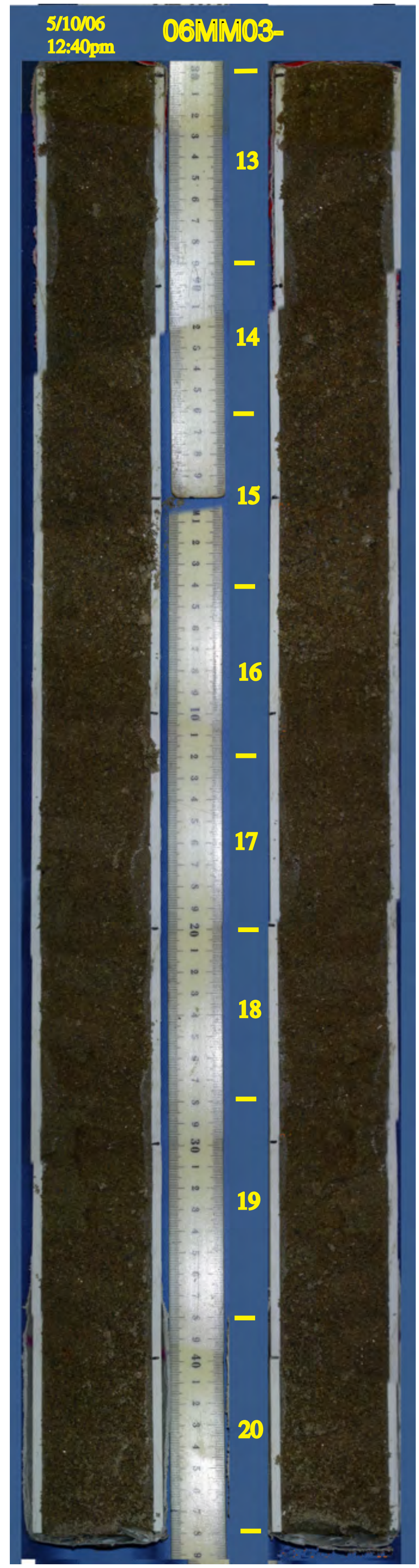


Figure A3B. Photograph of core 06MM03 showing sample intervals 13–20 (80–148 cm). Scale is in centimeters.

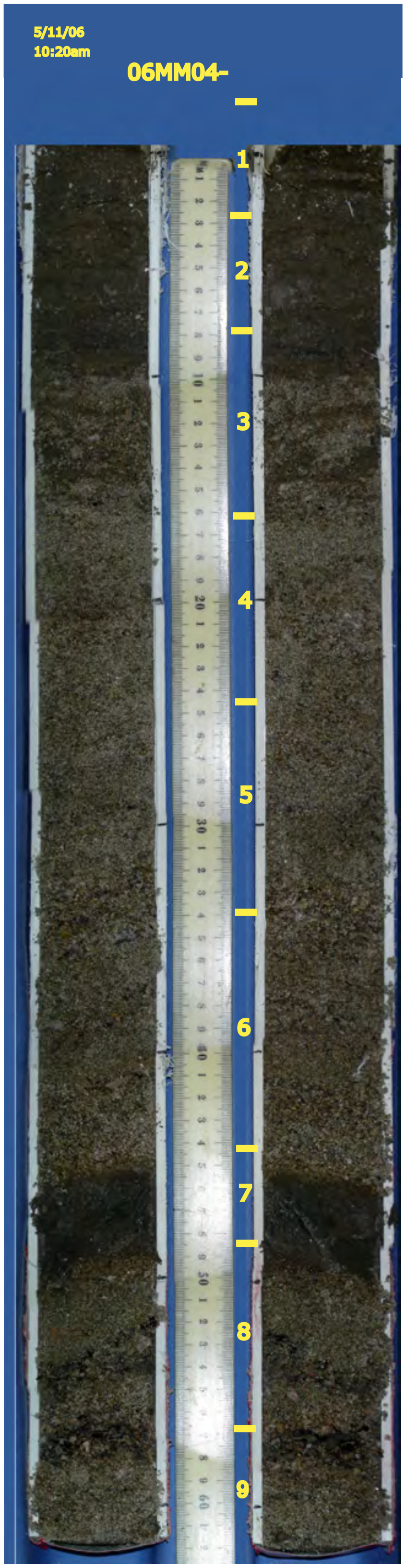


Figure A4A. Photograph of core 06MM04 showing sample intervals 1–9 (0–62 cm). Scale is in centimeters.

