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Sediment and Radionuclide Transport in Rivers

Phase 3
Field Sampling Program for Cattaraugus and Buttermilk Creeks, New York

Prepared by R. M. Ecker, W. H. Walters, Y. Onishi

Pacific Northwest Laboratory
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ABSTRACT

A field sampling program was conducted on Cattaraugus and Buttermilk Creeks, New York during April 1979 to investigate the transport of radionuclides in surface waters as part of a continuing program to provide data for application and verification of Pacific Northwest Laboratory's (PNL) sediment and radionuclide transport model, SERATRA. Bed sediment, suspended sediment and water samples were collected during unsteady flow conditions over a 45 mile reach of stream channel. Radiological analysis of these samples included gamma ray spectrometry analysis, and radiochemical separation and analysis of Sr-90, Pu-238, Pu-239,240, Am-241 and Cm-244. Tritium analysis was also performed on water samples. Based on the evaluation of radionuclide levels in Cattaraugus and Buttermilk Creeks, the Nuclear Fuel Services facility at West Valley, New York, may be the source of Cs-137, Sr-90, Cs-134, Co-60, Pu-238, Pu-239,240, Am-241, Cm-244 and tritium found in the bed sediment, suspended sediment and water of Buttermilk and Cattaraugus Creeks. This field sampling effort was the last of a three phase program to collect hydrologic and radiologic data at different flow conditions.

SUMMARY

As part of a study on sediment and radionuclide transport in rivers, Pacific Northwest Laboratory (PNL) is investigating the effect of sediment on the transport of radionuclides in Cattaraugus and Buttermilk Creeks, New York, during different flow conditions. One source of radioactivity in these creeks is the Western New York Nuclear Service Center which consists of a low-level waste disposal site and a nuclear fuel reprocessing plant. Reprocessing operations were terminated in 1972 and waste disposal was discontinued in 1975. Other sources of radioactivity include fallout from worldwide weapons testing and natural background radioactivity.

The major objective of the PNL Field Sampling Program is to provide data on sediment and radionuclide characteristics in Cattaraugus and Buttermilk Creeks to verify the use of the sediment and radionuclide transport model, SERATRA, for nontidal rivers. The sampling program is comprised of three phases of data collection. Phase 1 data collection was conducted during November and December 1977 and the Phase 2 data collection was conducted in September 1978. This report covers the results of field data collected during April 1979 for Phase 3.

Suspended sediment, bed sediment and water samples were collected at ten transects covering approximately 45 miles of stream channel of Cattaraugus and Buttermilk Creeks. Radiological analysis of sand, silt and clay size fractions of suspended and bed sediment, and water were performed. Results of these analyses indicate that the principal radionuclides with levels higher than background found in the two streams were Cesium-137 and Strontium-90. Both of these radionuclides had significantly higher activity levels above background in the bed and suspended sediment and water samples. Other radionuclides that are possibly being released into the surface water environment by the Nuclear Fuel Services facilities are Cesium-134, Cobalt-60, Plutonium-238 and 239,240, Americium-241, Curium-244, and Tritium.

ACKNOWLEDGMENTS

This report summarizes the results of research conducted by Pacific Northwest Laboratory for the U.S. Nuclear Regulatory Commission on Cattaraugus and Buttermilk Creeks, New York, during April 1979. In addition to the authors of this report, significant contributions were made by R. G. Parkhurst and S. J. Phillips for field data collection. The authors also wish to acknowledge the assistance of Mr. Steve Mollelo of the New York State Geological Survey in the field work and the guidance provided by Dr. Phillip R. Reed of the U.S. Nuclear Regulatory Commission.

Support work for the project was performed under subcontract to Dr. William R. Schell of the University of Washington, Laboratory of Radiation Ecology for radiological analyses.

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INTRODUCTION

This study is part of a comprehensive program by the U.S. Nuclear Regulatory Commission to investigate the importance of fluvial sediment in the transport of radionuclides in surface water systems. The study includes a three-phase field data collection program followed by a mathematical model verification effort of the sediment-contaminant transport model, SERATRA, developed by Pacific Northwest Laboratory (Onishi 1977). The field program will provide radiological and hydrological data for model calibration and verification. The Phase 3 program (April 1979) is the third and final field data collection effort conducted to provide data representative of three different flow conditions below bankfull. The results of the Phase 1 and Phase 2 field programs have been reported by Ecker and Onishi (1979) and Walters, Ecker and Onishi (1981), respectively.

The study area selected by the U.S. Nuclear Regulatory Commission is located within the watershed of Cattaraugus Creek, in rural western New York. During the 1960's the State of New York authorized the construction of a reprocessing plant near Cattaraugus Creek for spent fuel from nuclear reactors near West Valley, New York, and to operate a radioactive waste disposal site at the same location.

During the mid-1960's all burial trenches in the northern portion of the site began to fill with water after the covers were in place. This created a serious problem regarding burial of radioactive wastes at West Valley as the water could transport the buried radionuclides out of the trenches and into the environment. This led to the changing of burial procedures for the trenches in the southern portion of the site. The revised procedures specified new capping designs and were required by the State in 1968 in an effort to prevent surface water from entering the trenches.

In the early 1970's small increases of radioactivity were detected in the streams adjacent to the burial site area by the New York State Department of Environmental Conservation (NYSDEC). The NYSDEC requested the U.S. Environmental Protection Agency (USEPA) to provide assistance for an on-site investigation of the problem to determine whether radionuclides were migrating from the low-level waste burial areas through the subsurface to the surrounding environment. A lithological boring study conducted in 1973 and 1974 showed tritium contamination of the surface area and of the first 10 to 15 feet of strata immediately adjacent to the burial trenches. Although the results were inconclusive, the study indicated the possibility of several sources of tritium contamination: 1) downward migration resulting from fallout from the adjacent nuclear fuel reprocessing plant, 2) spillage occurring during burial operations, and 3) lateral migration through the geologic medium directly from the burial trenches

By 1974 trenches in the north burial site area had accumulated high levels of water while the water levels in the south trenches remained low due to the modified capping procedures. In March 1975 water in one trench in the north area seeped through the trench cap contaminating the adjacent surface area and a nearby stream. Shortly thereafter similar seepage was discovered at another trench and based on these discoveries Nuclear Fuel Services, Inc. (NFS) closed the burial site.

The NYSDEC and NFS agreed that a program to control the water levels in the north trenches was needed to prevent further seepage. A plan to pump water from the trenches that had high water levels to a radioactive waste treatment facility was approved by NYSDEC. The water was then to be diluted and released into Erdmans Brook (also known as Franks Creek) under controlled conditions. This pumpdown and treatment procedure was unacceptable for the long-term maintenance of the burial site but could be used as a temporary measure of control of radioactive waste releases.

The purpose of this study is to provide surface water radiological and hydrologic data at selected sampling points outside the exclusion fence at NFS along the Buttermilk-Cattaraugus Creek system between the NFS site and Lake Erie. The data is to be used in calibration and verification of a sediment-contaminant transport model.

SITE DESCRIPTION

The Western New York Nuclear Service Center, shown in Figure 1, is located about 30 miles south of Buffalo, New York. The Center consists of a 3345-acre site in north central Cattaraugus County near the village of West Valley, New York and within the Cattaraugus Creek watershed. This Cattaraugus Creek watershed is shown in Figure 1 and the Center boundary in Figure B.1 (Appendix B). The Center is situated along an elongated rolling plain with glaciated bedrock hills along the eastern, western and southern boundaries, and Buttermilk Valley along the northern boundary. All surface drainage of the Center discharges into Buttermilk Creek. At the northwest end of the property, Buttermilk Creek joins Cattaraugus Creek which flows in a westerly direction into Lake Erie, 39 miles away. Cattaraugus Creek flows in a general westerly direction through the Zoar Valley, past Gowanda, New York and the Cattaraugus Indian Reservation, and discharges into Lake Erie about 27 miles southwest of Buffalo, New York. The distance from the confluence of Buttermilk and Cattaraugus Creeks to Gowanda is about 20 creek miles and from that point about another 19 creek miles to Lake Erie.

The Franks Creek watershed, which includes Erdmans Brook collects the drainage from both the low- and high-level nuclear waste burial sites. The creek joins Buttermilk Creek about 0.5 miles downstream from the burial site. About 100 ft upstream from its confluence with Buttermilk Creek the flow passes through a 12 ft wide concrete railroad culvert. The creek is entrenched in a narrow V-shaped valley downcut through previously undisturbed glacial till containing significant amounts of very stiff, erosion resistant material. The creek channel is steep with chutes and pools and a cross-sectional width varying from 2 to 10 ft. Swampy areas can be found at certain locations along the stream course.

Buttermilk Creek has a drainage area of approximately 29.4 mi^2. For the period of record from October 1961 to September 1968, the average discharge of Buttermilk Creek was 46.5 cubic feet per second (cfs). The extreme maximum and minimum discharges during the period of record were 3,910 cfs on 28 September 1967 and 2.1 cfs on 10 October 1963, respectively. Buttermilk

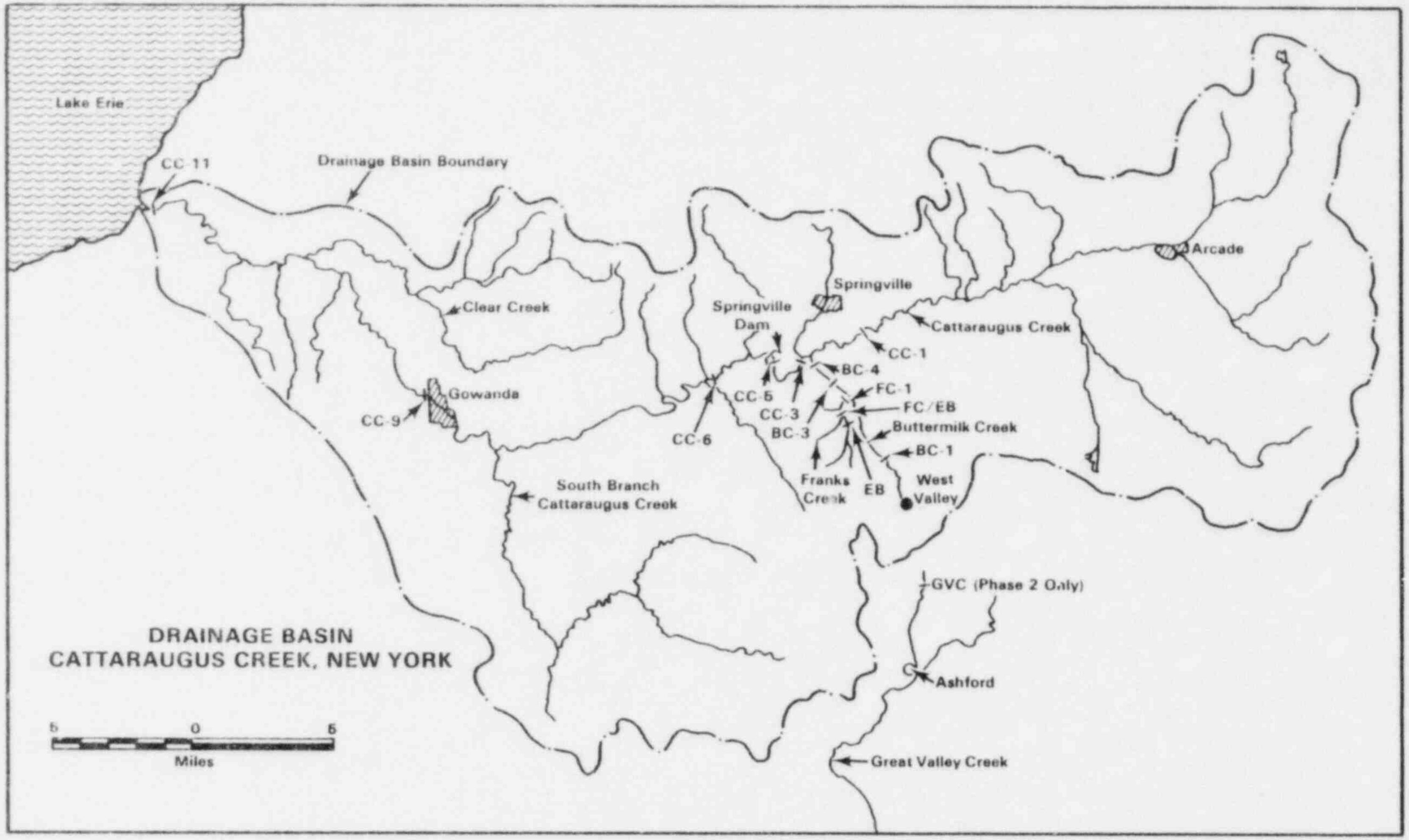

FIGURE 1. Map of the Radiological Sampling Stations on the Cattaraugus Creek System

Creek flows into Cattaraugus Creek about 2.25 miles downstream of the confluence with Franks Creek. The creek width under normal conditions varies from about 20 ft at the upper end to about 75 ft near the confluence with Cattaraugus Creek. The channel bed is comprised of sand, gravel, and cobbles with minor amounts of silt and clay size material. Water frequently overflows the channel banks leaving deposits of gravel, sand, silt, and clay on the narrow floodplain area. The floodplain varies in width from 300 to 500 ft and is bounded by high bluffs along most of its length.

Cattaraugus Creek has an estimated drainage area of 564 mi^2 at Lake Erie, 432 mi^2 at Gowanda and 218 mi^2 at the confluence with Buttermilk Creek. Based on the United States Geological Survey (USGS) flow data records for Cattaraugus Creek at Gowanda, New York, the average discharge for the period of record, 1940 to 1976, is 731 cfs. The extreme maximum and minimum daily discharges during the period of record were 34,600 cfs (7 March 1956), and 6 cfs (21 August 1941), respectively.

Peak discharges generally occur on Cattaraugus Creek in October and November, prior to the onset of winter snowfall and again in February and March as a result of snowmelt. Low discharges generally occur during the summer months of July through September when rainfall is less and again during the winter months of December and January when persistent freezing conditions exist. Cattaraugus Creek, as well as Buttermilk Creek, can be categorized as "flashy" due to their very rapid changes in discharge. Cattaraugus Creek discharges can vary upwards of 5000 cfs in a 24-hour period.

Cattaraugus Creek flows unrestricted from its headwaters to Lake Erie except for Springville Dam located about 2.5 miles downstream from the confluence of Buttermilk Creek. Springville Dam is a 20-ft high dam that creates a small reservoir extending about 0.5 miles upstream through a narrow rock gorge approximately 1000 ft in elevation. The dam and reservoir system provides water supply for a run-of-the-river hydroelectric plant operated by the village of Springville. The plant's generators supply about 20 percent of the electric power requirements of the village.

