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Uranium Concentrations in Lake and Stream Waters
and Sediments from Selected Sites
in the Susitna River Basin, Alaska

by

Dwight E. Hill

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URANIUM CONCENTRATIONS IN LAKE AND STREAM WATERS
AND SEDIMENTS FROM SELECTED SITES
IN THE SUSITNA RIVER BASIN, ALASKA

by

Dwight E. Hill

ABSTRACT

During the summer of 1976, 141 water and 211 sediment samples were taken from 147 locations in the Susitna River basin in Alaska by the Geophysical Institute of the University of Alaska for the LASL. These samples were taken to provide preliminary information on the uranium concentrations in waters and sediments from the Susitna River basin and to test the analytical methods proposed for the NURE Hydrogeochemical and Stream Sediment Reconnaissance for uranium in Alaska. The uranium determinations resulting from the fluorometric analysis of the water samples and the delayed-neutron counting of the sediment samples are contained in the Appendixes of this report. The low levels of uranium in the water samples, many of which were below the detectable limit of the LASL fluorometric technique, indicate that a more sensitive analytical method is needed for the analysis of Alaskan water samples from this area. An overlay showing numbered sample locations and overlays graphically portraying the concentrations of uranium in the water and sediment samples, all at 1:250 000 scale for use with existing USGS topographic sheets, are also provided as plates.

I. INTRODUCTION

The purpose of this report is to make available to the public the results of a hydrogeochemical survey for uranium in the stream and lake waters and sediments of the Susitna River basin, Alaska. This work was done by the Los Alamos Scientific Laboratory (LASL) for the US Energy Research and Development Administration (ERDA) as part of the National Uranium Resource Evaluation (NURE) program. The ERDA Grand Junction Office (GJO), in Grand Junction, Colorado, is responsible for completing the Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) project in the states of New Mexico, Colorado, Wyoming, Montana, and

Alaska.¹⁻⁷ The applicability of hydrogeochemical and stream sediment survey techniques to uranium exploration throughout the world is the subject of an annotated bibliography by R. R. Sharp, Jr.⁸

Between July 10 and July 26, 1976, a total of 141 water and 211 sediment samples were taken from 147 locations in the Susitna River basin and vicinity, Alaska. These samples were taken by personnel of the Geophysical Institute of the University of Alaska (GIUA) under the direction of Dr. Robert B. Forbes. They were taken at the request of the LASL to obtain information on uranium concentrations in waters and sediments for use in planning future HSR work in adjacent parts of Alaska. The sample locations were chosen by GIUA personnel as part of a larger sampling program they were carrying out in the Susitna and Copper River basins. The field data and uranium concentrations for each of the water and sediment samples collected are listed in Appendixes A and B, and the parameters included in these listings are defined in Appendix C. Methods used in taking and analyzing the samples are set forth in Appendix D.

II. LOCATION

The location of the area covered by this survey is approximately 280 km northeast of Anchorage and is shown in Fig. 1. It is surrounded on the west by the Talkeetna Mountains, on the east by the Wrangell Mountains, on the south by the Chugach Mountains, and on the north by the Alaska Range. The study area is drained by both the Susitna and Copper River systems, with the largest number of sample locations (122, or 83% of the total) being in the Susitna River basin near the confluence of the Susitna and MacLaren Rivers. The remaining 19 sample locations are near Paxson Lake in the Gulkana River drainage of the Copper River basin. These sample locations are shown on Plate I, which is designed to overlay the US Geological Survey (USGS) 3° topographic map sheets entitled "Talkeetna Mountains" and "Gulkana" as shown in Fig. 1. Detailed information on the geology, mineral occurrences, and radiometric investigations has been published by several investigators.⁹⁻¹⁷

III. FIELD TREATMENT AND ANALYTICAL METHODS

A summary of the standard field procedures as well as the analytical methods is contained in Appendix D. Several of the parameters listed under Field Measurements in Appendixes A and B (air temperature, water temperature, PH, specific conductance, and scintillometer reading) were not taken at the time of sampling because of a lack of equipment.

Water Samples

All water samples were taken in 25-ml polyethylene containers which were pre-washed in nitric acid, rinsed with distilled water, and capped before shipment to the field. Each water sample was acidified to a pH of approximately 1 by the addition of 8M reagent grade nitric acid. This was done to inhibit the growth of biological matter, which can concentrate uranium, as well as to prevent adsorption of uranium on the walls of the polyethylene containers. Such acidification was the only treatment given the water samples taken in this study. The uranium concentrations in the water samples are graphically shown on Plate II. A summary of the water sample sources and treatments is given in Table I.

Fig. 1

Location map for Susitna River basin survey.

TABLE I
SUMMARY OF WATER SAMPLE SOURCES AND TREATMENTS
THE SUSITNA RIVER BASIN, ALASKA

<u>Sample Source</u>	<u>Sample Treatment</u>	<u>Number of Samples</u>
Stream	Acidified only	95
Natural pond	Acidified only	<u>46</u>
Total number of water samples		141

Sediment Samples

The sediment samples taken in the study were placed in polyethylene bags at the time of sampling and sent directly to the LASL. Upon receipt at the LASL, the sediments were dried in an oven at a temperature of $\leq 100^{\circ}\text{C}$ and sieved to obtain the -100 mesh fraction. Replicate sediment samples taken at several locations are indicated by a digit other than zero in the replicate columns of the data listings in Appendix B. On the uranium concentration overlay for sediment (Plate III), the single uranium value shown for locations from which replicate samples were taken is the average concentration for all samples taken at that location. A summary of the sediment sample sources and treatments is given in Table II.