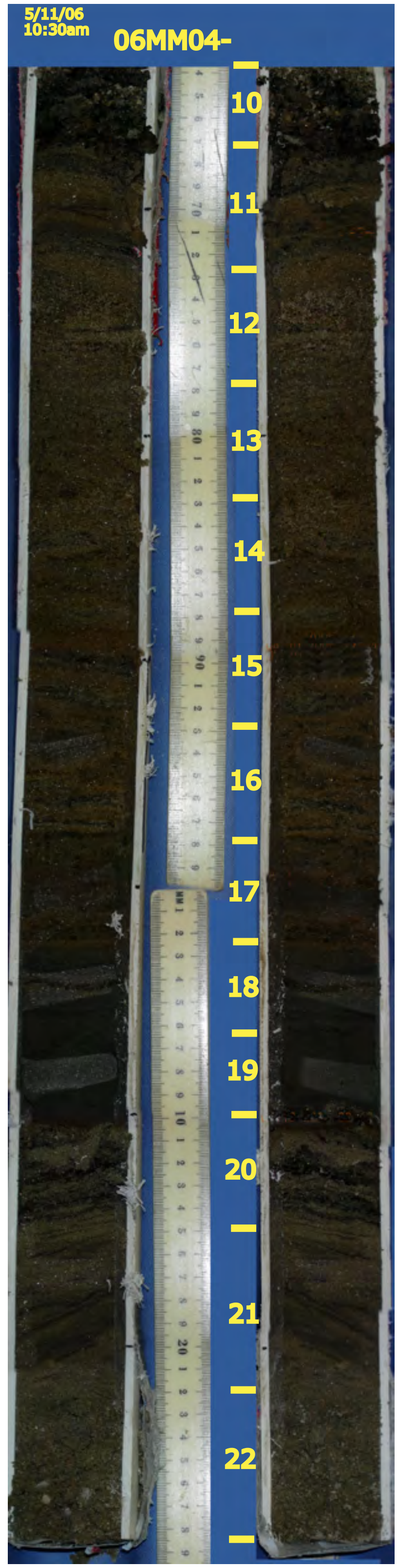


Figure A4B. Photograph of core 06MM04 showing sample intervals 10–22 (64–128.5 cm). Scale is in centimeters.