PHASE 3 SAMPLING PROGRAM

The Phase 3 data collection program was intended to gather radiological and hydrologic information under unsteady flow conditions. The field work was conducted from April 26 through April 29, 1979.

RADIOLOGICAL SAMPLING PROCEDURES

It was necessary to process up to 400 gallons of water in the field for radiological analysis of suspended sediment and water because of the very low radioactivity levels found in the water of Cattaraugus and Buttermilk Creeks. The separation of suspended sediment from water was included in the field sampling to eliminate the need of transporting large volumes of water. The instream sampling of water and suspended sediment was accomplished by utilizing a large volume water and suspended sediment sampler. The sampling apparatus is shown in Figure 2. A discussion of the principle of the large volume water sampler and the analysis procedure can be found in Appendix A. Basically the method allows the processing of a large volume of water in the field within a relatively short period of time that eliminates the necessity of separating the suspended sediment and other particulates from the water in the laboratory. The procedure concentrates the suspended sediment and radionuclides dissolved in water while in the field, thus, providing a larger sample for laboratory analysis.

Water and Suspended Sediment Sampling

Suspended sediment was separated from the water in the field using a high-speed continuous flow centrifuge. A Westfalia Model OTA 7-00-066 clarifuge was used which has the capability of processing about 300 gallons of water per hour at about 9000 rpm. The sediment retained in the centrifuge was separated into sand, silt and clay size fractions by further centrifuging in the laboratory prior to radiological analysis.

After passing through the centrifuge, water then flowed through the large volume water sampler (LVWS). The LVWS consisted of a set of three 0.3 μ fiberglass filters to trap any remaining particulate material not removed by the

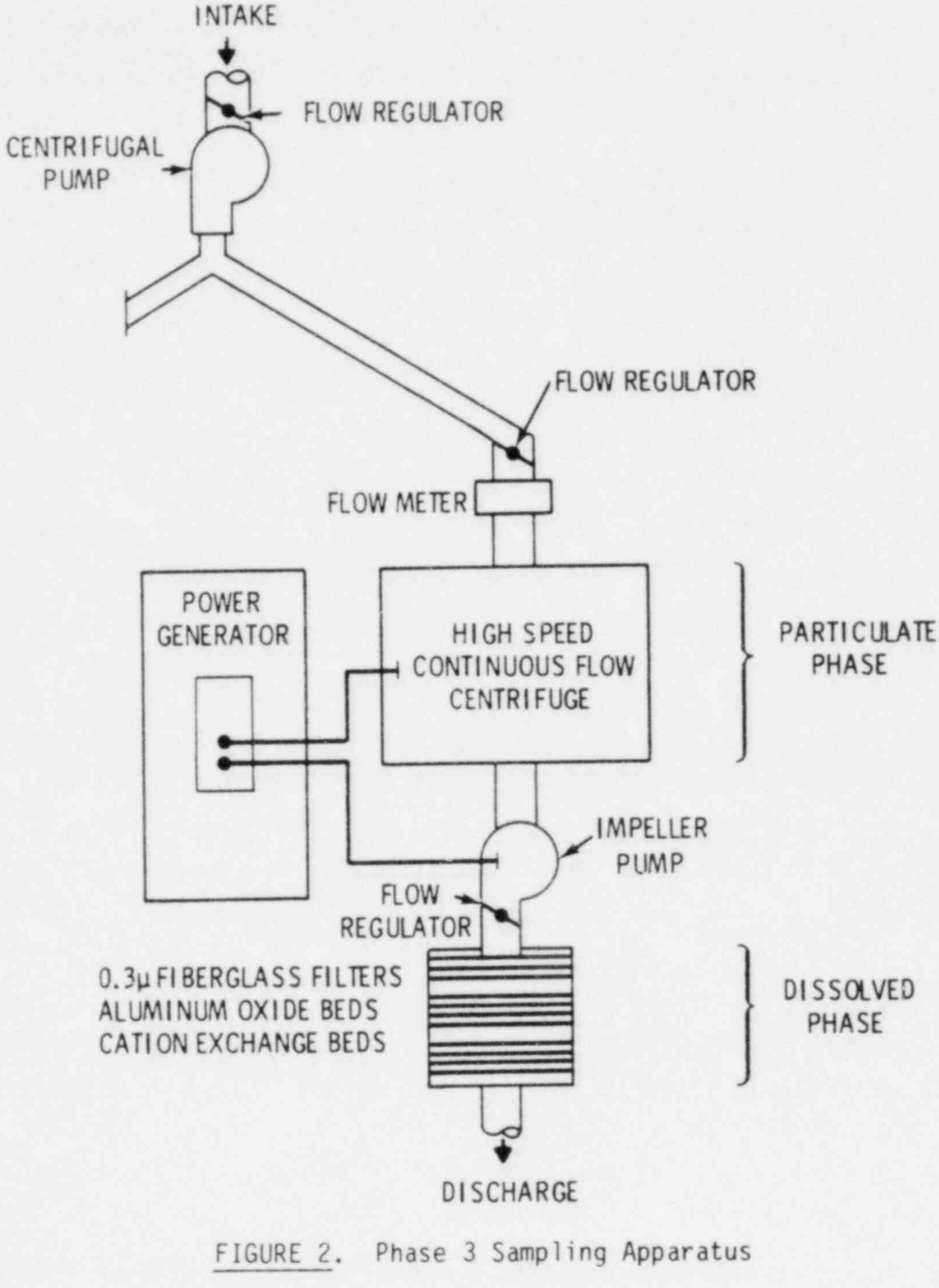

FIGURE 2. Phase 3 Sampling Apparatus

centrifuge and a series of three aluminum oxide (Al_2O_3) beds, and three cation exchange beds to capture the colloidal and dissolved radionuclides. Water samples were also taken at the discharge end of the system for tritium analysis.

Bed Sediment Sampling

Bed sediment samples were collected independently with the use of a scoop at each sampling station. The samples were later separated into sand, silt and clay size fractions in the laboratory for radiological analysis. Bed sediment core samples were collected in Lake Erie just offshore from the mouth of Cattaraugus Creek. The core samples were collected by divers by pushing 1 1/2 inch acrylic tubes into the lake bed and then capping the tubes prior to removal. The core samples were later sectioned into three two-inch segments in the laboratory for radiological analysis.

WATER QUALITY CHARACTERISTICS

Certain water quality parameters were measured at the radiological sampling stations during the Phase 3 sampling program. The parameters included suspended solids, temperature, pH, hardness, dissolved oxygen and total organic carbon. Analytical methods for determining these water quality characteristics are discussed in the section on "Laboratory Procedures."

HYDROLOGIC DATA

Extensive hydrologic data were collected during the Phase 3 sampling program to provide input data of the actual flow conditions during the sampling period for unsteady flow modeling. The results of the unsteady flow computations provided hydraulic input data for the sediment-contaminant transport model, SERATRA. The hydrologic data included river stage measurements versus time at temporary gage locations, vertical velocity measurements, channel cross-section surveys, water surface slopes, suspended sediment concentrations versus time, and bed material samples. The hydrologic data collection program is discussed in Appendix B.

SAMPLING STATIONS

The Phase 3 field sampling effort involved the collection of hydrologic and radiological data at three stations on Franks Creek, three stations on Buttermilk Creek, six stations on Cattaraugus Creek and four stations in Lake Erie. Sampling stations on Franks Creek, Buttermilk Creek, and Cattaraugus Creek are shown on Figure 1 and briefly described in the following paragraphs.

Buttermilk Creek-Station 1 (BC-1)

This station is upstream of the mouth of Franks Creek and therefore upstream of the outflow from the NFS facility. It is a background station for Buttermilk Creek. The stream cross-section is located about 40 ft upstream of the Fox Valley Road bridge and is plotted in Figure 3. The sample was taken at about mid-point along the cross-section.

Franks Creek-Station 1 (FC-1)

The NFS facility is located within the Franks Creek watershed and the creek is the main uncontrolled outflow point from the facility. The sampling station cross-section (Figure 4) is located at the Baltimore and Ohio Railroad culvert outlet which is about 150 feet upstream of the confluence with Buttermilk Creek. This creek is the only surface water outflow point for the NFS facility monitored in this study.

Erdmans Brook (EB)

Erdmans Brook, sometimes referred to as Franks Creek, is defined as a small tributary to Franks Creek. Only bed material samples were taken at this location to provide a comparison of radioactivity levels with bed material samples at other locations. No cross-section survey was made of the sampling station. The sampling station was located about 1500 feet upstream of the confluence of Franks Creek and Buttermilk Creek.

Franks Creek-Erdmans Brook (FC/EB)

Only bed material samples were taken at this location to provide a comparison of radioactivity levels with bed material samples at other locations.

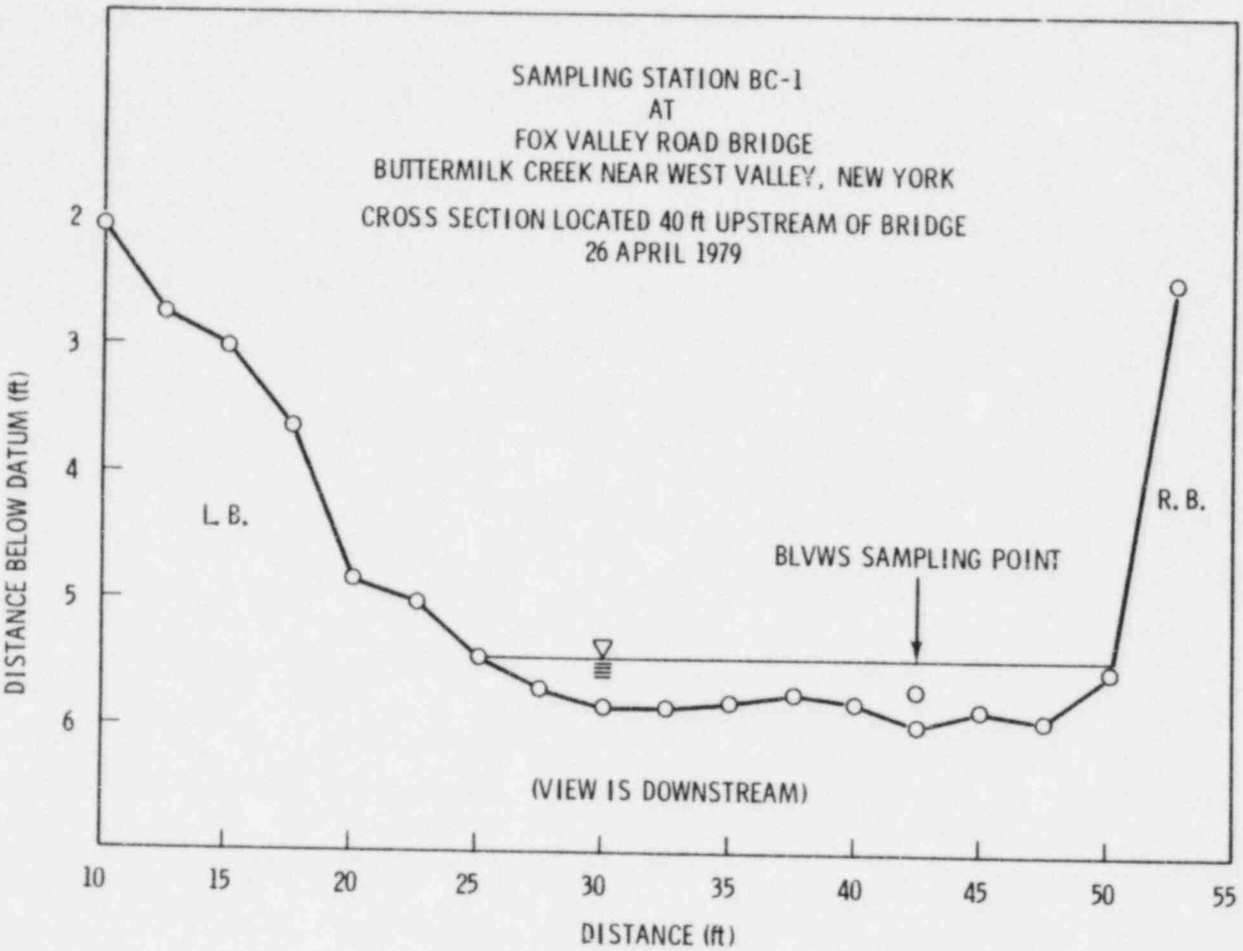

FIGURE 3. BC-1 Sampling Station

No cross-section survey was made at the sampling station. The sampling station was located about 2000 feet upstream of the confluence of Franks Creek and Buttermilk Creek.

Buttermilk Creek-Station 3 (BC-3)

This station is an intermediate sampling station between the Franks Creek outflow point and Cattaraugus Creek. The cross-section shown on Figure 5 is located about 100 feet downstream of the abandoned Bond Road Bridge.