TABLE II
SUMMARY OF SEDIMENT SAMPLE SOURCES AND TREATMENTS
THE SUSITNA RIVER BASIN, ALASKA

<u>Sample Source</u>	<u>Sample Treatment</u>	<u>Number of Samples^a</u>
Wet stream	Dried, sieved -100 mesh	151
Wet natural pond	Dried, sieved -100 mesh	57
Dry stream	Dried, sieved -100 mesh	<u>3</u>
Total number of sediment samples		211

^aIncludes replicates.

Fluorometric Method

All water samples were analyzed for uranium by fluorometry. The fluorometric technique used at the LASL is presently the most economic one available and was developed for maximum sensitivity. The lower detection limit for this method is about 0.2 parts per billion (ppb) of uranium. Duplicate measurements are made on each sample and then averaged to give the uranium value in the listing. Any sample with a uranium level below the detectable limit of 0.2 ppb

is reported as 0.1 ppb. A detailed description of the fluorometric method used by the LASL is contained in a report by Hues, et al.¹⁸

Delayed-Neutron Counting Method

All sediment samples were analyzed by delayed-neutron counting (DNC) for total uranium content in an 8-MW light-water research reactor at the LASL. Each dried and sieved sediment sample was loaded into a 4-ml polyethylene rabbit, inserted into the reactor for irradiation, and removed from the reactor and counted with specially designed neutron counters. The minimum sensitivity of the technique used is 0.01 parts per million (ppm) of uranium.

IV. RESULTS

The results of the uranium analyses of the 141 water and 211 sediment samples taken in this study are given in Appendixes A and B, and the sample locations and uranium concentrations are shown on Plates I, II, and III. Plate I is the sample location overlay for the study. The sample numbers shown on Plate I are the last four digits of the six-digit LASL sample number given in the listings in Appendixes A and B.

Plate II is the uranium concentration overlay for all water samples taken, with the uranium concentrations shown in ppb. The uranium concentrations in the water samples are low (that for all but one sample falls below 1.0 ppb), ranging between 0.1 ppb (below the limit of detection) and 6.31 ppb, with the mean being 0.21 ppb. The low levels of uranium in the water samples, many of which were below the detectable limit of the LASL fluorometric technique, indicate that a more sensitive analytical method is needed for the analysis of Alaskan water samples from this area.

Plate III is a uranium concentration overlay for all sediment samples taken, with the uranium concentrations shown in ppm. The uranium concentrations in the sediments range between 0.3 ppm and 4.6 ppm, with a mean of 1.75 ppm. Whenever replicate sediment samples were taken, the uranium value shown on the concentration overlay is an average of all samples taken at that location.

ACKNOWLEDGMENTS

Acknowledgment is due the Geophysical Institute of the University of Alaska, whose personnel, under the direction of Dr. Robert B. Forbes, collected the samples reported upon herein. The fluorometric analyses of uranium in the water samples were done by the LASL Analytical Chemistry Group, CMB-1, of the Chemistry and Materials-Science Division, under the supervision of Glenn R. Waterbury and William H. Ashley. The determinations of uranium in sediments by delayed-neutron counting were done by the Research Reactor Group, P-2, of the Physics Division, under the supervision of Merle E. Bunker and Michael M. Minor. The effort of Jesse Cheadle III and Richard J. Beckman, of the Energy Systems and Statistics Group, Q-12, of the Energy Division, in management of the data and production of sample location and concentration overlay maps is also greatly appreciated. Acknowledgment is likewise made of Alcario R. Marquez and Patricia O'Rourke, both of the Geochemical Applications Group, G-5, in the illustrating and typing of this report. Lastly, the collective efforts of the LASL Group G-5 in designing the sample collection and treatment procedures, the data collection, handling, and output formats, and the standardized methods making the timely reporting of this data possible are gratefully acknowledged.

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APPENDIX A

LISTINGS OF FIELD DATA AND URANIUM CONCENTRATIONS

FOR

ACIDIFIED WATER SAMPLES

FROM THE

SUSITNA RIVER BASIN, ALASKA

SAMPLES ANALYZED BY FLUOROMETRY

(See Appendix C for Codes to Listings)

LASL Uranium Hydrogeochemical and Stream Sediment Reconnaissance Data Listing

[illegible]

LASL Uranium Hydrogeochemical and Stream Sediment Reconnaissance Data Listing

ERDA SAMPLE NUMBER				LAST SAMPLE NUMBER AND FIELD DATA												U CONCENTRATION																
SITE	LATITUDE	LONGITUDE	ERDA LAB	SAMPLE TYPE	REPLICATE	LAST SAMPLE NUMBER	TIME SAMPLED		AIR TEMPERATURE	WATER TEMPERATURE	COMMENTS	pH	SPECIFIC CONDUCTANCE (µmhos/cm)	SCINTILLOMETER (cpd/cm)	ROCK TYPE	ROCK COLOR	SEDIMENT TYPE	SEDIMENT COLOR	WATER FLOW	WATER LEVEL	WATER COLOR	STREAM CHANNEL	VEGETATION	RELIEF	WETLAND	CONTOUR	WELL TYPE	WELL DEPTH (feet)	WELL COVER (feet)	WATER DEPTH (feet)	SAMPLE TYPE	U CONCENTRATION
							DATE	HOUR																								
02-42	1133-161	107-1077A	02-42	1133-161	02-42	1133-161	07/10/74	14	C																						0.10	
02-42	1133-161	107-1077A	02-42	1133-161	02-42	1133-161	07/10/74	15	C																						0.10	
02-42	1133-161	107-1077A	02-42	1133-161	02-42	1133-161	07/10/74	16	C																						0.10	
02-42	1133-161	107-1077A	02-42	1133-161	02-42	1133-161	07/10/74	17	C																						0.10	
02-42	1133-161	107-1077A	02-42	1133-161	02-42	1133-161	07/10/74	18	C																						0.10	
02-42	1133-161	107-1077A	02-42	1133-161	02-42	1133-161	07/10/74	19	C																						0.10	
02-42	1133-161	107-1077A	02-42	1133-161	02-42	1133-161	07/10/74	20	C																						0.10	
02-42	1133-161	107-1077A	02-42	1133-161	02-42	1133-161	07/10/74	21	C																						0.10	
02-42	1133-161	107-1077A	02-42	1133-161	02-42	1133-161	07/10/74	22	C																						0.10	
02-42	1133-161	107-1077A	02-42	1133-161	02-42	1133-161	07/10/74	23	C																						0.10	
 																							