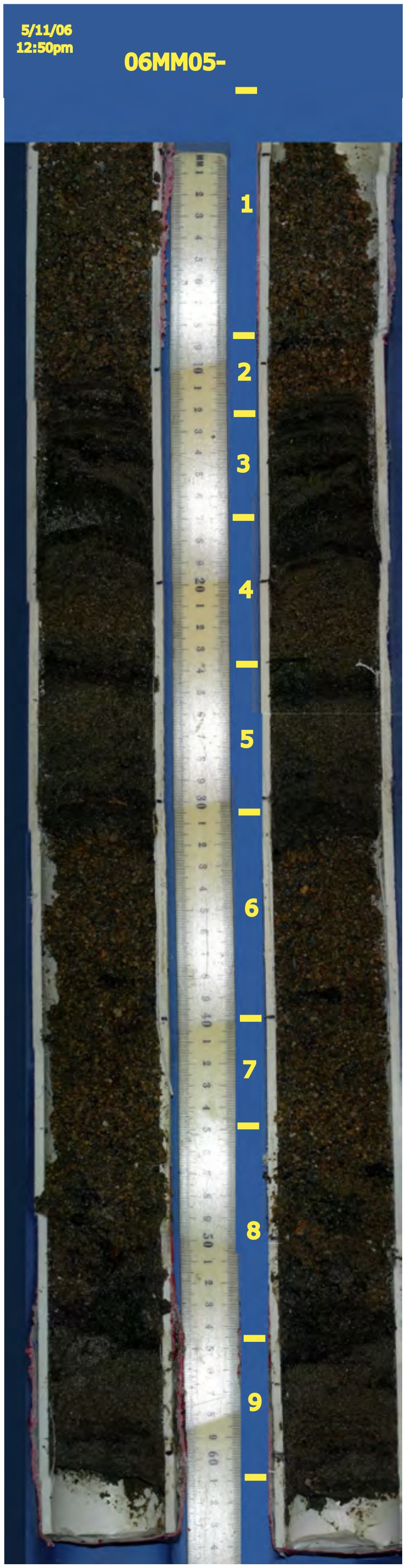


Figure A5. Photograph of core 06MM05 showing sample intervals 1–9 (0–61 cm). Scale is in centimeters.

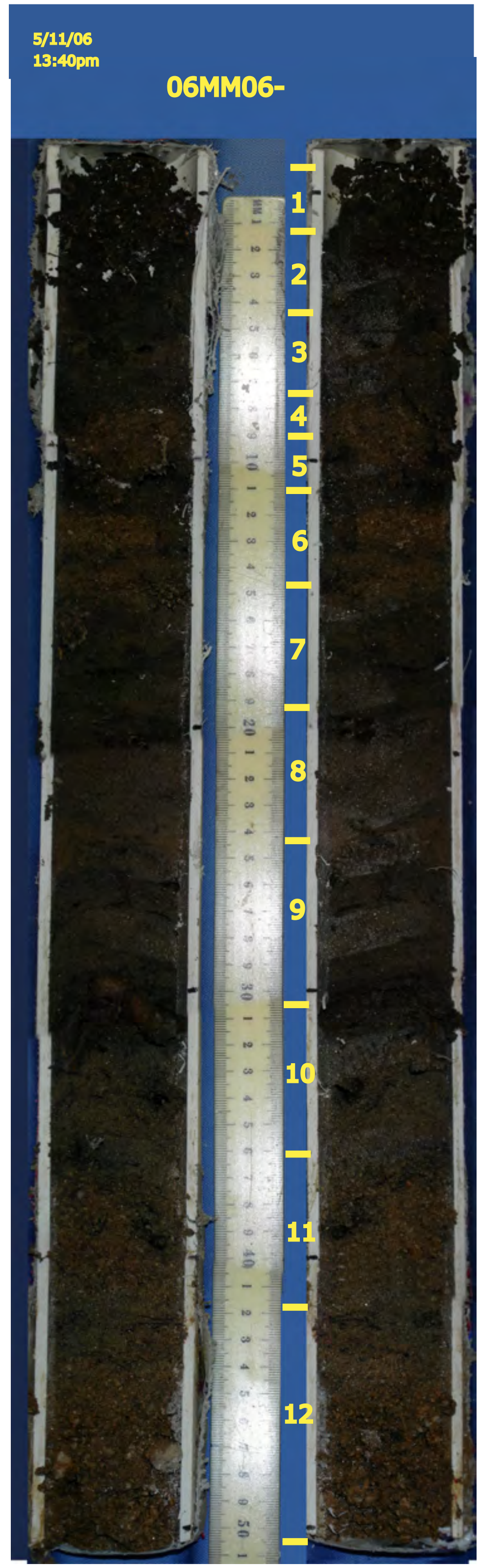


Figure A6. Photograph of core 06MM06 showing sample intervals 1–12 (0–50.5 cm). Scale is in centimeters.