Buttermilk Creek-Station 4 (BC-4)

The station at BC-4 is an intermediate sampling station between the Franks Creek outflow point and Cattaraugus Creek. The cross-section shown on Figure 6

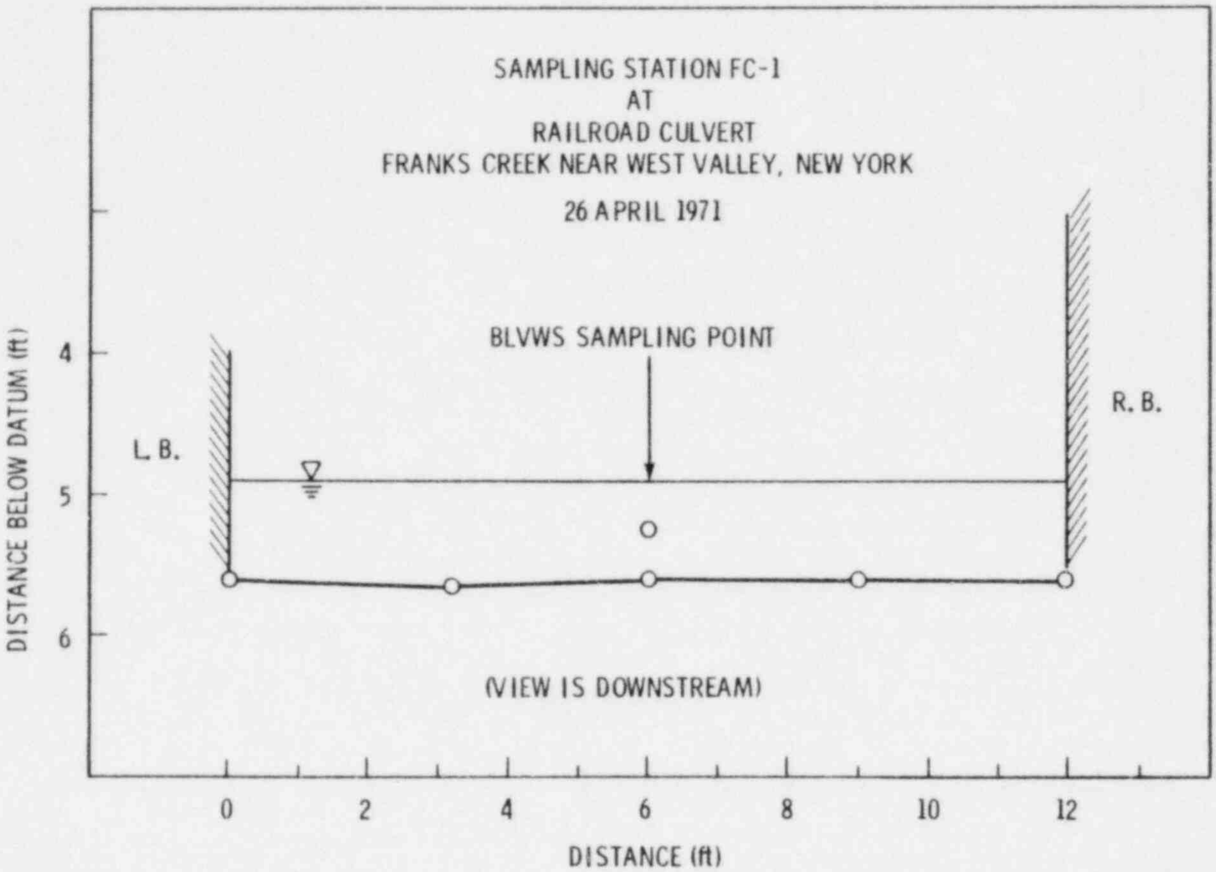

FIGURE 4. FC-1 Sampling Station

is located approximately 100 ft downstream from the Thomas Corners Road Bridge and 0.2 miles upstream from Cattaraugus Creek.

Cattaraugus Creek-Station 1 (CC-1)

This station is located directly beneath and parallel to Bigelow Bridge (Elk Street Bridge) and is the upstream inflow point of the Cattaraugus Creek study area. The station also provides background data for Cattaraugus Creek. The cross-sectional sampling point was positioned next to the right bank bridge abutment as shown in Figure 7.

Cattaraugus Creek-Station 3 (CC-3)

This station is located approximately 100 feet downstream of Felton Bridge (Mill Street Bridge). This is the first sampling station downstream of the

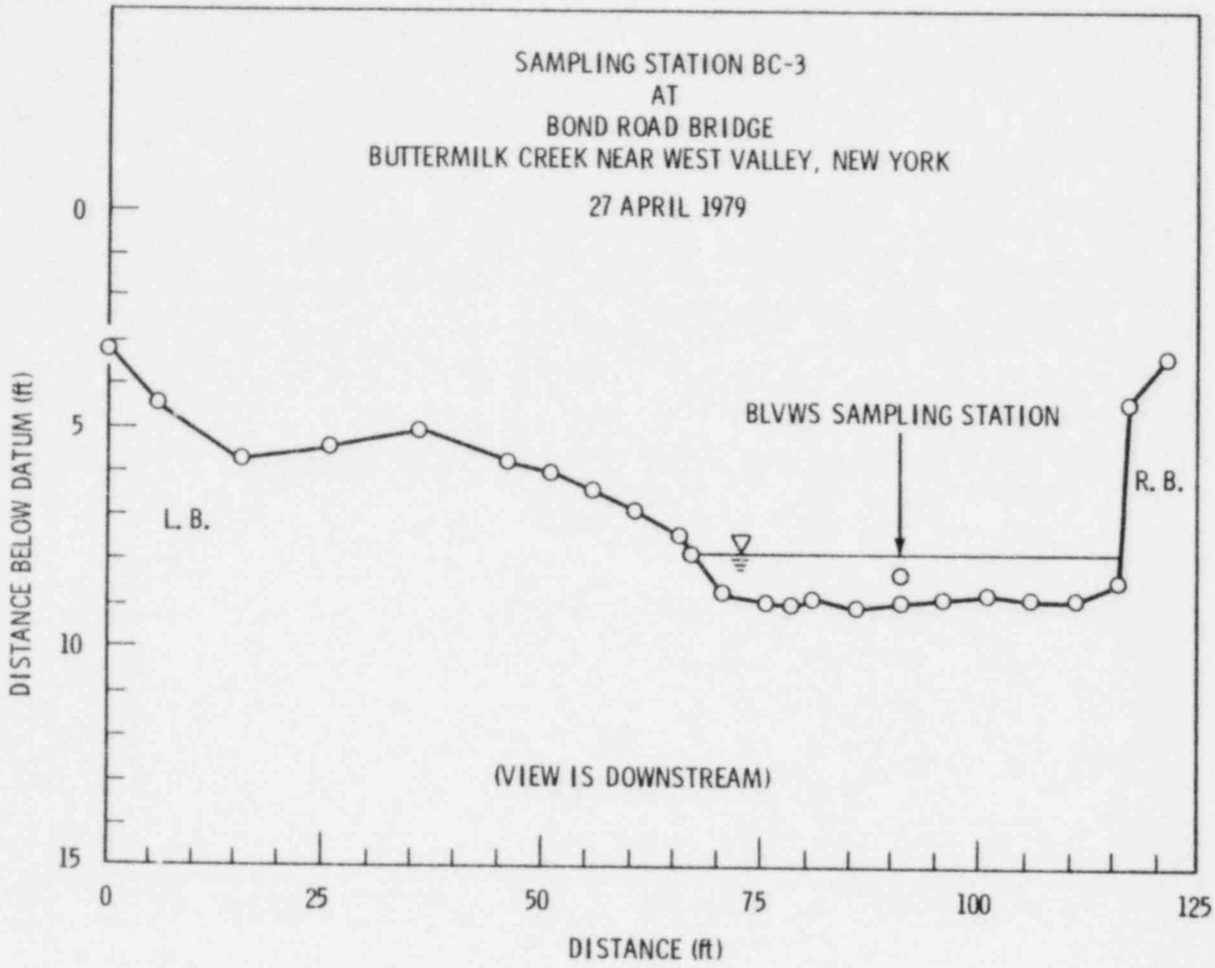

FIGURE 5. BC-3 Sampling Station

confluence of Buttermilk Creek and Cattaraugus Creek. The cross-section and sampling location are shown on Figure 8.

Cattaraugus Creek-Station 5 (CC-5)

This station is located in Springville Reservoir approximately 500 feet upstream of the dam. Ths cross-section and sampling station at CC-5 are shown on Figure 9.

Cattaraugus Creek-Station 6 (CC-6)

This station is located in Zoar Valley near Frye Bridge and is an intermediate sampling point between Springville Dam and Lake Erie. The CC-6 cross-section is shown on Figure 10.

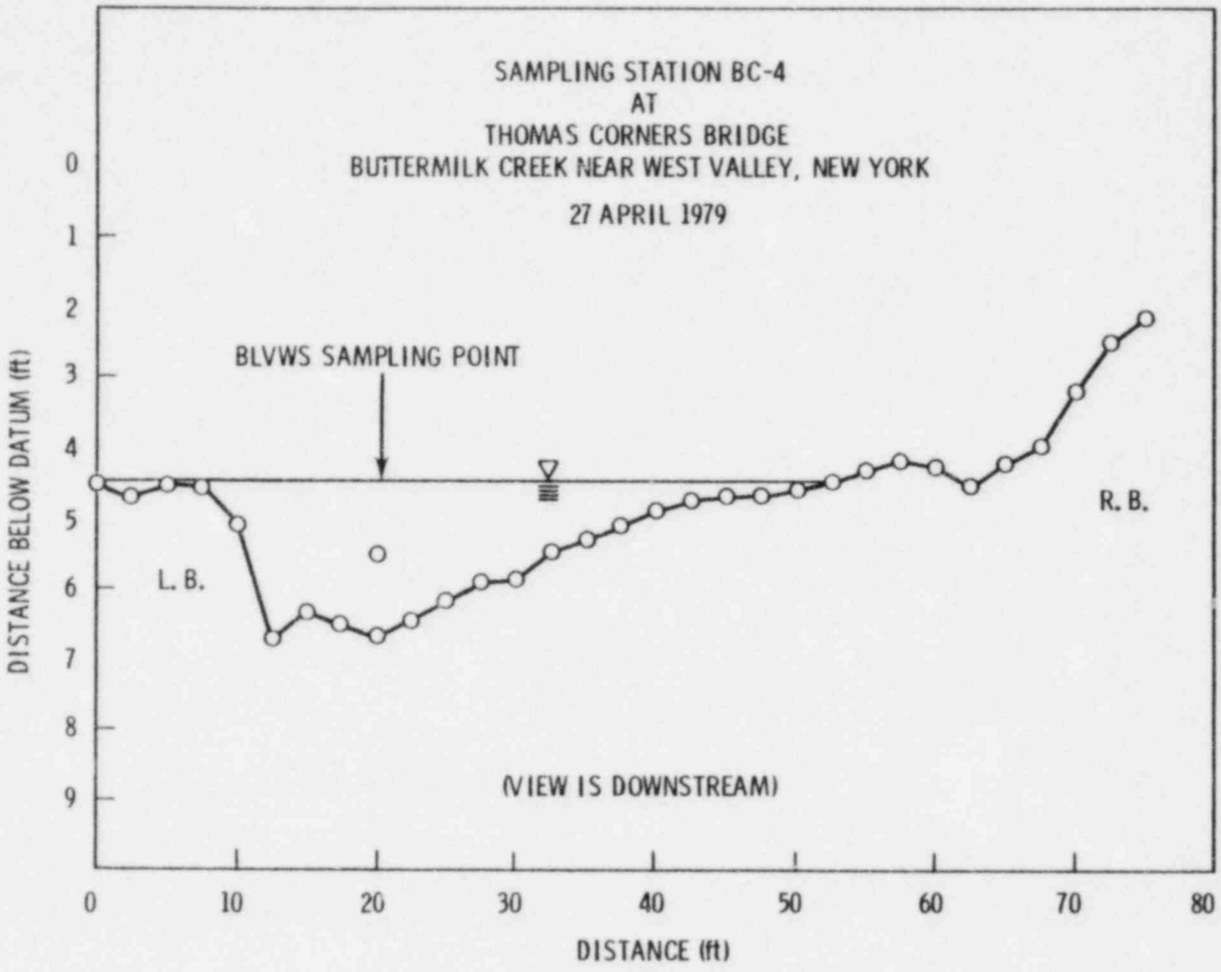

FIGURE 6. BC-4 Sampling Station

Cattaraugus Creek-Station 9 (CC-9)

This station is located at Gowanda, about 21 miles downstream from Springville Dam. The stream cross-section, shown on Figure 11 is located about 150 feet downstream of Taylor Hollow Road Bridge. The station is about 19 miles upstream from Lake Erie and is an intermediate point between Springville Dam and Lake Erie.

Cattaraugus Creek-Station 11 (CC-11)

This station is located underneath the New York Central Railroad Bridge about 4000 feet upstream from the mouth of Cattaraugus Creek at Lake Erie. The stream cross-section is shown on Figure 12.

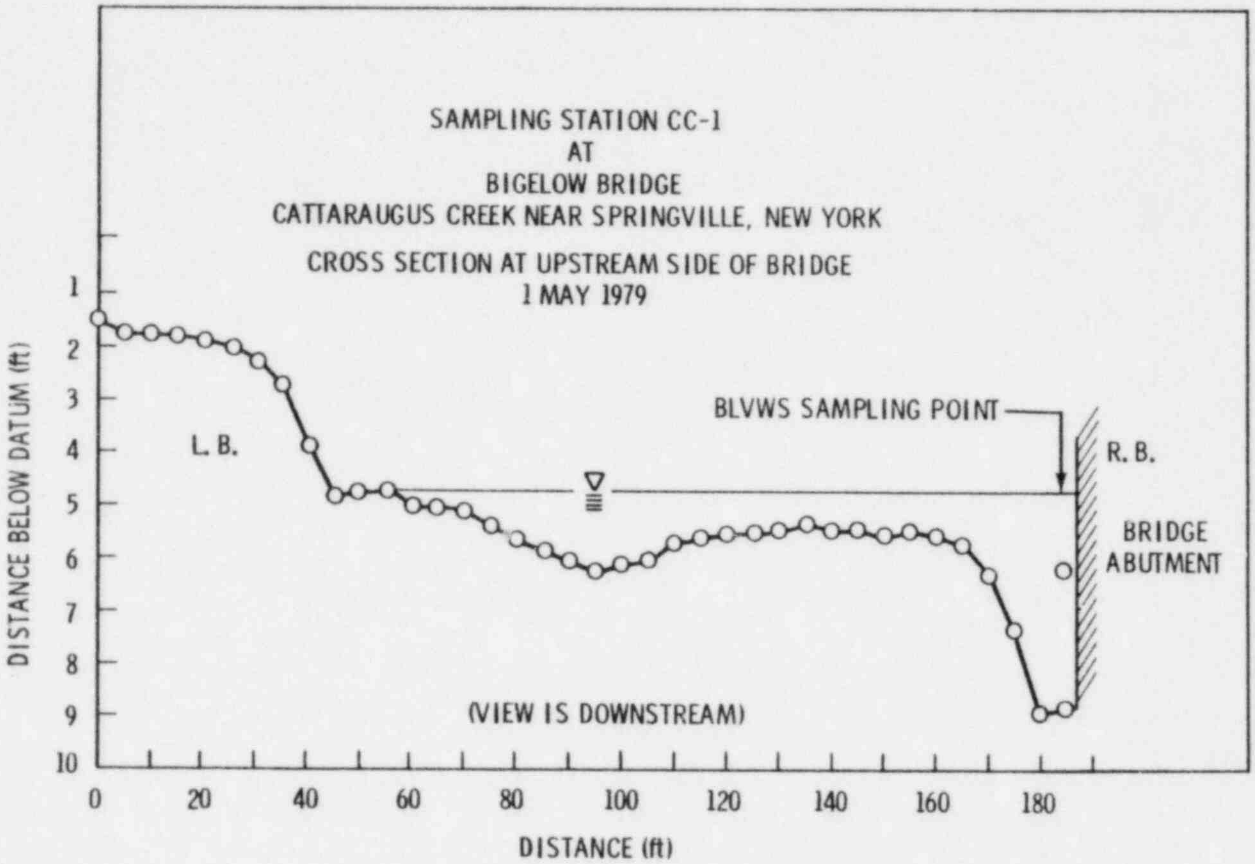

FIGURE 7. CC-1 Sampling Station

Lake Erie Stations 1, 2, 3, and 4

Core samples of bed sediment were taken at four sampling stations offshore from the mouth of Cattaraugus Creek. All four stations are located along a line paralleling the shoreline about 0.75 mile offshore. The stations are spaced at about 0.5 mile intervals along the line and are numbered one through four from west to east. Station 3 is located directly offshore from the mouth of Cattaraugus Creek.