[illegible]

APPENDIX B

LISTINGS OF FIELD DATA AND URANIUM CONCENTRATIONS

FOR

DRIED AND SIEVED SEDIMENT SAMPLES

FROM THE

SUSITNA RIVER BASIN, ALASKA

SAMPLES ANALYZED BY DELAYED-NEUTRON COUNTING

(See Appendix C for Codes to Listings)

LASL Uranium Hydrogeochemical and Stream Sediment Reconnaissance Data Listing

[illegible]

[illegible]

LASL Uranium Hydrogeochemical and Stream Sediment Reconnaissance Data Listing

ERDA SAMPLE NUMBER					LASL SAMPLE NUMBER AND FIELD DATA																				U CONCENTRATION									
STATE	LATITUDE	LONGITUDE	ERDA LAB	SAMPLE TYPE	REPLICATE	LASL SAMPLE NUMBER	TIME SAMPLED		AIR TEMPERATURE	WATER TEMPERATURE	COMMENTS	SPECIAL MEASUREMENTS	PH	SPECIFIC CONDUCTANCE (umhos/cm)	SCINTILLOMETER (AU DPM)	ROCK TYPE	ROCK COLOR	SEDIMENT TYPE	SEDIMENT COLOR	WATER FLOW	WATER LEVEL	WATER COLOR	STREAM CHANNEL VEGETATION TYPE	VEGETATION DENSITY	RELIEF	WEATHER	OWNERSHIP	CONTAMINANTS	WELL TYPE	WELL DIAMETER (INCHES)	WELL DEPTH (FEET)	WATER DEPTH (FEET)	SAMPLE TYPE 1-10, 21-30 ARE WATER	SAMPLE TYPE 11-20, 31-40 ARE SEDIMENT
							DATE	HOUR																										
02-A2	0411-167	1433-2-1	0-401453	07/20/76																												2.20		
02-A2	0411-167	1433-2-13	0-401453	07/20/76																												2.00		
02-A2	0343-167	1264-2-13	0-401454	07/20/76																												1.00		
02-A2	0337-167	1427-2-12	0-401455	07/20/76																												3.00		
02-A2	0227-167	1424-2-12	0-401455	07/20/76																												3.30		
02-A2	0147-167	1116-2-12	0-401456	07/20/76																												1.80		
02-A2	0147-167	1116-2-12	0-401456	07/20/76																												2.20		
02-A2	0041-167	1475-2-12	0-401457	07/20/76																												3.60		
02-A2	0041-167	1475-2-12	0-401457	07/20/76																												3.90		
02-A2	0007-167	1072-2-12	0-401458	07/20/76																												2.10		
02-A2	0243-167	7900-2-12	0-401459	07/20/76																												2.80		
02-A2	0243-167	7900-2-12	0-401459	07/20/76																												3.80		
02-A2	0544-147	7427-2-12	0-401460	07/21/76																												1.80		
02-A2	0544-147	7427-2-12	0-401460	07/21/76																												2.00		
02-A2	0544-147	7427-2-12	0-401461	07/21/76																												1.80		
02-A2	0642-147	7308-2-12	0-401462	07/21/76																												2.70		
02-A2	0642-147	7308-2-12	0-401462	07/21/76																												2.20		
02-A2	0508-167	7027-2-12	0-401463	07/21/76																												1.70		
02-A2	0544-147	7427-2-12	0-401463	07/21/76																												1.60		
02-A2	0313-167	7067-2-12	0-401464	07/21/76																												2.20		
02-A2	0313-167	7067-2-12	0-401464	07/21/76																												2.20		
02-A2	0344-167	4050-2-12	0-401465	07/21/76																												2.40		
02-A2	0344-167	4050-2-12	0-401465	07/21/76																												1.70		
02-A2	0277-147	4005-2-12	0-401466	07/21/76																												1.90		
02-A2	0277-147	4005-2-12	0-401466	07/21/76																												2.40		
02-A2	0340-147	4125-2-12	0-401467	07/21/76																												2.70		
02-A2	0340-147	4125-2-12	0-401467	07/21/76																												2.50		
02-A2	0513-167	4026-2-13	0-401468	07/21/76																												1.90		
02-A2	0600-167	6643-2-13	0-401901	07/21/76																												1.60		
02-A2	0574-167	6633-2-12	0-401902	07/21/76																												4.10		
02-A2	0514-147	6433-2-12	0-401902	07/21/76																												4.80		
02-A2	0541-147	6496-2-12	0-401903	07/21/76																												2.20		
02-A2	0277-167	6603-2-13	0-401904	07/21/76																												1.50		
02-A2	0345-167	6410-2-13	0-401905	07/21/76																												0.90		
02-A2	0343-167	6430-2-13	0-401906	07/21/76																												1.00		
02-A2	0537-167	6576-2-13	0-401907	07/21/76																												1.00		
02-A2	0507-167	6783-2-13	0-401908	07/21/76																												2.30		
02-A2	0607-167	6797-2-13	0-401910	07/21/76																												1.90		
02-A2	0706-167	6627-2-13	0-401911	07/21/76																												1.70		
02-A2	0477-167	6705-2-12	0-401912	07/21/76																												1.50		
02-A2	0408-167	6608-2-13	0-401913	07/21/76																												1.90		
02-A2	0216-167	6777-2-13	0-401914	07/21/76																												1.70		
02-A2	0207-167	7169-2-12	0-401915	07/21/76																												1.50		
02-A2	0167-167	7702-2-12	0-401921	07/26/76																												2.10		
02-A2	0047-167	6069-2-12	0-401922	07/26/76																												2.50		
02-A2	0357-167	6647-2-13	0-401923	07/26/76																												1.80		