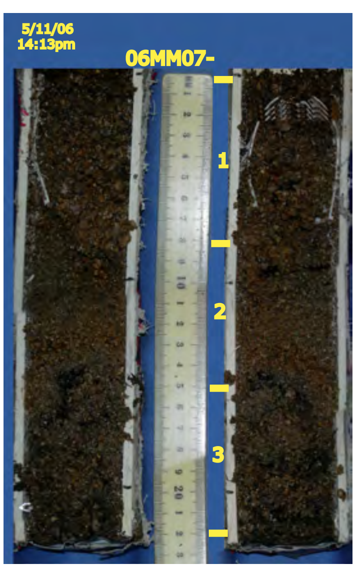


Figure A7. Photograph of core 06MM07 showing sample intervals 1–3 (0–22 cm). Scale is in centimeters.

Figure A8A. Photograph of core 06MM08 showing sample intervals 1–12 (0–48.5 cm). Scale is in centimeters.

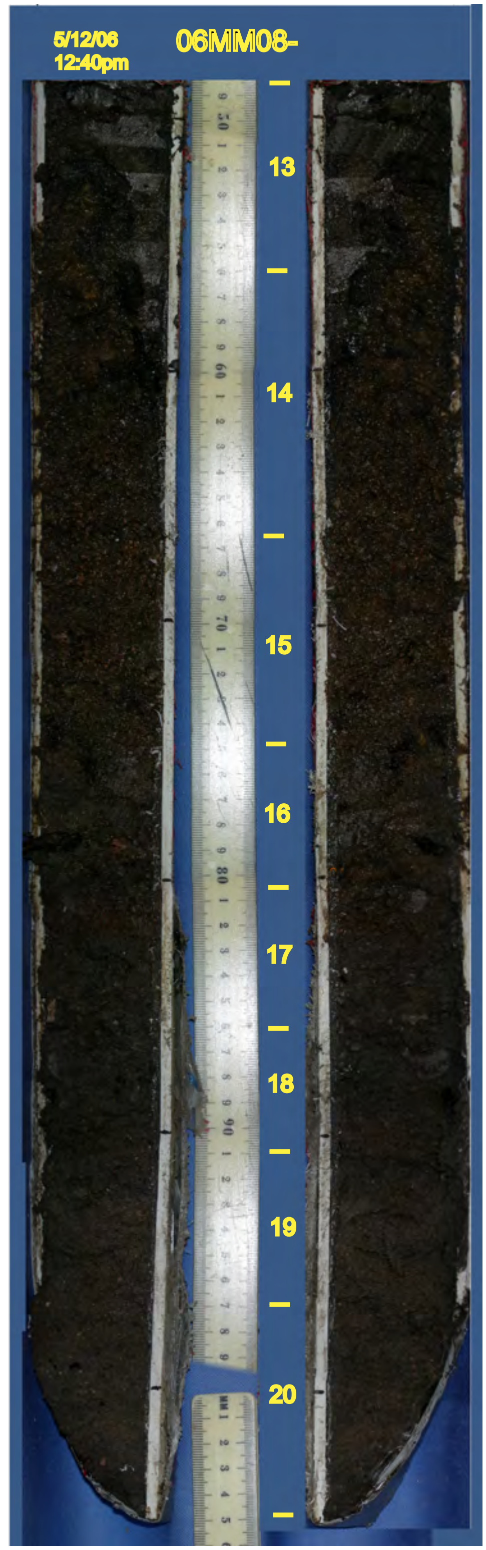


Figure A8B. Photograph of core 06MM08 showing sample intervals 13–20 (48.5–105 cm). Scale is in centimeters.

Appendix B.