LABORATORY PROCEDURES

Sediment Samples

Suspended sediment samples collected by centrifugation and bed sediment grab samples were returned to the laboratory for separation into sand, silt and

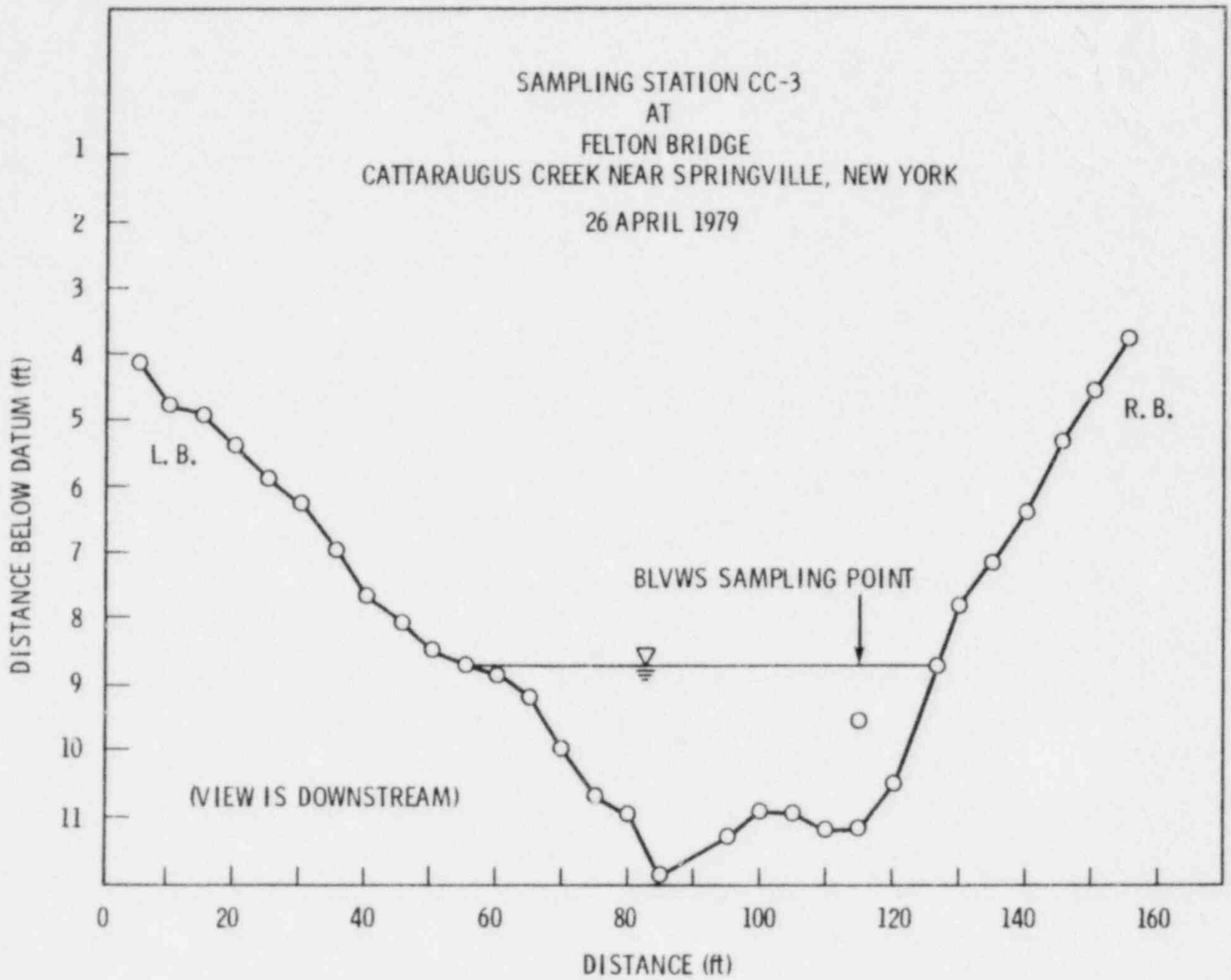

FIGURE 8. CC-3 Sampling Station

clay size fractions. The separated samples were then shipped to the University of Washington, Laboratory of Radiation Ecology for radiological analysis.

Suspended sediment collected from the centrifuge was separated into sand, silt and clay size fractions using the procedure outlined in "Soil Chemical Analysis" (Jackson 1956). The suspended sediment samples were initially wet-sieved through a No. 200 U.S. Standard Sieve. The material retained on the sieve was dried, weighed, and reported as sand (>74μ). The material passing through the sieve was dispersed using an electric mixer (ASTM Stirring Apparatus A) and centrifuged at 750 rpm for 3.3 minutes. The material remaining

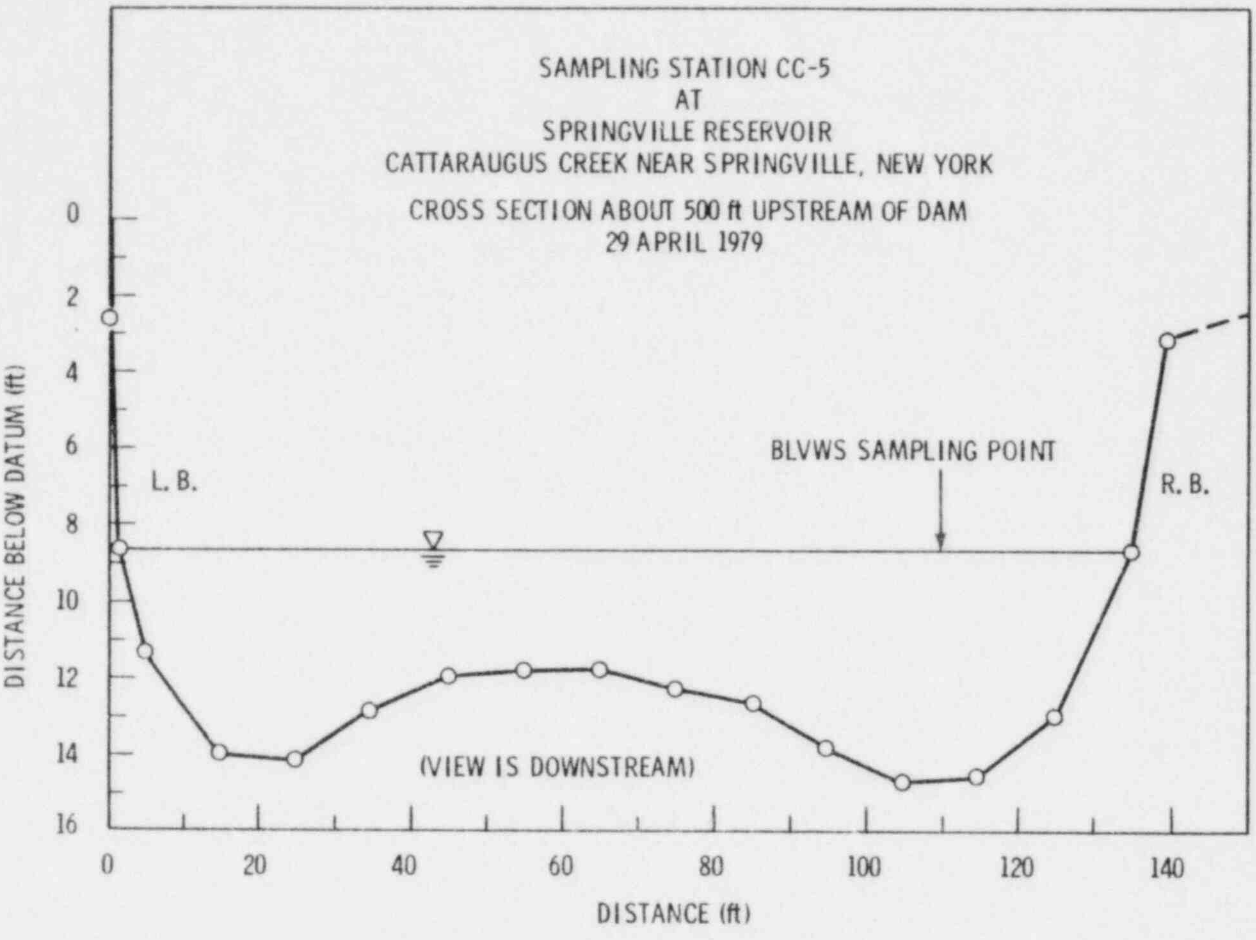

FIGURE 9. CC-5 Sampling Station

after centrifugation was decanted, evaporated to dryness, weighed, and reported as clay (<4μ). The material deposited in the centrifuge cups after decantation of the suspended clay was dried, weighed and reported as silt (74μ x 4μ).

Bed sediment samples were first dried in an oven at 103 degrees Fahrenheit and then sieved on a RoTap Shaker. The material remaining on the No. 10 sieve (>2.0 mm), classified as very fine gravel or larger, was weighed and discarded. The sand fraction was separated into coarse (2.0 to 0.42 mm), medium (0.42 to 0.125 mm), and fine (0.125 to 0.074 mm) sand. The remaining portion of the sample was allowed to soak overnight in distilled water, then separated into silt and clay size fractions by the same method used for suspended sediment.

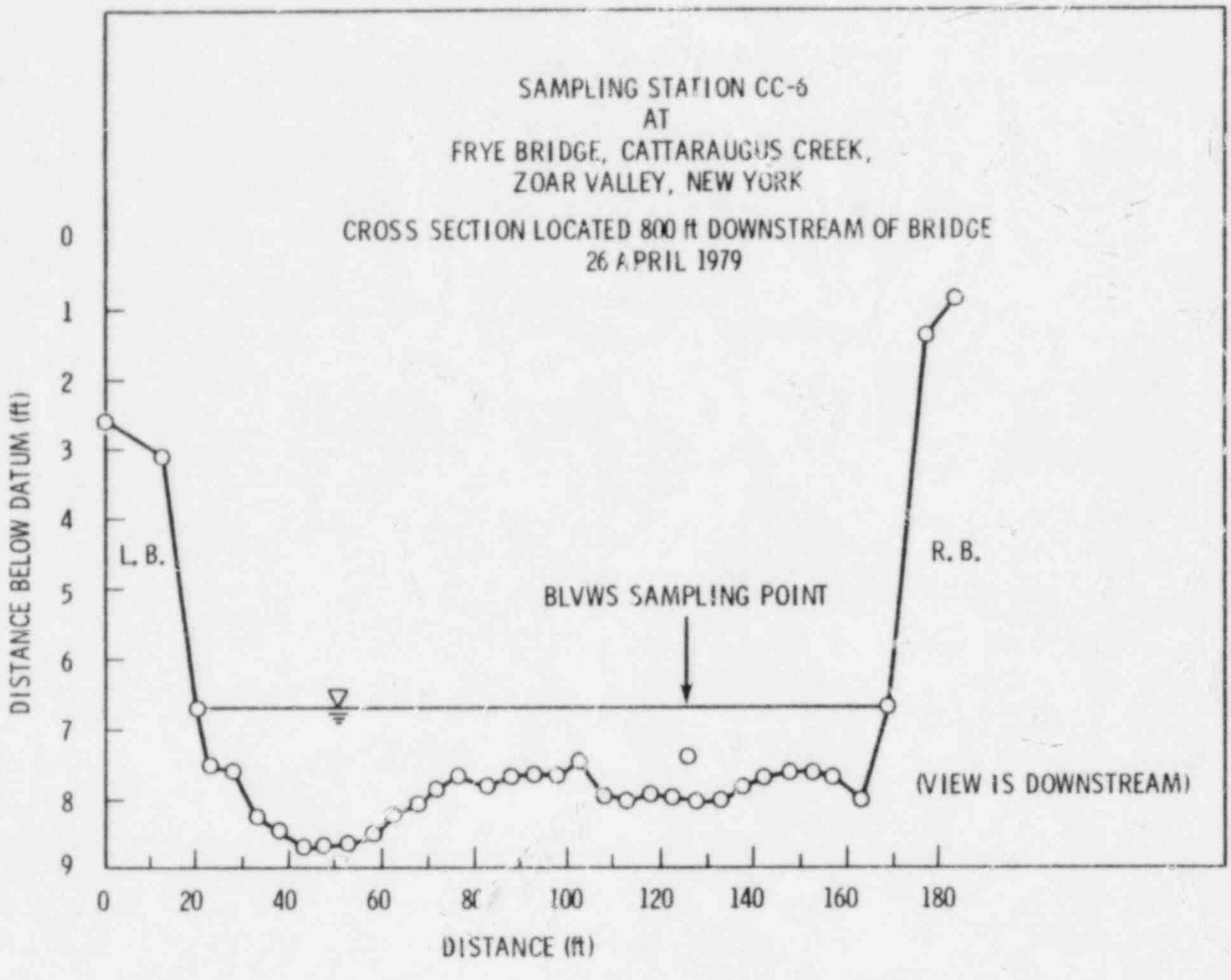

FIGURE 10. CC-6 Sampling Station

Water Samples

Water temperature, pH and hardness were measured in the field. Temperature was measured using a Kane-May Mark III Digital Dependatherm thermometer. Water pH was taken with a Corning Model 3 portable pH meter. The meter was standardized with a pH buffer solution immediately before each measurement. Water hardness was measured in the field utilizing the procedure described in Standard Methods (1975), No. 309B, using commercial reagents manufactured by Betz Laboratories. Standard EDTA solutions were prepared from standard ampoules obtained from Baker Chemical Company. Total organic carbon (TOC) samples were collected in one-ounce polyethylene bottles and acidified to pH 2