LASL Uranium Hydrogeochemical and Stream Sediment Reconnaissance Data Listing[illegible]

APPENDIX C

CODE TO DATA LISTINGS AND SAMPLE TYPES USED

BY

THE LOS ALAMOS SCIENTIFIC LABORATORY

IN THE

NURE HYDROGEOCHEMICAL AND STREAM SEDIMENT RECONNAISSANCE

ITEM C-I

EXPLANATION OF CODE USED IN THE LASL HSSR DATA LISTINGS

AND

ITEM C-II

NUMERICAL KEY TO SAMPLE TYPES TAKEN IN THE LASL HSSR

APPENDIX ITEM C-I

EXPLANATION OF CODE USED IN OPEN-FILE LISTINGS OF HSSR DATA PROVIDED BY THE LOS ALAMOS SCIENTIFIC LABORATORY

ERDA SAMPLE NUMBER

STATE: A two-digit Federal Information Processing Standards (FIPS) code, designating the state from which each sample came. For the states being covered by the LASL, the code numbers are:

Alaska	= 02	New Mexico	= 35
Colorado	= 08	Wyoming	= 56
Montana	= 30		

LATITUDE AND LONGITUDE: Sample location, in degrees and decimal degrees to four places. However, though generally much better, locational accuracy cannot be guaranteed closer than about 300 meters (1000 feet).

ERDA LAB: An Energy Research and Development Administration (ERDA) one-digit identifier designating the national laboratory responsible for taking the sample and the data shown in the listing, as well as providing the analysis giving the uranium and other elemental concentrations, if any. The LASL is designated by the Number 2.

SAMPLE TYPE: A two-digit identifier which specifically designates the pertinent properties defining the sample type to which the listed data relate. For explanation of the code used, refer to the attached "Numerical Key and Specifications for Sample Types Taken by the LASL" (Appendix Item C-II).

REPLICATE: A three-digit sequential number assigned to indicate a multiple sample of a single sample type from a single location. The largest number in use indicates the most recent sample taken, and there will always be smaller sequential numbers representing earlier samples back to 000, which is the initial sample from any given location. Except in the case of special studies, there will be no replicate samples and this entry will therefore be 000.

LASL SAMPLE NUMBER AND FIELD DATA

LASL SAMPLE NUMBER: A unique six-digit number permanently assigned by the LASL to every location sampled in each state. For internal use, these numbers are assigned in blocks to the various areas individually treated and reported upon and therefore serve to generally locate the samples within the various states as follows.

	<u>Location Numbers</u>		<u>State</u>
from	000 001 through 099 999	=	New Mexico
from	100 001 through 199 999	=	Colorado
from	200 001 through 299 999	=	Wyoming
from	300 001 through 399 999	=	Montana
from	400 001 through and above	=	Alaska

TIME SAMPLED: The DATE that the sample was taken, in terms of the number of the MONTH, followed by the DAY, and finally the YEAR, separated by slashes, and then the TIME it was taken on that date to the nearest whole HOUR on a military (24-hour) clock.

AIR TEMPERATURE: The temperature that was measured in the shade at the time of sampling, to the nearest whole degree Celsius ($^{\circ}\text{C}$).

WATER TEMPERATURE: The temperature that was measured in the sample water (in situ whenever possible) at the time of sampling, to the nearest one-tenth of a degree Celsius (0.1°C).

COMMENTS: A "C" in this column indicates that some secondary comment not included in the listing was recorded at the sample location. This information will be used by the LASL in evaluating the data and, if appropriate, it will be mentioned in the final report.

SPECIAL MEASUREMENTS: A "S" in this column indicates that one or more field measurements in addition to those listed were made at the sample location. A description of any special parameters measured, and the measured value at each sample location, will be included in the final HSSR report on the area by the LASL.

pH: The pH, to the nearest one-tenth (0.1) of a pH unit, that was measured in the water at the sample location at the time of sampling.

SPECIFIC CONDUCTANCE: The conductivity, in $\mu\text{mhos/cm}$, that was measured in the water at the sample location at the time of sampling.

SCINTILLOMETER: The equivalent uranium (eU), in parts per million (ppm), as measured on a flat ground surface within ten meters of the sample location using a scintillometer fitted with a differential gamma sampler (DGS). The effect of the DGS is to introduce a fixed geometry into the measurement and remove the background.

ROCK TYPE: The single digit in this column provides a general description of the dominant lithologic regime at or near the sample location as given below.