Standard Operating Procedure for Sampling Sediments with Driven Core Sediment Sampler (DCSS) on the Spokane Indian Reservation (SOP_DCSS)

STANDARD OPERATING PROCEDURE FOR SAMPLING SEDIMENTS WITH DRIVEN CORE SEDIMENT SAMPLER (DCSS) ON THE SPOKANE INDIAN RESERVATION (SOP_DCSS)

PREPARED BY

AESE, INC.
P.O. Box 50392
Henderson, NV 89016-0392

FOR

The Midnite Mine Natural Resources Council
P.O. Box 312
Valleyford, WA 99036

and

The Spokane Tribe of Indians
Department of Natural Resources
P.O. Box 100
Wellpinit, WA

SOP for Drive Core Sediment Sampling (SOP_DCSS)

TABLE OF CONTENTS

1.0 PURPOSE AND SCOPE 1
2.0 RELATED STANDARD OPERATING PROCEDURES 1
3.0 EQUIPMENT NECESSARY FOR SAMPLING WITH THE DCSS 1
4.0 SAMPLE LOCATION SURVEYING 2
4.1 SAMPLE LOCATION (predetermined) 2
4.2 SAMPLE LOCATION (determined in the field w/GPS) 2
4.3 SAMPLE LOCATION (determined in the field w/GPS at a later date) 3
5.0 DECONTAMINATION 3
6.0 Safety 4
7.0 Sampling 4
8.0 SAMPLE HANDLING AND DOCUMENTATION 5
9.0 Demobilization 6

SOP for Drive Core Sediment Sampling (SOP_DCSS)

1.0 PURPOSE AND SCOPE

This SOP describes operation of the Drive Core Sediment Sampler (DCSS) in environments in which the sediments are unconsolidated.

2.0 RELATED STANDARD OPERATING PROCEDURES

- SOP-PGP Pancake Gamma Probe and Meter Calibration
- SOP-VSS Vibracore Sediment Sampler
- SOP-GPS Global Positioning System Receiver
- SOP-SHD Sample Handling and Documentation

3.0 EQUIPMENT NECESSARY FOR SAMPLING WITH THE DCSS

- Field Sampling Plan Complete with Prospective Sampling Locations
- Cultural Clearance
- Ladder
- 6 to 10lb Double-Jack
- Torpedo Level
- Brunton Compass
- Tape Measure
- 2-in OD x 10' Lengths Schedule 40 PVC pipe
- 2-in OD Schedule 40 PVC pipe End Caps
- 2-in ID Schedule Egg-Shell Internal Core Catcher
- Field Logbook
- Permanent Ink pens (Sharpies)/Ball-Point
- Gloves
- Soap & DI water

SOP for Drive Core Sediment Sampling (SOP_DCSS)

- Kimwipes
- Polytarpaulin

4.0 SAMPLE LOCATION SURVEYING

Three different procedures for three different instances are described below. In all cases select a location that appears to be free of obstructions. If obstructions are encountered and the sample location must be moved, record the new location and rationale for relocating in the field logbook. Photographs of each location are required in the event that the site has to be revisited in the future. The photographs will also document any changes that may have occurred since samples were acquired.

4.1 SAMPLE LOCATION (predetermined)

If a location has been predetermined, attempt to locate the point in the field using a map. Next operate the Global Positioning System receiver as described in SOP-GPS. Once the location has been determined, drive a survey stake into the sediment a distance away from the sample point. Record the distance and bearing from the sample point to the survey stake in the field logbook.

4.2 SAMPLE LOCATION (determined in the field w/GPS)

If sampling on the “fly”, drive a survey stake into the sediment a distance away from the sample point. Record the distance with a tape measure and bearing from the sample point to the survey stake with a Brunton compass in the field logbook. Mark the best estimate of the sampling location on the field map. Operate the Global Positioning System receiver as described in SOP-GPS. Record the sampling location in the field logbook.

SOP for Drive Core Sediment Sampling (SOP_DCSS)

4.3 SAMPLE LOCATION (determined in the field w/GPS at a later date)

If sampling on the "fly" and a GPS is not available at the time of sampling, drive a survey stake into the sediment a distance away from the sample point. Record the distance with a tape measure and bearing with a Brunton from the sample point to the survey stake in the field logbook. Mark the best estimate of the sampling location on the field map. Provide a copy of the map to the surveyor at the end of the day. Communicate any obstacles to the surveyor.