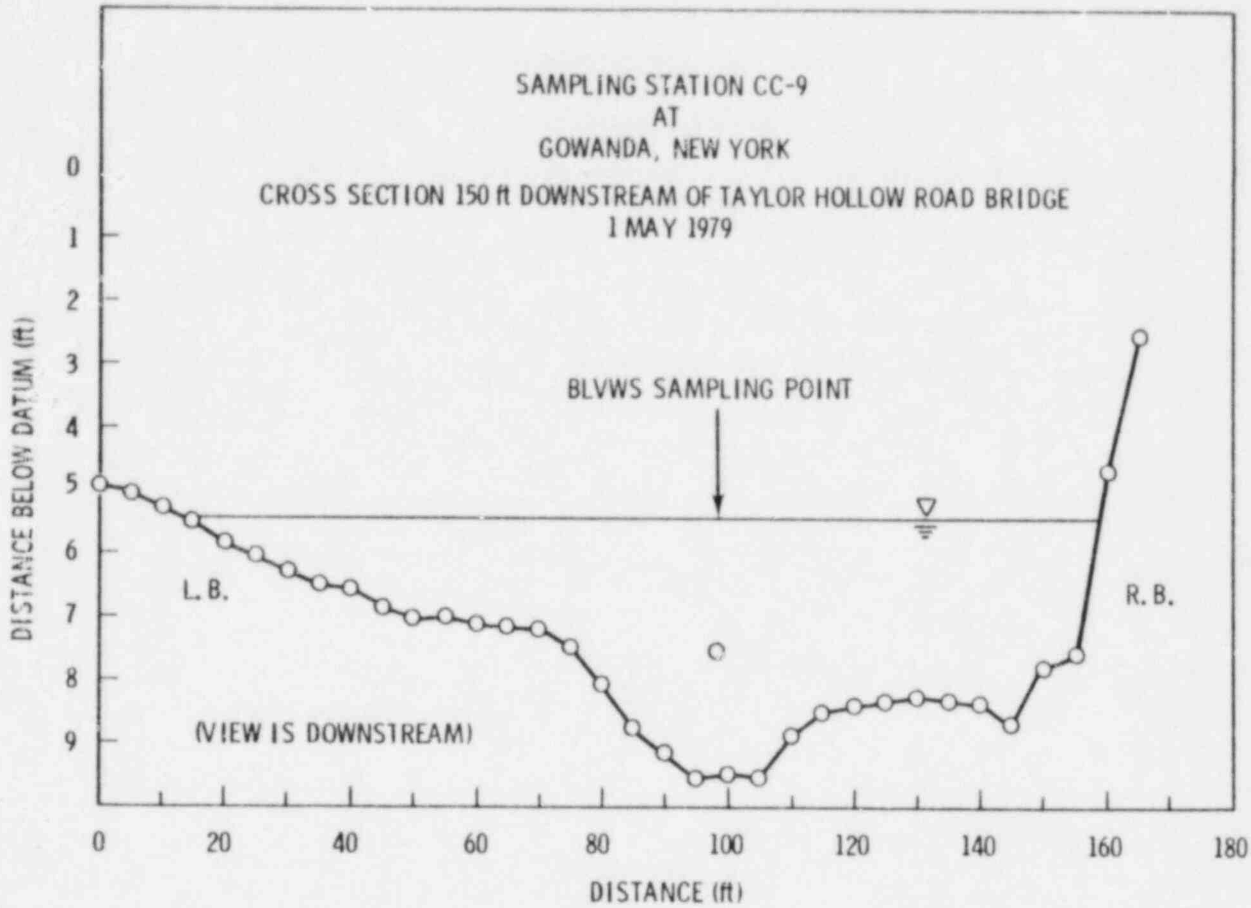

FIGURE 11. CC-9 Sampling Station

in the field. The samples were returned to the laboratory and analyzed with a Beckman Model 915 Total Organic Carbon Analyzer. Standard organic carbon solutions were prepared according to Standard Methods (1975), No. 505. Total suspended solids samples were collected in one liter polyethylene bottles and analyzed in the laboratory according to Standard Methods (1975), No. 208D. Gooch crucibles and Whatman GF/C filters were used to filter duplicate 100 ml samples which were dried for a minimum of two hours and weighed.

Radiological Counting Procedures

The separated sediment samples, filters, aluminum oxide and resin beds, and water samples were forwarded to the Laboratory of Radiation Ecology (LRE) at the University of Washington for radiological analysis. The laboratory

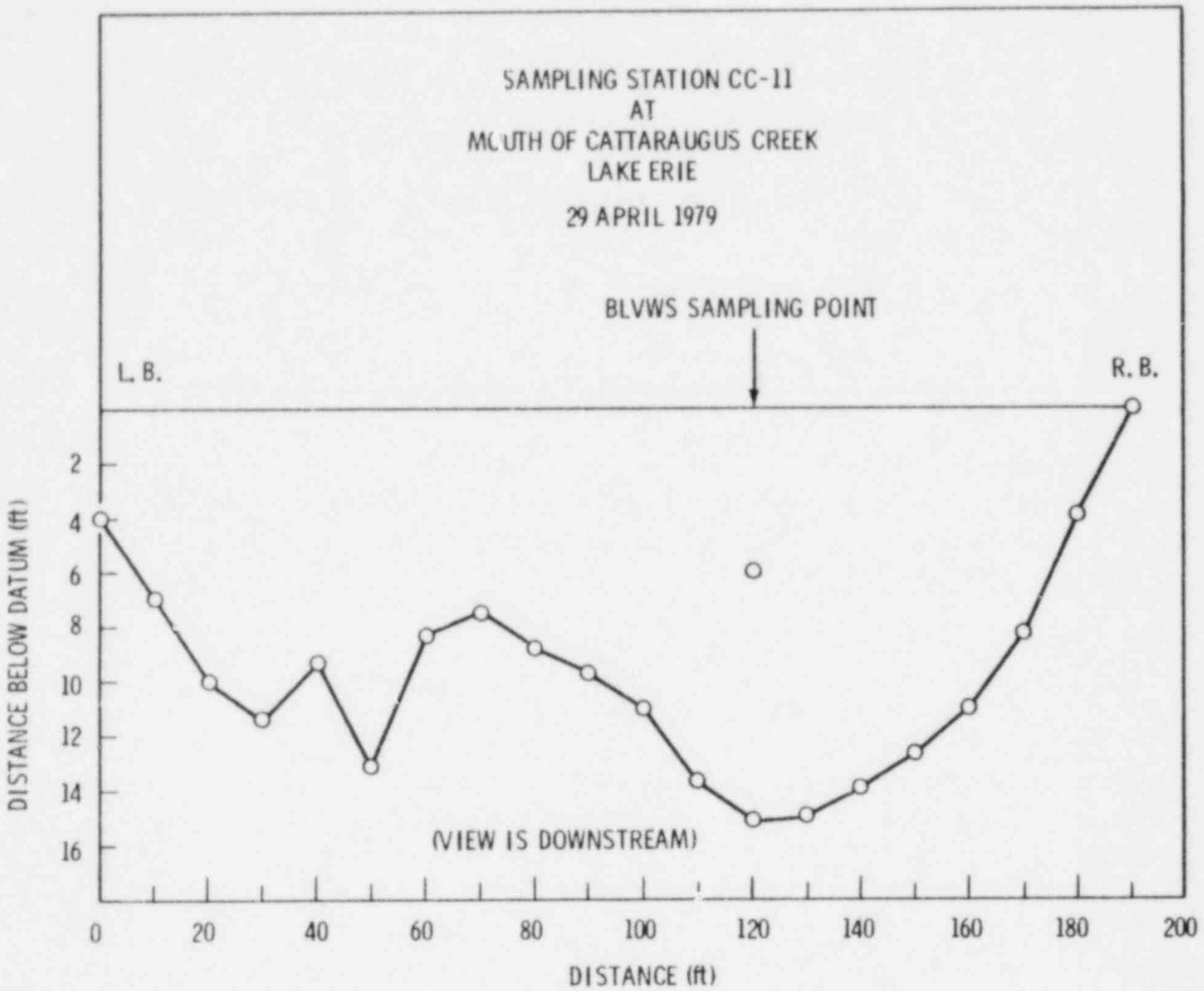

FIGURE 12. CC-11 Sampling Station

procedures used by the University of Washington are described in Appendix C. The gamma-emitting radionuclides were detected using gamma ray spectrometry. Radiochemical separation techniques were used to detect Sr-90, Pu-238, Pu-239,240, Am-241 and Cm-244. Water samples were analyzed for tritium and selected dried sediment samples were analyzed for both tritium and carbon-14. The radionuclides detected during the Phase 3 sampling program are summarized in Table 1.

TABLE 1. Radionuclides Found in Water and Sediment of the Cattaraugus Creek Watershed During Phase 3 Sampling. Isotope data from Public Health Service (1970).

	Isotope	Symbol	Atomic No.	Half-Life	Major Radiations
1.	Tritium	H-3 or T	1	12,262Y	β^-
2.	Carbon-14	C-14	6	5745Y	β^-
3.	Potassium-40	K-40	19	1.26×10^9Y	β^-,β^+,γ
4.	Cobalt-60	Co-60	27	5.263Y	β^-,γ
5.	Strontium-90	Sr-90	38	27.7Y	β^-
6.	Niobium-95	Nb-95	41	35d	β^-,γ
7.	Ruthenium-106	Ru-106	44	367d	β^-,daughter radiation from 30S Rh-106
8.	Rhodium-101	Rh-101	45	3.0Y	γ,e^-
9.	Rhodium-102	Rh-102	45	2.9Y	γ
10.	Antimony-125	Sb-125	51	2.71Y	β^-,e^-,γ
11.	Cesium-134	Cs-134	55	2.046Y	β^-,γ
12.	Cesium-137	Cs-137	55	30.0Y	β^-,e^-,γ
13.	Cerium-139	Ce-139	58	140d	γ,e^-
14.	Cerium-141	Ce-141	58	32.5d	β^-,e^-,γ
15.	Cerium-144	Ce-144	58	284d	β^-,e^-,γ
16.	Europium-152	Eu-152	63	12.7Y	$\beta^-,\beta^+,e^-,\gamma$
17.	Europium-155	Eu-155	63	1.811Y	β^-,e^-,γ
18.	Lead-210	Pb-210	82	20.4Y	$\alpha,\beta^-,e^-\gamma$
19.	Bismuth-207	Bi-207	83	30.2Y	e^-,γ
20.	Bismuth-214	Bi-214	83	19.9m	β^-,γ,α, daughter radiation from Po-214
21.	Radium-226	Ra-226	88	1602Y	α,e^-,γ
22.	Radium-228	Ra-228	88	6.7Y	β^-,e^-, daughter radiations from Ac-228, Th-228, Ra-224, etc.
23.	Thorium-228	Th-228	90	1.910Y	α,γ,e^-
24.	Thorium-232	Th-232	90	1.41×10^{10}Y	α,γ,e^-
25.	Uranium-235	U-235	92	7.1×10^8Y	α,γ
26.	Uranium-238	U-238	92	4.51×10^9Y	α,γ,e^-
27.	Plutonium-238	Pu-238	94	86.4Y	α,γ,e^-
28.	Plutonium-239,240	Pu-239,240	94	24,390Y	α,γ,e- 6580Y
29.	Americium-241	Am-241	95	458Y	α,e^-,γ
30.	Curium-244	Cm-244	96	17.6Y	α,γ,e^-

α = Alpha-particle emission
β^- = Negative Beta-particle (negatron) emission
β^+ = Positive Beta-particle (positron) emission
γ = Gamma-ray emissions
e^- = electron emissions

STREAMFLOW CONDITIONS DURING SAMPLING

Average daily discharges for the period of April 10 to April 30, 1979 at the USGS Gowanda, New York gaging station on Cattaraugus Creek are shown on Figure 13. During the Phase 3 sampling program the discharge at Gowanda increased from 556 cubic feet per second (cfs) on April 26 to 751 cfs on April 28, then decreased to 629 cfs on April 29. Approximately two weeks prior to the Phase 3 sampling program, Cattaraugus Creek experienced very high flows. The peak discharge during this period was 3,330 cfs on April 13 1979.

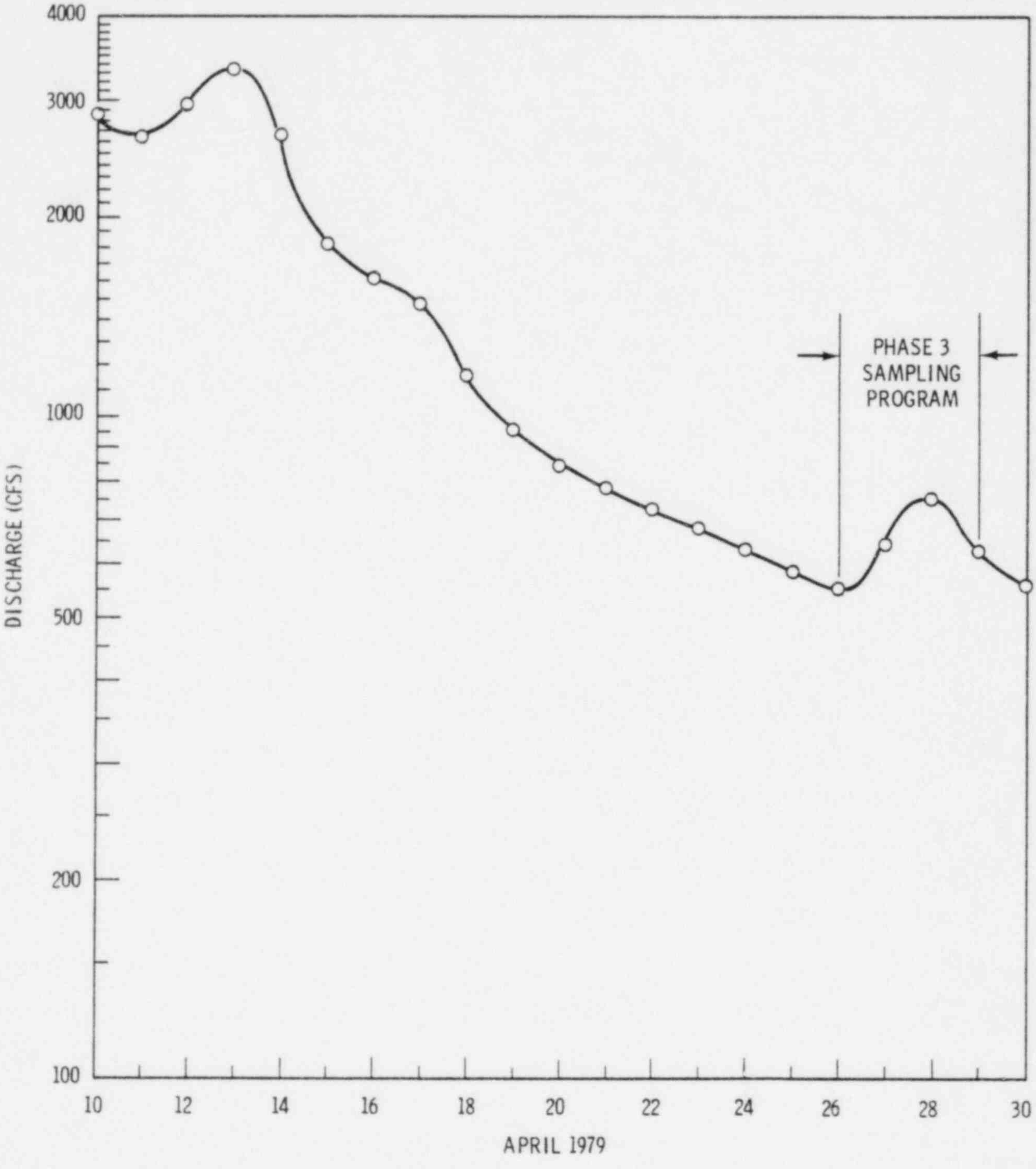

FIGURE 13. Average Daily Discharges Cattaraugus Creek Gowanda Gaging Station April 10-30, 1979