1 = Sedimentary	3 = Igneous
2 = Metamorphic	4 = Unknown

ROCK COLOR: The single digit in this column provides an indication of the observed dominant color of local bedrock exposures at or near the sample location as given below.

1 = White/Buff	4 = Pink/Red	7 = Gray
2 = Yellow	5 = Green	8 = Black
3 = Orange	6 = Brown	9 = Other

SEDIMENT TYPE: The single digit in this column provides a subjective evaluation of the dominant sediment type at the sample location as given below.

1 = Boulders	4 = Sand	6 = Muck
2 = Cobbles	5 = Mud	7 = Other
3 = Gravel		

SEDIMENT COLOR: The single digit in this column indicates the observed dominant color of the bottom sediment (stream channel, lake bed, etc.) at the sample location at the time of sampling as given below.

1 = White/Buff	4 = Pink/Red	7 = Gray
2 = Yellow	5 = Green	8 = Black
3 = Orange	6 = Brown	9 = Other

WATER FLOW: The single digit in this column provides a subjective evaluation of the water movement at the sample location at the time of sampling as given below.

1 = Stagnant	3 = Moderate	5 = Torrent
2 = Slow	4 = Fast	

WATER LEVEL: The single digit in this column provides a subjective estimate of water quantity at the time of sampling relative to its usual condition at the sample location as given below.

1 = Dry	3 = Normal	5 = Flood
2 = Low	4 = High	

WATER COLOR: The single digit in this column provides a subjective evaluation of suspended load in the sample water as given below.

1 = Clear	3 = Cloudy	5 = Algal
2 = Murky	4 = Muddy	6 = Other

STREAM CHANNEL: The single digit here gives a subjective evaluation of stream channel character at the sample location at the time of sampling as given below.

1 = Depositing	2 = Eroding	3 = Unknown

VEGETATION TYPE: The single digit in this column provides a subjective evaluation of the dominant plant type in the vicinity of the sample location according to the key below.

1 = Conifers	4 = Grass	6 = Marsh
2 = Deciduous	5 = Moss	7 = Other
3 = Brush		

VEGETATION DENSITY: The single digit in this column provides a subjective estimate of the amount of plant cover in the vicinity of the sample location according to the key below.

1 = Barren	3 = Moderate	5 = Very Dense
2 = Sparse	4 = Dense	

RELIEF: The single digit in this column provides a subjective evaluation of the topography within a few hundred meters of the sample location according to the key below.

1 = Flat	3 = Gentle (15-60 m)	5 = High (> 300 m)
2 = Low (< 15 m)	4 = Moderate (60-300 m)	

WEATHER: The single digit in this column gives the observed climatic condition at the sample location at the time of sampling as given by the key below.

1 = Clear	3 = Overcast	5 = Snowy
2 = Partly cloudy	4 = Rainy	6 = Other

OWNERSHIP: The single digit here gives a broad classification of administrative responsibility or general ownership of the land at the sample location according to the key below.

1 = Federal	3 = Private	5 = Other
2 = State	4 = Indian	

CONTAMINANTS: The single digit here indicates known or suspected local factors likely to influence analytical results according to the key below.

1 = None	4 = Industry	7 = Urban
2 = Mining	5 = Sewage	8 = Recreation
3 = Agriculture	6 = Power generation	9 = Other

WELL TYPE: The single digit in this column provides a general description of the type of water well from which the sample was taken (if, in fact, it was a well sample) according to the key below.

1 = Windmill- stock	4 = Suction pump	7 = Hand bail
2 = Windmill-domestic	5 = Jet pump	8 = Unknown
3 = Submersible pump	6 = Large turbine	9 = Other

WELL DIAMETER: The one or two digits (if any) in this column give the measured or estimated inside diameter, in inches, of the casing of the well from which the sample (if taken from a well) came.

WELL DEPTH: The one, two, or three digits (if any) in this column give the total drilled depth from the surface, in feet, of the well from which the sample (if taken from a well) came.

WATER DEPTH: The one, two, or three digits in this column give the depth, in feet, from the surface to the standing water in the well, if known (if the sample was taken from a well).

URANIUM CONCENTRATION: The value given in this column is the analytically-derived value of the uranium concentration found in the water sample in parts per billion (ppb), or in the sediment sample in parts per million (ppm). Sample Type Nos. 1 through 10 and 21 through 30 are water samples, with their uranium concentrations given in ppb, while Sample Type Nos. 11 through 20 and 31 through 40 are sediment samples, with their uranium concentration given in ppm.

APPENDIX ITEM C-II

NUMERICAL KEY AND SPECIFICATIONS
FOR SAMPLE TYPES TO BE TAKEN BY
THE LOS ALAMOS SCIENTIFIC LABORATORY (LASL)
IN
THE NATIONAL URANIUM RESOURCE EVALUATION (NURE)
HYDROGEOCHEMICAL AND STREAM SEDIMENT RECONNAISSANCE (HSSR)

The ~~two-digit~~ number assigned each sample type in these specifications designates three distinct properties of all samples taken by the LASL in the NURE HSSR project. These properties are:

- (A) The general sample source (i.e., spring or stream or dry stream, etc.);
- (B) The sample medium (i.e., water or sediment, etc.); and
- (C) The treatment given the sample in the field or laboratory prior to its analysis by the LASL.