5.0 DECONTAMINATION

The operator should wear rubber or polyethylene based gloves at all times while handling the core tube. Decontamination must occur prior to obtaining each sample and prior to storage. The core tube should be cleaned during demobilization and prior to storage:

1. Fill core rinse tube approximately 2/3 of the way with deionized water
2. Insert the core tube into the core rinse tube and cap
3. Shake the entire assembly from approximately 30 secs or until both the inside and outside of the core tube is free from dirt.
4. squeegee the outside of the core tube by wrapping a large Kimwipe core tube and slowly pulling the core tube out of core rinse tube.
5. Repeat steps 1-4 three consecutive times.
6. Prepare a sample bottle and chain of custody for the rinsate blank if required.

SOP for Drive Core Sediment Sampling (SOP_DCSS)

6.0 SAFETY

Injury to extremeties or slip and trip type injuries resulting from driving the core while standing on a stepmladder is generally the major safety precaution when operating the DCSS.

7.0 SAMPLING

This SOP describes operation of the Drive Core Sediment Sampler (DCSS) in wet and dry environments in which the sediments are unconsolidated. The DCSS is a rugged, light-weight, versatile tool capable of sampling shallow sediments. Sampling depth is limited only by wall friction and hard obstructions.

Once decontamination procedures have been completed, affix the eggshell core catcher to the lower end of the 2-inch Schedule 40 PVC core barrel. Measure the length of the core tube assemble. Position the assembly over the sample location. Slide the steel drive can over the top of the assembly. Drive the assembly via repetive blows with the 6-10 lb double jack.

If rocks or other encumbrances are encountered. Note the depth of the rock and the new sampling location in the field log book. Also note depths in which any changes in advance rates are observed.

Once the desired depth has been achieved and recorded in the field log book, remove the drive can and affix an 2-Inch Schedule 40 PVC end-cap. Connect the core tube extraction jack or similar device and remove the core tube from the ground. Draw an arrow directly on the outside of the barely pointing upward and annotate as “UP”.

SOP for Drive Core Sediment Sampling (SOP_DCSS)

Remove the top endcap and cut the top of the assembly with a hacksaw blade flush with sediment inside of the core barrel. Flip the assembly over (arrow now pointed downward toward the ground) and cutt-off the egg-shell core catcher. Affix this end with an Schedule 40 PVC encap. Record the total length of the core in the field logbook as well as any deviations/problems that could affect sample acquisition. Measure the actual length of the sample and record in the field logbook. The difference between the apparent depth and the actual length of core will give insight to the amount of compaction that occurred during sampling or the amount of sample loss upon extraction.

Wipe-down the outside of the core sleeve with a wet Kimwipe. Place the sleeve against a white surface and photograph. Record the photo frame number in the field logbook. Store the sample in an appropriate facility (long ice chest if necessary) for subsequent geologic logging and other tests such as gamma screening (SOP_GSS). Complete the Chain of Custody Form. If a duplicate sample is required at this location, re-do the process beginning with Section 2.0. If a duplicate sample is not required begin demobilization (below).

8.0 SAMPLE HANDLING AND DOCUMENTATION

All documentation regarding soil sub samples shall be in accordance with SOP-SHD, shall be recorded in a field logbook, and shall include as appropriate:

- Sampler's names
- Sample location and identification numbers
- Date of sampling
- Type of sample (e.g. standard, dupe, etc.)
- Any deviations from planned procedures.

SOP for Drive Core Sediment Sampling (SOP_DCSS)

This documentation will constitute a portion of the permanent project record.

9.0 Demobilization

Wash down field equipment with appropriate solvent, dry with Kimwipes, and store in the service vehicle.

USGS

Church and others—**Geochemical Background and Sediment Contamination, Midnite Mine, WA**—U.S. Geological Survey Scientific Investigations Report 2007–5262