RESULTS OF PHASE 3 SAMPLING

Table 2 is a summary of the radiological samples collected during the Phase 3 sampling program on Cattaraugus and Buttermilk Creeks from April 25 through April 29, 1979. In addition to the radiological analysis of water, bed and suspended sediment samples, certain water quality parameters were measured, and the size distribution of sediment samples was determined. A total of 17 bed sediment samples, and 23 suspended sediment and water samples were collected from Cattaraugus, Buttermilk and Franks Creek, and Lake Erie. Some stations were sampled daily or twice daily (AM, PM) to provide data on the temporal variability of radionuclide concentrations.

WATER QUALITY CHARACTERISTICS

Suspended solids, water temperature, pH, water hardness, dissolved oxygen and total organic carbon were measured at most the radiological sampling stations during the Phase 3 sampling program. Table 3 is a summary of these water quality characteristics. The suspended solids loadings varied substantially during the sampling program. The highest loadings were found in Franks Creek (FC-1) with a suspended solids loading of 366.6 mg/l on the morning of April 27. The suspended solids loadings in Buttermilk Creek were generally higher than in Cattaraugus Creek. In Buttermilk Creek the loadings varied from 12.8 mg/l at Fox Valley Road (BC-1) on April 28 to 114.2 mg/l at Thomas Corners Bridge (BC-4) on April 27. The suspended solids loadings in Cattaraugus Creek varied from 15.8 mg/l at Bigelow Bridge (CC-1) on April 26 to 64.0 mg/l in Springville Reservoir (CC-5) on April 27. The suspended solids loadings at all sampling stations were highest on April 27 due to rain showers occurring during the night of April 26 and early morning of April 27 which increased the discharges of the creeks.

Water temperatures varied from 7°C in Franks Creek (FC-1) in the afternoon of April 27 to 17°C in Springville Reservoir on April 26. There was a marked decrease in water temperature at all measured sampling stations between April 26 and April 27. No trends in pH were evident during the sampling program. The pH varied between 6.0 and 7.9. Water hardness, measured in mg/l as

TABLE 2. Phase 3 Radiological Samples

Sampling Station	Date(s) Sampled	Bed Sediment			Suspended Sediment			Dissolved
		Sand	Silt	Clay	Sand	Silt	Clay	
BC-1 Fox Valley Road	4-26-79	X	X	X	X	X	X	X
	4-27-79				X	X	X	X
	4-28-79				X	X	X	X
EB Erdmans Brook	4-29-79	X	X	X				
FC/EB Confluence Erdmans Brook and Franks Creek	4-29-79	X	X	X				
FC-1 Franks Creek	4-26-79 am				X	X	X	X
	4-26-79 pm				X	X	X	X
	4-27-79 am				X	X	X	X
	4-27-79 pm				X	X	X	X
	4-28-79 am				X	X	X	X
	4-29-79	X	X	X				
	4-29-79	X	X	X				
BC-3 Bond Road Bridge	4-27-79				X	X	X	X
BC-4 Thomas Corners Bridge	4-26-79	X	X	X	X	X	X	X
	4-27-79				X	X	X	X
	4-28-79				X	X	X	X
CC-1 Bigelow Bridge	4-26-79				X	X	X	X
	4-27-79				X	X	X	X
Tributary	4-28-79	X	X	X				
Bigelow Bridge	4-29-79	X	X	X				
CC-3 Felton Bridge	4-27-79	X	X	X	X	X	X	X
CC-5 Springville Reservoir	4-26-79				X	X	X	X
	4-27-79				X	X	X	X
	4-28-79	X	X	X	X	X	X	X
CC-6 Frye Bridge	4-26-79	X	X	X	X	X	X	X
	4-27-79				X	X	X	X
	4-28-79				X	X	X	X
CC-9 Gowanda Bridge	4-29-79	X	X	X	X	X	X	X
CC-11 Mouth Cattaraugus Creek	4-29-79	X	X	X	X	X	X	X
1. Lake Erie								
2. Lake Erie								
3. Lake Erie								
4. Lake Erie								

TABLE 3. Water Quality Characteristics

Sampling Station	Date	S.S. mg/l	Temp °C	pH	Hardness mg/l CaCo3	D.O. mg/l	TOC mg/l
BC-1 Fox Valley Raod	4-26-79	14.7	13	6.2	4.2	9.2	7.0
	4-27-79	49.3	9	7.7	2.7	8.6	7.0
	4-28-79	12.8	9	7.0	8.1	7.4	7.5
FC-1 Franks Creek	4-26-79 am	98.5	16	7.2	3.9	8.6	7.0
	4-26-79 pm	107.9	16	7.2	10.5	10.1	7.5
	4-27-79 am	366.6	9	6.1		12.4	14.0
	4-27-79 pm	274.3	7	6.0	6.8	8.6	13.0
	4-28-79 am	86.9					
BC-3 Bond Road Bridge	4-27-79	111.4	10		8.8	9.8	7.0
BC-4 Thomas Corners Bridge	4-26-79	20.6	16	7.9	10.2	9.2	6.0
	4-27-79	114.2					
	4-28-79	23.8	8	7.4	4.2	10.2	7.0
CC-1 Bigelow Bridge	4-26-79	15.8	14.5	6.7	9.2	13.3	8.0
	4-27-79	52.6	10	7.1	5.4	10.9	
CC-3 Felton Bridge	4-27-79	21.1	11.5	7.3	12.8	9.0	6.0
CC-5 Springville Reservoir	4-26-79	25.3	17	7.2	7.9	10.1	7.0
	4-27-79	64.0		6.2	4.2	7.0	7.5
	4-28-79	27.7		7.6	7.5	10.8	8.0
CC-6 Frye Bridge	4-26-79	20.6	14.75	7.9	2.0	9.9	8.0
	4-27-79	47.2		6.0	6.0	7.1	7.5
	4-28-79	36.2		7.7	9.5	10.8	7.5
CC-9 Gowanda Bridge	4-29-79	20.3					
CC-11 Mouth Cattaraugus Creek	4-29-79	27.2					

$CaCO_3$ varied from 2.0 mg/l to 12.8 mg/l. No trends in water hardness were evident. Dissolved oxygen (D.O.) levels of the water varied from 7.0 mg/l to 13.3 mg/l. In Franks Creek (FC-1) the D.O. varied from 8.6 mg/l to 12.4 mg/l, the highest level being measured in the morning of April 27. Dissolved oxygen levels in Buttermilk Creek varied from 7.4 mg/l at Fox Valley Road (BC-1) on April 28 to 10.2 mg/l at Thomas Corners Bridge on April 28. Dissolved oxygen levels in Cattaraugus Creek varied from 7.0 mg/l in Springville Reservoir on

April 27 to 13.3 mg/l at Bigelow Bridge (BC-1) on April 26. Total organic carbon levels during the Phase 3 sampling program varied from 6.0 mg/l to 8.0 mg/l, except in Franks Creek (FC-1) on April 27 where T.O.C. levels were 14.0 mg/l and 13.0 mg/l.

SEDIMENT CHARACTERISTICS

A summary of the size characteristics of bed and suspended sediment collected during the Phase 3 sampling program is provided in Tables 4 and 5. The sediment has been broken down into three size groups; sand (greater than 0.074 mm), silt (0.004 to 0.074 mm), and clay (less than 0.004 mm).

The bed material in Cattaraugus and Buttermilk Creeks was comprised principally of sand sizes or greater, whereas the suspended load was comprised almost entirely of silt and clay size material for the flow conditions during sampling. The sand size fraction in bed sediment samples was in excess of 90 percent except in the Lake Erie samples, mouth of Cattaraugus Creek, and at Bigelow Bridge tributary (CC-1). The silt size fraction of bed sediment in Cattaraugus, Buttermilk and Franks Creeks was generally less than 10 percent, and the clay size fraction generally accounted for less than one percent. Lake Erie bed samples were comprised principally of the silt size fraction.

The suspended sediment load was comprised principally of the silt size fractions, ranging from 65 percent to greater than 80 percent of the total suspended load. The sand size fraction generally accounted for less than 10 percent of the total suspended load. The clay size fraction ranged from less than 10 percent to greater than 30 percent of the total suspended load.

RADIOLOGICAL ANALYSIS

Results of radiological analysis of bed sediment, suspended sediment and water samples collected during the Phase 3 sampling program are presented in Appendix D. Radionuclide concentrations of bed and suspended sediment samples from Cattaraugus, Buttermilk and Franks Creek are reported as pCi per gram associated with the sand, silt and clay size fractions. The sand fraction of some samples is further separated into radionuclide concentration associated

TABLE 4. Bed Sediment Characteristics

Sampling Station	Date	% Sand	% Silt	% Clay
BC-1 Fox Valley Road	4-26-79	99.1	0.9	0.01
EB Erdmans Brook				
FC/EB Confluence Franks Creek and Erdmans Brook				
FC-1 Franks Creek	4-29-79	89.3	9.9	0.8
FC-1 Franks Creek	4-29-79	96.9	2.8	0.3
BC-4 Thomas Corners Bridge	4-26-79	99.4	0.6	0.04
CC-1 Tributary	4-28-79	58.2	40.7	1.1
CC-1 Bigelow Bridge	4-29-79	99.8	0.2	0.01
CC-3 Felton Bridge	4-27-79	99.8	0.2	0.004
CC-5 Springville Reservoir	4-28-79	99.5	0.5	0.01
CC-6 Frye Bridge	4-26-79	99.8	0.2	0.005
CC-9 Gowanda Bridge	4-29-79	94.9	5.0	0.1
CC-11 Mouth Cattaraugus Creek	4-29-79	60.5	38.9	0.6
STA 1 Lake Erie (Top 2 in.)	4-25-81	3.8	94.4	1.8
STA 2 Lake Erie (Top 2 in.)	4-25-81	9.0	89.5	1.5
STA 3 Lake Erie (Top 2 in.)	4-25-81			
STA 4 Lake Erie (Top 2 in.)	4-25-81	83.7	16.7	0.2

with the coarse, medium and fine sand. Composite radionuclide concentrations have been computed based on the sample weight distribution of the sand, silt and clay size fractions.

The sample weights for radiological analysis of sand in suspended sediment samples and clay in the bed sediment samples are in many cases comprised of less than one gram of sample. These small weights are due to the clay fraction

TABLE 5. Suspended Sediment Characteristics

Sampling Station	Date	% Sand	% Silt	% Clay	Total Sus. Sed. Load mg/l
BC-1 Fox Valley Road	4-26-79	1.7	87.6	10.7	14.7
	4-27-79	4.8	83.4	11.8	49.3
	4-28-79	3.5	71.1	25.4	12.8
FC-1 Franks Creek	4-26-79 am	0.7	72.8	26.5	98.5
	4-26-79 pm	5.3	71.7	23.0	107.9
	4-27-79 am	0.6	70.4	29.0	366.6
	4-27-79 pm	1.4	68.7	29.9	274.3
	4-28-79 am	0.6	64.7	37.7	86.9
BC-3 Bond Road Bridge	4-27-79	4.0	80.0	16.0	111.4
BC-4 Thomas Corners Bridge	4-26-79				20.6
	4-27-79	0.9	78.9	20.2	114.2
	4-28-79	1.1	76.8	22.1	23.8
CC-1 Bigelow Bridge	4-26-79	3.4	91.5	5.1	15.8
	4-27-79	1.4	78.6	20.0	52.6
CC-3 Felton Bridge	4-27-79	5.0	77.3	17.7	21.1
CC-5 Springville Reservoir	4-26-79	1.4	79.0	19.6	25.3
	4-27-79	3.1	82.1	14.8	64.0
	4-28-79	7.9	81.9	10.2	27.7
CC-6 Frye Bridge	4-26-79	0.9	76.5	22.6	20.6
	4-27-79	6.0	83.4	10.6	47.2
	4-28-79	6.7	77.0	16.3	36.2
CC-9 Gowanda Bridge	4-29-79	11.1	74.5	14.4	20.3
CC-11 Mouth Cattaraugus Creek	4-29-79	19.6	70.7	9.7	27.2

being a very small percentage of the total bed material and the sand fraction being a very small percentage of the total suspended load. Radiological analysis of these small sample weights could lead to counting errors not accounted for in the computed standard deviations. Therefore, care should be taken in interpreting the concentrations in Appendix D where the sample weights of the clay fraction in bed sediment and sand fraction in the suspended sediment are less than one gram.

The Lake Erie core samples were not separated into size fractions. Instead, the cores were divided into three depth intervals -- 0 to 2 inches, 2 to 4 inches and 4 to 6 inches-- and the composite (sand, silt and clay size fractions) analyzed.