The express purpose of this numerical key and the accompanying specifications is to provide the user with the necessary tie between each individual suite of field and laboratory data and the specific type, or form of sample, to which they relate. This key and these specifications therefore define the various sample types to be collected by the LASL in the Energy Research and Development (ERDA) HSSR for uranium. The key numbers are inserted in the appropriate columns of the specially formatted ERDA sample numbering system to positively identify the sample type for all LASL sample data submitted to the Grand Junction Office.

SAMPLE

KEY NO.	<u>SOURCE</u> / <u>MEDIUM</u> / <u>TREATMENT</u>
01 -	<u>Spring water</u> sample <u>untreated</u>
02 -	<u>Stream water</u> sample <u>untreated</u>
03 -	<u>Well water</u> sample <u>untreated</u>
04 -	<u>Natural pond water</u> sample <u>untreated</u>
05 -	<u>Artificial pond water</u> sample <u>untreated</u>
06 -	<u>Spring water</u> sample <u>filtered</u> through a 0.45-micron membrane filter <u>and acidified</u> to a pH of ≤ 1 with reagent-grade nitric acid (HNO_3)
07 -	<u>Stream water</u> sample <u>filtered</u> through a 0.45-micron membrane filter <u>and acidified</u> to a pH of ≤ 1 with reagent-grade nitric acid (HNO_3)
08 -	<u>Well water</u> sample <u>filtered</u> through a 0.45-micron membrane filter <u>and acidified</u> to a pH of ≤ 1 with reagent-grade nitric acid (HNO_3)
09 -	<u>Natural pond water</u> sample <u>filtered</u> through a 0.45-micron membrane filter <u>and acidified</u> to a pH of ≤ 1 with reagent-grade nitric acid (HNO_3)
10 -	<u>Artificial pond water</u> sample <u>filtered</u> through a 0.45-micron membrane filter <u>and acidified</u> to a pH of ≤ 1 with reagent-grade nitric acid (HNO_3)

SAMPLE

KEY NO.	SOURCE / MEDIUM / TREATMENT
11 -	<u>Wet spring sediment sample dried at $\leq 100^{\circ}\text{C}$ and sieved to -100 mesh through stainless steel sieves</u>
12 -	<u>Wet stream sediment sample dried at $\leq 100^{\circ}\text{C}$ and sieved to -100 mesh through stainless steel sieves</u>
13 -	<u>Wet natural pond sediment sample dried at $\leq 100^{\circ}\text{C}$ and sieved to -100 mesh through stainless steel sieves</u>
14 -	<u>Wet artificial pond sediment sample dried at $\leq 100^{\circ}\text{C}$ and sieved to -100 mesh through stainless steel sieves</u>
15 -	<u>Dry stream sediment sample dried at $\leq 100^{\circ}\text{C}$ (if necessary) and sieved to -100 mesh through stainless steel sieves</u>
16 -	<u>Wet spring sediment sample dried at $\leq 100^{\circ}\text{C}$ and sieved to -230 mesh through stainless steel sieves</u>
17 -	<u>Wet stream sediment sample dried at $\leq 100^{\circ}\text{C}$ and sieved to -230 mesh through stainless steel sieves</u>
18 -	<u>Wet natural pond sediment sample dried at $\leq 100^{\circ}\text{C}$ and sieved to -230 mesh through stainless steel sieves</u>
19 -	<u>Wet artificial pond sediment sample dried at $\leq 100^{\circ}\text{C}$ and sieved to -230 mesh through stainless steel sieves</u>
20 -	<u>Dry stream sediment sample dried at $\leq 100^{\circ}\text{C}$ (if necessary) and sieved to -230 mesh through stainless steel sieves</u>
21 -	<u>Spring water sample filtered through a 0.45-micron membrane filter</u>
22 -	<u>Stream water sample filtered through a 0.45-micron membrane filter</u>
23 -	<u>Well water sample filtered through a 0.45-micron membrane filter</u>
24 -	<u>Natural pond water sample filtered through a 0.45-micron membrane filter</u>
25 -	<u>Artificial pond water sample filtered through a 0.45-micron membrane filter</u>
26 -	<u>Spring water sample acidified to a pH of ≤ 1 with reagent-grade nitric acid (HNO_3)</u>
27 -	<u>Stream water sample acidified to a pH of ≤ 1 with reagent-grade nitric acid (HNO_3)</u>
28 -	<u>Well water sample acidified to a pH of ≤ 1 with reagent-grade nitric acid (HNO_3)</u>
29 -	<u>Natural pond water sample acidified to a pH of ≤ 1 with reagent-grade nitric acid (HNO_3)</u>
30 -	<u>Artificial pond water sample acidified to a pH of ≤ 1 with reagent-grade nitric acid (HNO_3)</u>