Radionuclide concentrations of the water samples are reported as pico Curies (pCi) per total sample associated with the fine particulate ($<0.3\mu$), aluminum oxide and resin beds. The dissolved and fine particulate concentrations have been computed, based on the volume of water filtered, and are reported as pCi per liter. No attempt was made to determine dissolved radionuclide concentrations using the LVWS efficiency method as described in Appendix A. Most of the laboratory analysis results for the aluminum oxide and resin beds indicated activity levels below detection. Where activity levels were detected, the results were too inconsistent for use in efficiency calculations. Therefore, the detectable levels were summed over the series of filters and beds for each radionuclide and should be considered as minimum total values present in the water.

Stations BC-1 and CC-1 are upstream control stations on Buttermilk and Cattaraugus Creeks. Because these stations are upstream of the influence of the Nuclear Fuel Services, Inc. (NFS) complex at West Valley, New York, the radioactivity associated with the surface waters at these stations can be considered to be background.

Gamma Ray Spectrometry

Gamma ray spectrometry analyses were performed on bed sediment, suspended sediment and water samples collected during the Phase 3 sampling program. The principal gamma emitters detected were K-40, Cs-137, Ra-226, Th-228, and U-238. The concentrations of the gamma-emitting radionuclides detected in the bed sediment, suspended sediment, and the waters at each sampling station are listed in Tables D.1, D.2 and D.3, respectively. Because the suspended sediment samples were collected for more than one day at most stations and the separation of each sample into sand, silt, and clay, only the results for one day per station was plotted. The suspended sediment results from Table D.2 not plotted are footnoted in the table for each station.

Potassium-40

K-40 concentrations associated with the sand, silt and clay size fractions of bed and suspended sediment, and associated with water are shown on Figures 14, 15 and 16, respectively. The highest levels were generally found in the suspended sediment and in most cases were associated with the clay size fractions. Background concentrations ranged from 27.16 ± 1.94 pCi/gm in the bed sediment to 42.88 ± 6.30 pCi/gm in suspended sediment. Distribution of K-40 in bed and suspended sediment in Cattaraugus and Buttermilk Creeks was fairly uniform and the concentrations in most bed and suspended sediment samples were near to or below the concentrations at the two upstream control stations. Slightly elevated K-40 concentrations were found in the bed clay fractions at Erdmans Brook (EB) and at the confluence of Erdmans Brook and Franks Creek (FC/EB) with concentrations of 36.2 ± 4.7 pCi/gm and 33.7 ± 11.6 pCi/gm, respectively.

K-40 concentrations dissolved in water varied from slightly less than 1 pCi/l to greater than 17 pCi/l. The highest background level was 5.50 pCi/l at CC-1 on April 26. Only two other water samples exceeded this background level; one sample at FC-1 in the afternoon of April 26 with a K-40 concentration of 17.27 pCi/l, and the other at CC-5 (Springville Reservoir) on April 26 with a concentration of 8.40 pCi/l.

Cesium-137

Figures 17, 18, and 19 show the distribution of Cs-137 associated with bed sediment, suspended sediment and water. Cs-137 concentrations in bed sediment were highest in Buttermilk Creek, Franks Creek (including Erdmans Brook) and Springville Reservoir on Cattaraugus Creek. The highest Cs-137 levels in bed sediment were found in Franks Creek (FC-1) with some concentrations exceeding 50 pCi/gm. The Cs-137 concentration of one bed clay sample at FC-1 was 244.8 ± 1.07 pCi/gm. The clay sizes of bed and suspended sediment samples generally had higher Cs-137 concentrations than the silt and sand. The highest bed sediment background concentration was 22.74 ± 3.26 pCi/gm, and was found in the clay of CC-1. The highest suspended sediment background Cs-137 concentration was also found at CC-1 with a concentration of 0.981 ± 0.036 pCi/gm.