SAMPLE

KEY NO.	SOURCE / MEDIUM / TREATMENT
31 -	<u>Wet spring sediment sample dried at $\leq 100^{\circ}\text{C}$ and sieved to +40 mesh through stainless steel sieves</u>
32 -	<u>Wet stream sediment sample dried at $\leq 100^{\circ}\text{C}$ and sieved to +40 mesh through stainless steel sieves</u>
33 -	<u>Wet natural pond sediment sample dried at $\leq 100^{\circ}\text{C}$ and sieved to +40 mesh through stainless steel sieves</u>
34 -	<u>Wet artificial pond sediment sample dried at $\leq 100^{\circ}\text{C}$ and sieved to +40 mesh through stainless steel sieves</u>
35 -	<u>Dry stream sediment sample dried at $\leq 100^{\circ}\text{C}$ (if necessary) and sieved to +40 mesh through stainless steel sieves</u>
36 -	<u>Wet spring sediment sample dried at $\leq 100^{\circ}\text{C}$ and sieved to -80 mesh through stainless steel sieves</u>
37 -	<u>Wet stream sediment sample dried at $\leq 100^{\circ}\text{C}$ and sieved to -80 mesh through stainless steel sieves</u>
38 -	<u>Wet natural pond sediment sample dried at $\leq 100^{\circ}\text{C}$ and sieved to -80 mesh through stainless steel sieves</u>
39 -	<u>Wet artificial pond sediment sample dried at $\leq 100^{\circ}\text{C}$ and sieved to -80 mesh through stainless steel sieves</u>
40 -	<u>Dry stream sediment sample dried at $\leq 100^{\circ}\text{C}$ (if necessary) and sieved to -80 mesh through stainless steel sieves</u>
96 -	<u>Dry natural pond sediment sample dried at $\leq 100^{\circ}\text{C}$ (if necessary) and sieved to -100 mesh through stainless steel sieves</u>
97 -	<u>Dry artificial pond sediment sample dried at $\leq 100^{\circ}\text{C}$ (if necessary) and sieved to -100 mesh through stainless steel sieves</u>
98 - Other water	} These key numbers are to be used only for water (98) or sediment (99) samples coming from a special source and/or given a special treatment not described for any of the types of samples above. When used in a published listing, the source and treatment given the samples so designated must be described in the text of the publication.
99 - Other sediment	

APPENDIX D

SUMMARY OF STANDARD FIELD AND ANALYTICAL
PROCEDURES USED BY
THE LOS ALAMOS SCIENTIFIC LABORATORY
IN THE
NURE HYDROGEOCHEMICAL AND STREAM SEDIMENT RECONNAISSANCE

APPENDIX ITEM D-I

SUMMARY OF STANDARD PROCEDURES USED BY THE LOS ALAMOS SCIENTIFIC LABORATORY (LASL) IN THE US ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION (ERDA) NATIONAL URANIUM RESOURCE EVALUATION (NURE) HYDROGEOCHEMICAL AND STREAM SEDIMENT RECONNAISSANCE (HSSR)

I. FIELD PROCEDURES

Water Sampling

Water samples are taken directly from the source wherever possible and placed into pre-washed and sealed 25-ml polyethylene vials. These are then acidified to a pH of ≤ 1 with 8N, reagent-grade HNO_3 . All sample containers are doubly labeled with preprinted, adhesive labels carrying the same sample location number preprinted on the field data form. Springs are sampled as near to their point of emergence as possible; stream waters are taken from fast-flowing current away from the bank; ponds (including small lakes and reservoirs) are sampled from just below the surface, away from the bank; and well waters are taken near the wellhead if the well is pumping or from a holding tank if not.

Sediment Sampling (Wet or Dry)

Enough fine-grained, organic-rich, water-transported sediment to yield a composite sample of ~ 25 g after processing (as indicated below) is taken from beneath the water level (where water exists) at three closely adjacent spots at each location. This is done with a polyethylene scoop, after the water sample (if any) is taken. The sediment is put into a new, clean, and originally sealed rip-top, polyethylene bag and properly double-labeled for delivery (with the field data form) to the drying facility. After drying at $\leq 100^\circ\text{C}$, each sample is sieved through stainless steel sieves to -100 mesh. The -100 mesh fraction is put into a pre-washed, 25-ml polyethylene vial, appropriately double-labeled (using labels from the data form), and sealed for storage at the LASL.

Field Measurements

The air temperature, taken in the shade at the time of sampling, is recorded to the nearest whole degree centigrade. The water temperature is measured in the source water and recorded to the nearest one-half degree centigrade. All temperature measurements are made with quality, precalibrated thermometers. The pH of the source water is measured with a calibrated, portable pH meter or multi-range pH paper, and recorded to the nearest one-tenth of a pH unit. The specific conductance ($\mu\text{mho/cm}$) of the source water is measured with a calibrated, temperature compensated (25°C) portable meter after the attached sample cup has first been rinsed three times in the source water. The scintillometer readings, taken on a flat, dry spot within a few meters of the sample location, are measured with a portable scintillometer. Two readings are recorded, the first with a radiation shield in place (blocking out ground radiation), and the second with the shield removed. The readings (in counts/s) are converted by computer to give the equivalent uranium (eU) value set forth in the data listing.

Field Observations

These represent the best subjective judgment of the field sampler on location, and include very general descriptions of the local bedrock, sediment, water, vegetation, terrain, weather, possible contaminants, and water well configuration, if applicable.

Sample Location Verification

Each contractor is supplied field maps with the desired sample types and locations symbolically premarked at the LASL. The maps are normally USGS Quad-ranges (either 7.5' or 15') but, where not available, Forest Service, State Highway, or other reasonably detailed maps are provided. As each location is sampled, a unique sample location number, preprinted on transparent adhesive labels provided with the identically numbered field data forms, is pasted over the precisely marked site on the field map. The latitude and longitude of each location is computed by the sampling contractor. Every location is later checked (and corrected if necessary) at the LASL by overlaying computer produced location plots on the field maps used. The latitudes and/or longitudes are corrected if the overlay locations are displaced by more than 300 m from the locations marked on the field maps. When a desired location cannot be sampled as specified, an alternate sample type or location as near as possible to the original one is picked, and the new sample type and/or location is/are marked on the field map and properly labeled as above. In the case at hand, all sample locations were chosen by the GIUA.

II. ANALYTICAL PROCEDURES

Water Samples Analyzed for Uranium by Fluorometry

In a controlled laboratory environment, a NaF (98%)-LiF (2%) flux pellet is prepared and placed on a platinum dish. The 25-ml water vial is vigorously shaken and a 0.25-ml aliquot of water is withdrawn and dropped onto a flux pellet, then evaporated under a heat lamp. The sample flux is then heated until fused. After it cools, it is excited with ultra-violet radiation in the fluorometer, and the measured fluorescence is read, recorded, and put through a computer routine using standards and blanks run at the same time to obtain the uranium concentration. Water samples which have uranium concentrations in excess of 10 ppb (the upper limit of detection of the fluorometry system without recalibration) are reanalyzed using the delayed neutron counting technique described below.

Water Samples Analyzed for Uranium by Delayed Neutron Counting (DNC)

Only waters with > 10 ppb uranium are assayed using DNC. Samples taken in the 41-ml rabbits are thoroughly cleaned (exterior) before analysis. Samples received in 25-ml vials (used exclusively in some of the early work) are transferred to clean, labeled, 41-ml rabbits before being analyzed. Each water sample is weighed, and its weight (less that of the rabbit) and location number are recorded. The rabbits are then loaded into a 25-sample transfer clip. The reactor pneumatic transfer system and background radiation levels are checked, and the system is calibrated using four standards. The transfer clip is installed on the pneumatic feed line, and the count control is set (typically, a 60-s irradiation, a 30-s delay, and a 60-s count is used, but this can be changed to accommodate abnormally high or low uranium concentrations). The samples are automatically cycled through the system and the uranium concentration is automatically computed in ppb and entered into the data base. None of the water samples reported were > 10 ppb.

Uranium Analysis of Sediment Samples

All sediment samples are analyzed for total uranium by DNC. A split of each sample (dried and sieved as described) is transferred to a clean 4-ml rabbit, weighed (less the tare), and recorded along with the appropriate location number. The readied rabbits are loaded into a 50-sample transfer clip. The reactor pneumatic transfer system and background radiation levels are checked, and the system is calibrated as above. The transfer clip is installed and the count control is set (typically, a 20-s irradiation, a 10-s delay, and a 20-s count is used). The samples are cycled through the system and the uranium concentration is automatically measured, computed in ppm, and entered into the data base.

148°W
63°N

147°30'

147°W

1:25
MAP

TALKEETNA MOUNTAINS

1860 1861 1863 1902 1868 1908
1862 1901 1903 1907 1905
1859 1864 1865 1866 1867 1904 1906

1799 1796 1795 1793 1851 1852 1853
1797 1794 1854 1855 1856 1857 1858
1787 1791 1850

1792

1772 1771 1770 1769 1767 1766
1777 1775 1774 1776 1789 1788 1786
1780 1778 1781 1782 1784 1783

62°45'

62°30'

1763 1764 1757 1762 1765 1758 1755 1761 1756 1849

147°W

146°30'

146°W

1:250,000 TOPOGRAPHIC
MAP BOUNDARIES

GULKANA

1772

1770

1769

1779

1767

1766

1789

1788

1786

1785

1783

2

PLATE I

6°W

145°30'

145°W
63°N

62°45'

3

62°30'

62°30'

62°15'

62°N
148°W

147°30'

147°

1834
-1833

PLATE I

SAMPLE LOCATI

SUSITNA RIVER B

SCALE 1:250,000

5

147°W

146°30'

146°W

ATION OVERLAY R BASIN, ALASKA

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0 15 20 25 Miles

0 15 20 25 Kilometers

1:250,000

6

146°W

145°30'

62°N
145°W

62°30'

62°15'

148°W
63°N.

147°30'

147°W

1:25
MAP

TALKEETNA MOUNTAINS

62°45

62°30'

1:250,000 TOPGRAPHIC
MAP BOUNDARIES

GULKANA

2

46°W

145°30

145°W
63°N

62°45'

3

62°30'

62°30'

62°15'

62°N
148°W

147°30'

147°W

4

PLATE II URANIUM CONCENTRATION OVER SUSITNA RIVER BASIN, A

62°30'

OVERLAY (WATER, ppb) SIN, ALASKA

62°15'

U CONCENTRATION (ppb)

□	△ 0.0-0.25
□	△ 0.25-0.38
□	△ 0.38-0.50
□	△ 0.5-0.63
□	△ 0.63-0.75
□	△ 0.75-0.88
□	△ 0.88-1.0
□	△ >1.0

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15 20 25 Miles

15 20 25 Kilometer

6

145°30'

62°N
145°W

148°W
63°N

147°30'

147°W
1:250,000
MAP BOU

TALKEETNA MOUNTAINS

62°45'

62°30'

250,000 TOPOGRAPHIC
MAP BOUNDARIES

146°30

146°W

GULKANA

2

PLATE III

URANIUM CONCENTRATION OVER

145°30'

145°W
63°N

62°45'

3

62°30'

PLATE III URANIUM CONCENTRATION OVER SUSITNA RIVER BASIN

LEGEND

SYMBOLS

- SURFACE STREAM SEDIMENT
- △ NATURAL LAKE OR POND SEDIMENT

U G

5

62°30'

ON OVERLAY (SEDIMENTS, ppm) BASIN, ALASKA

LEGEND

U CONCENTRATIONS (ppm)

□	△ 0.0-0.5
□	△ 0.5-1.0
□	△ 1.0-1.5
□	△ 1.5-2.0
□	△ 2.0-2.5
□	△ 2.5-3.0
□	△ 3.0-3.5
□	△ > 3.5

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62°15'

15 20 25 Miles

20 25 Kilometers

6

62°N
145°W

146°W

145°30'