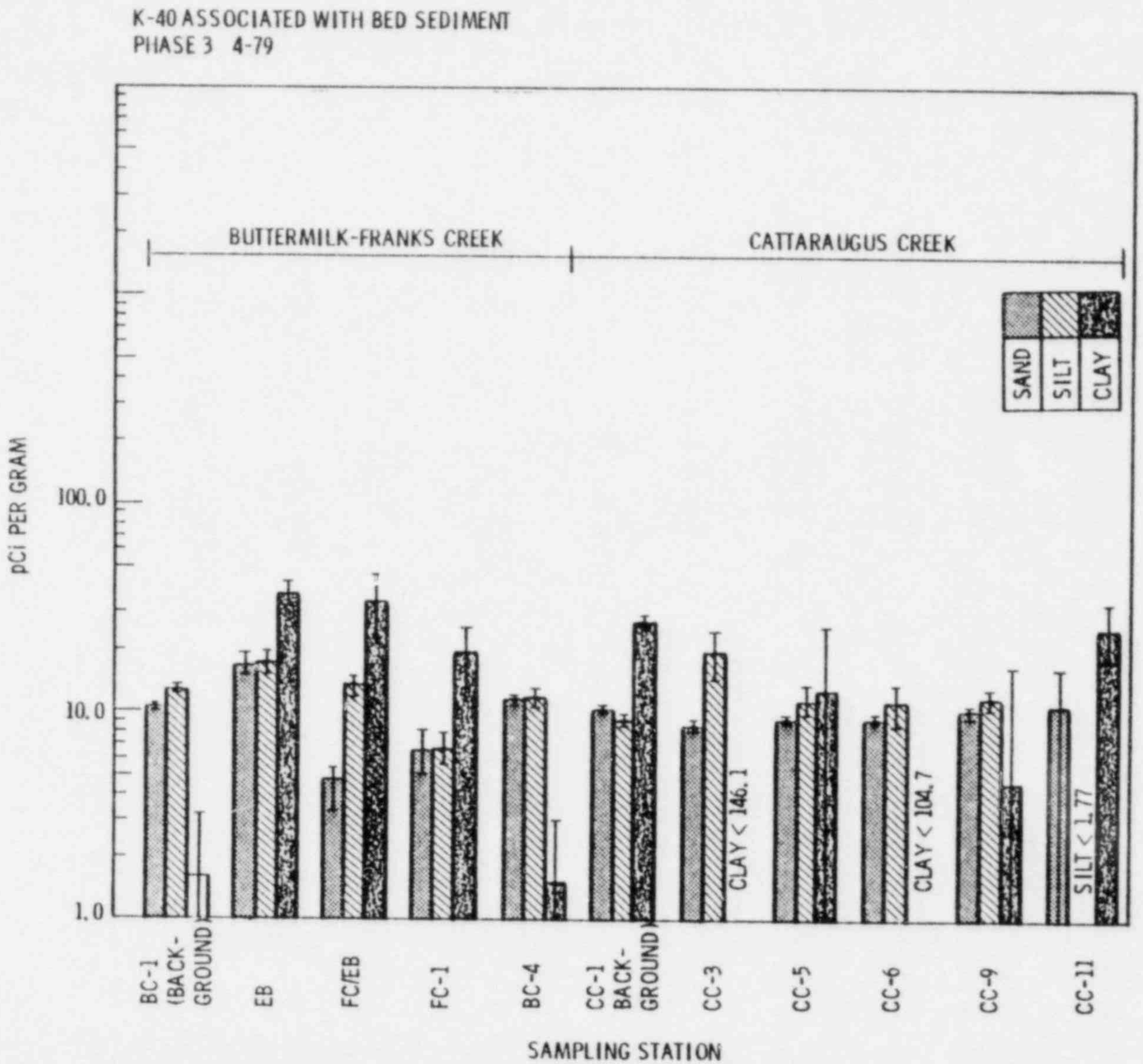

FIGURE 14. Potassium-40 in Bed Sediment

K-40 ASSOCIATED WITH SUSPENDED SEDIMENT
PHASE 3 4-79

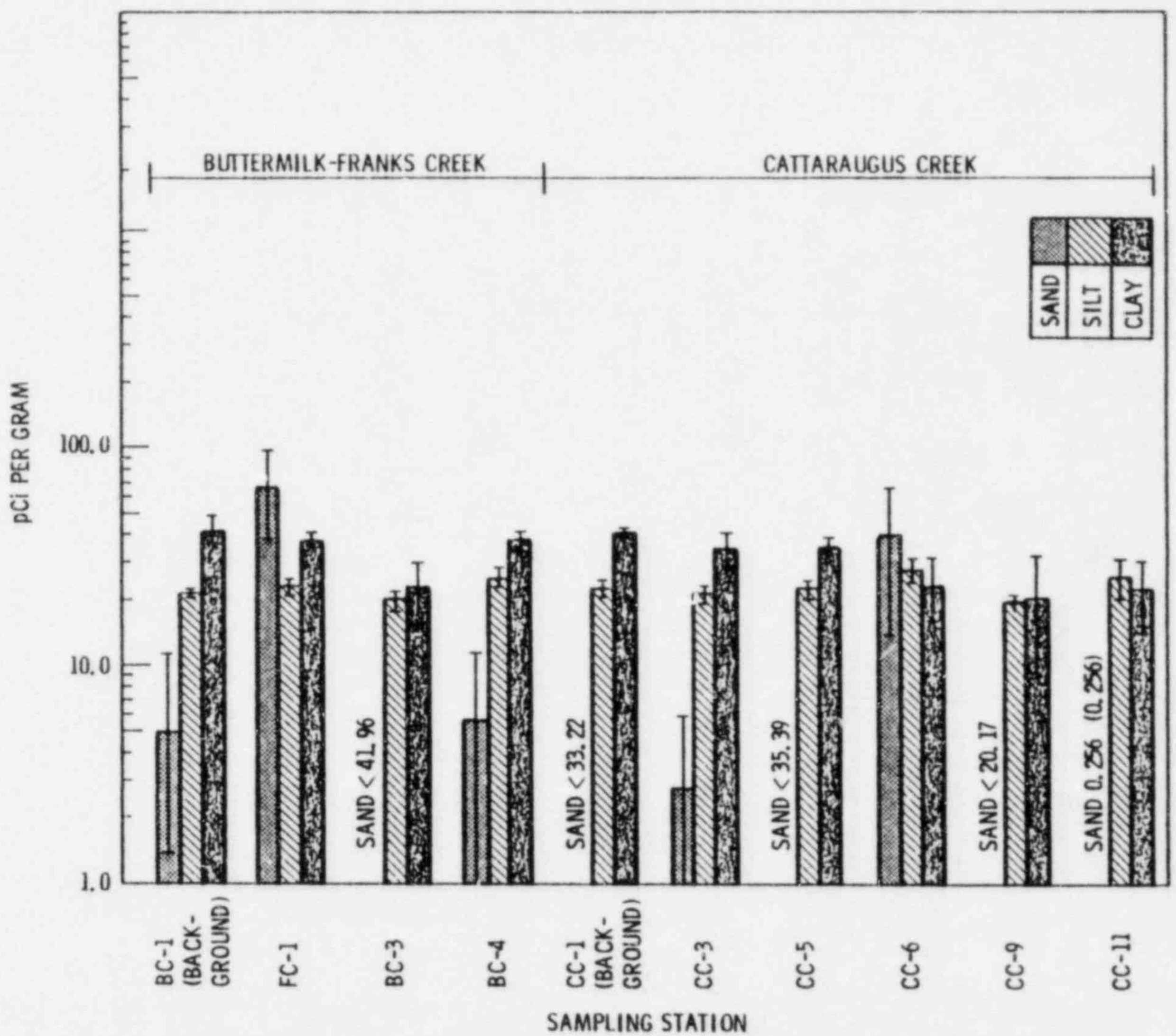

FIGURE 15. Potassium-40 in Suspended Sediment

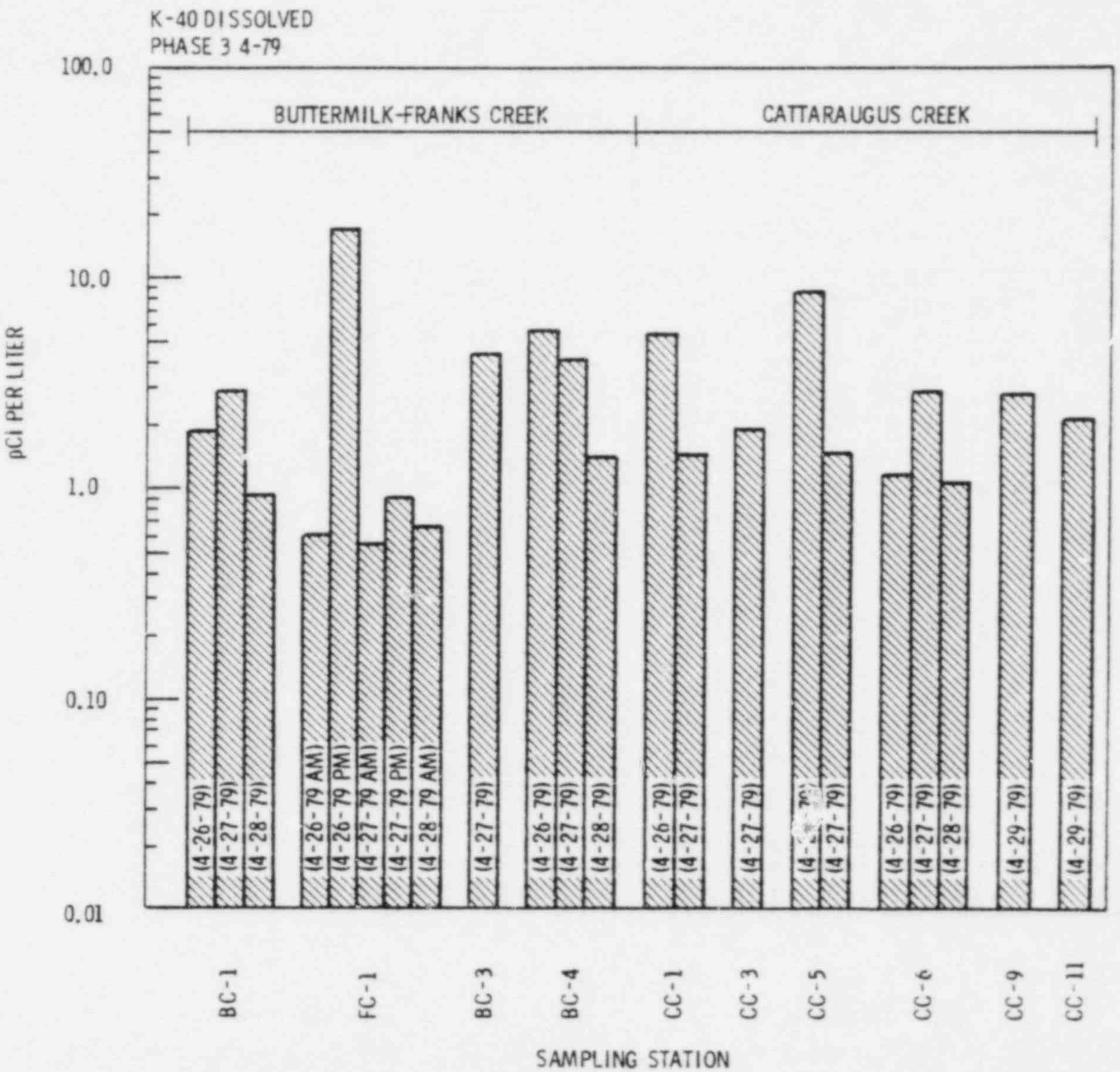

FIGURE 16. Potassium-40 in Water

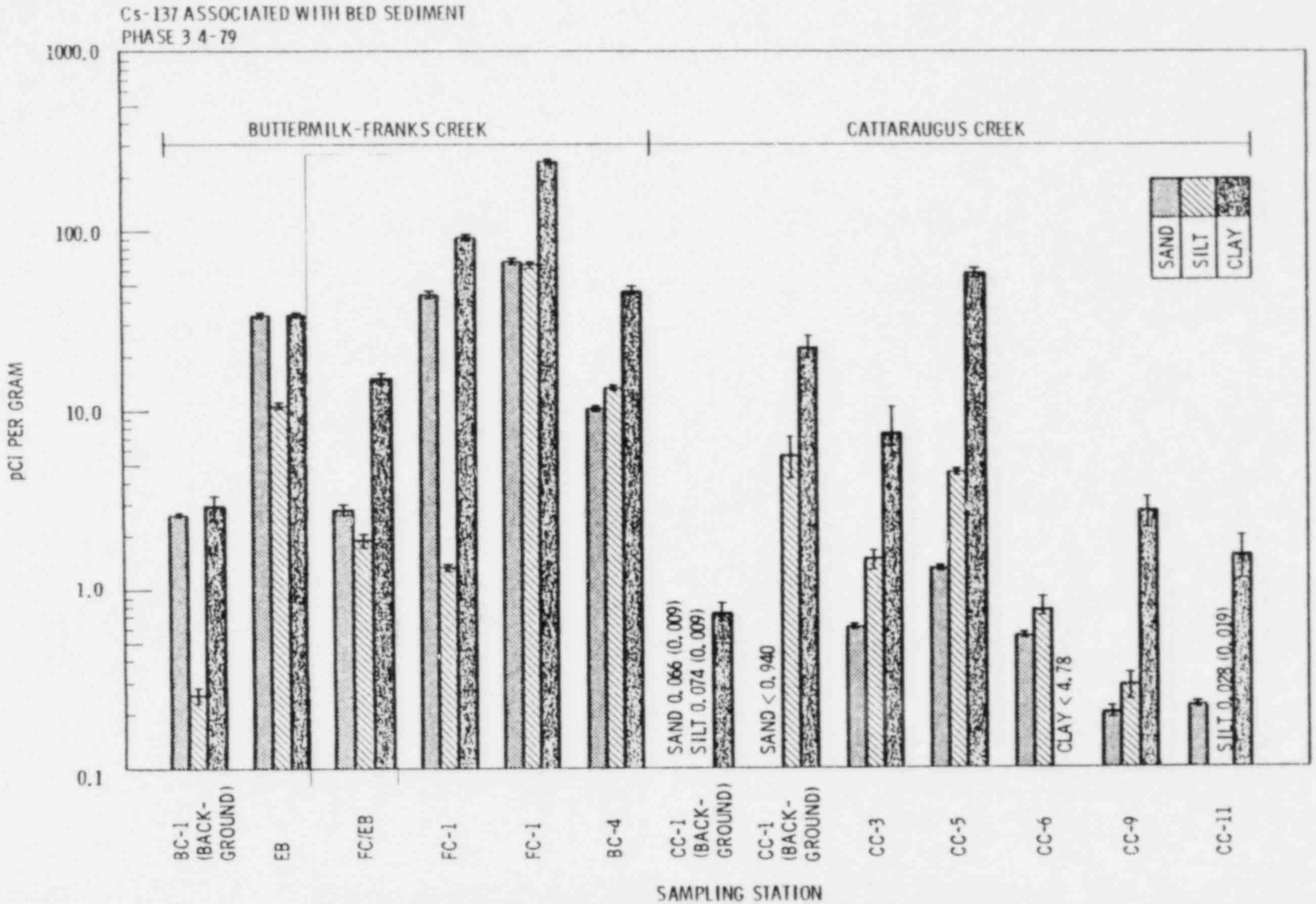

FIGURE 17. Cesium-137 in Bed Sediment

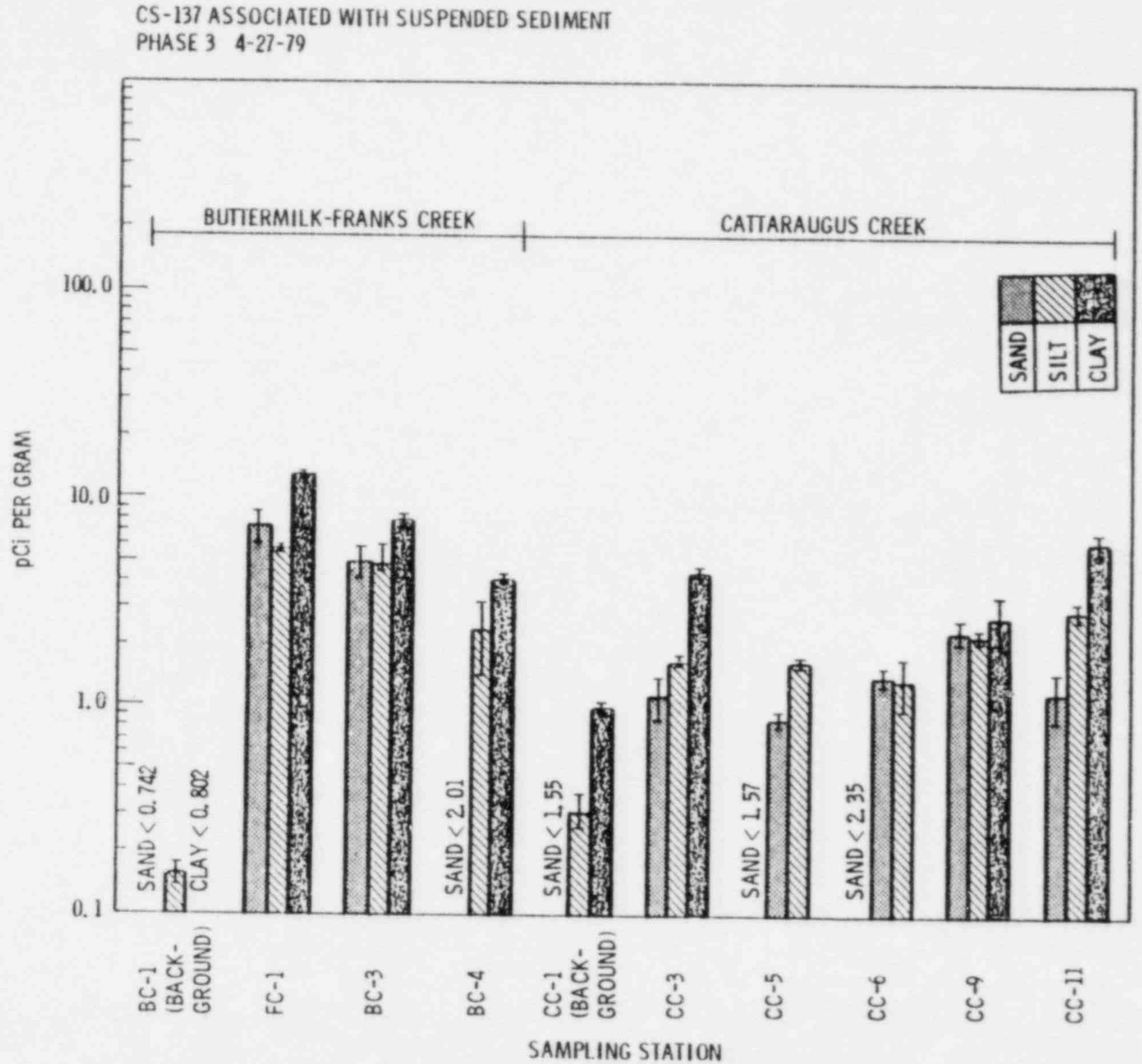

FIGURE 18. Cesium-137 in Suspended Sediment

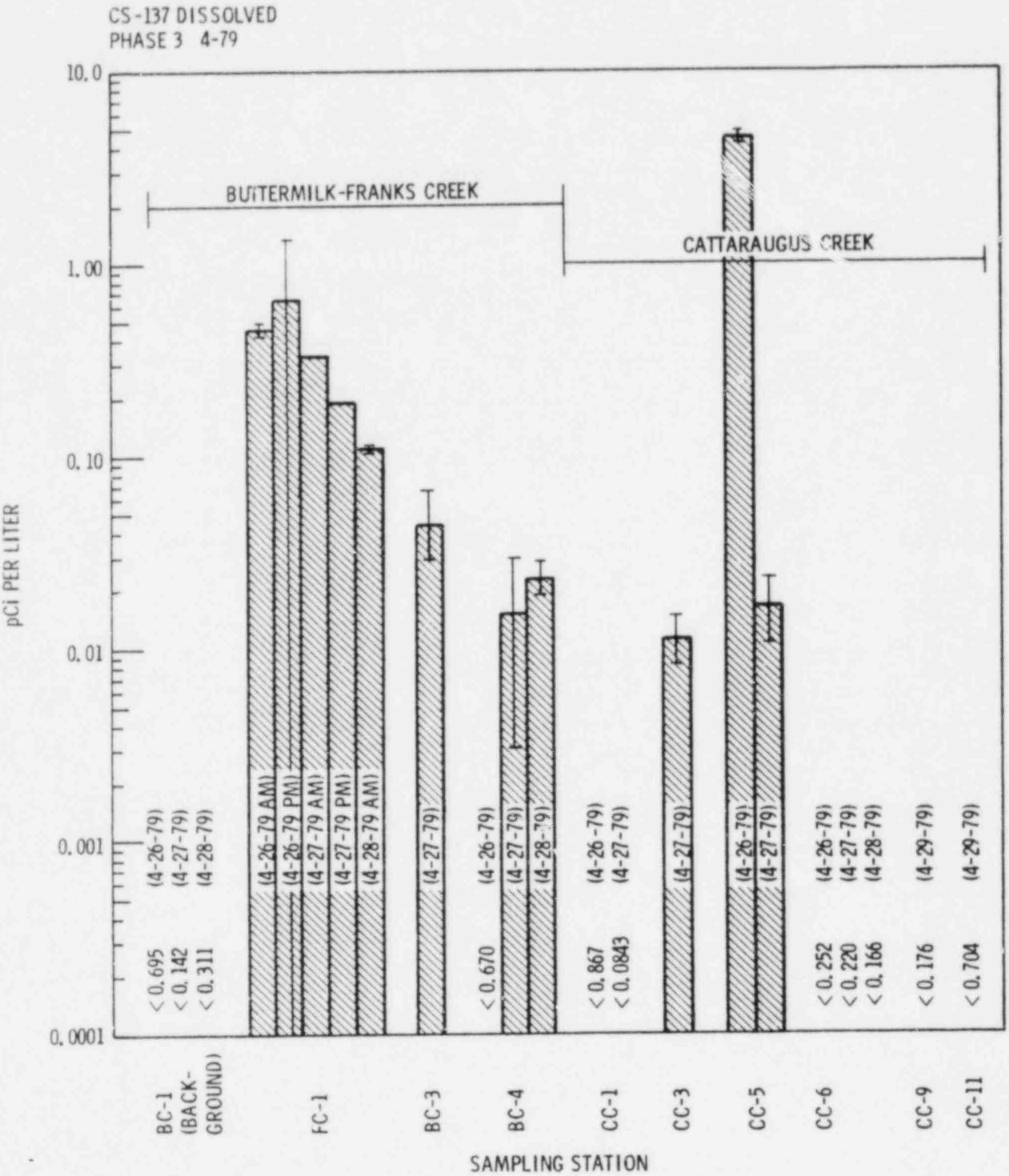

FIGURE 19. Cesium-137 in Water

Cs-137 concentrations in suspended sediment of Cattaraugus, Buttermilk and Franks Creek were fairly uniform varying from about 1 pCi/gm to about 25 pCi/gm (4-26-79). The highest levels were found in Franks Creek (FC-1), closely followed by Buttermilk Creek and then Cattauragus Creek. The lowest nonbackground Cs-137 concentrations in suspended sediment were found in Springville Reservoir (CC-5) and at Frye Bridge (CC-6) on Cattaraugus Creek.

Cs-137 concentrations in water were below detection limits at the upstream control stations on Cattaraugus and Buttermilk Creeks. The highest levels in water were found in Franks Creek (FC-1) where concentrations varied from 0.11 (0.0072) to 0.64 (0.64) pCi/l. One water sample in Springville Reservoir on April 26 had a Cs-137 concentration of 4.50 pCi/l.

Radium-226

Radium-226 concentrations in bed sediment, suspended sediment and water are shown in Figures 20, 21, and 22. The highest concentrations in bed sediment were found in the clay size fractions of the upstream control stations on Cattaraugus and Buttermilk Creeks with concentrations of 2.36 $\pm$ 0.17 pCi/gm and 9.97 $\pm$ 8.56 pCi/gm, respectively. The highest Ra-226 background level in suspended sediment was found at CC-1 with a concentration of 1.04 $\pm$ 0.07 pCi/gm. Radium-226 was found consistently in the suspended silt and clay in Franks and Buttermilk Creeks. Detectable levels became less consistent at the downstream stations on Cattaraugus Creek. Radium-226 was not detected in the suspended sand samples except in Springville Reservoir (CC-5) where an activity level of 3.05 $\pm$ 1.6 pCi/g was detected on April 28.

The highest Ra-226 level in water was found at the upstream control station on Cattaraugus Creek (CC-1) with a concentration of 0.381 pCi/l. All other water samples had Ra-226 levels near to or below the background concentrations.

Thorium-228

Figures 23, 24, and 25 show the Th-228 concentrations associated with bed sediment, suspended sediment and water. Th-228 levels in bed and suspended sediment are fairly uniform in Cattaraugus, Buttermilk and Franks Creek. The

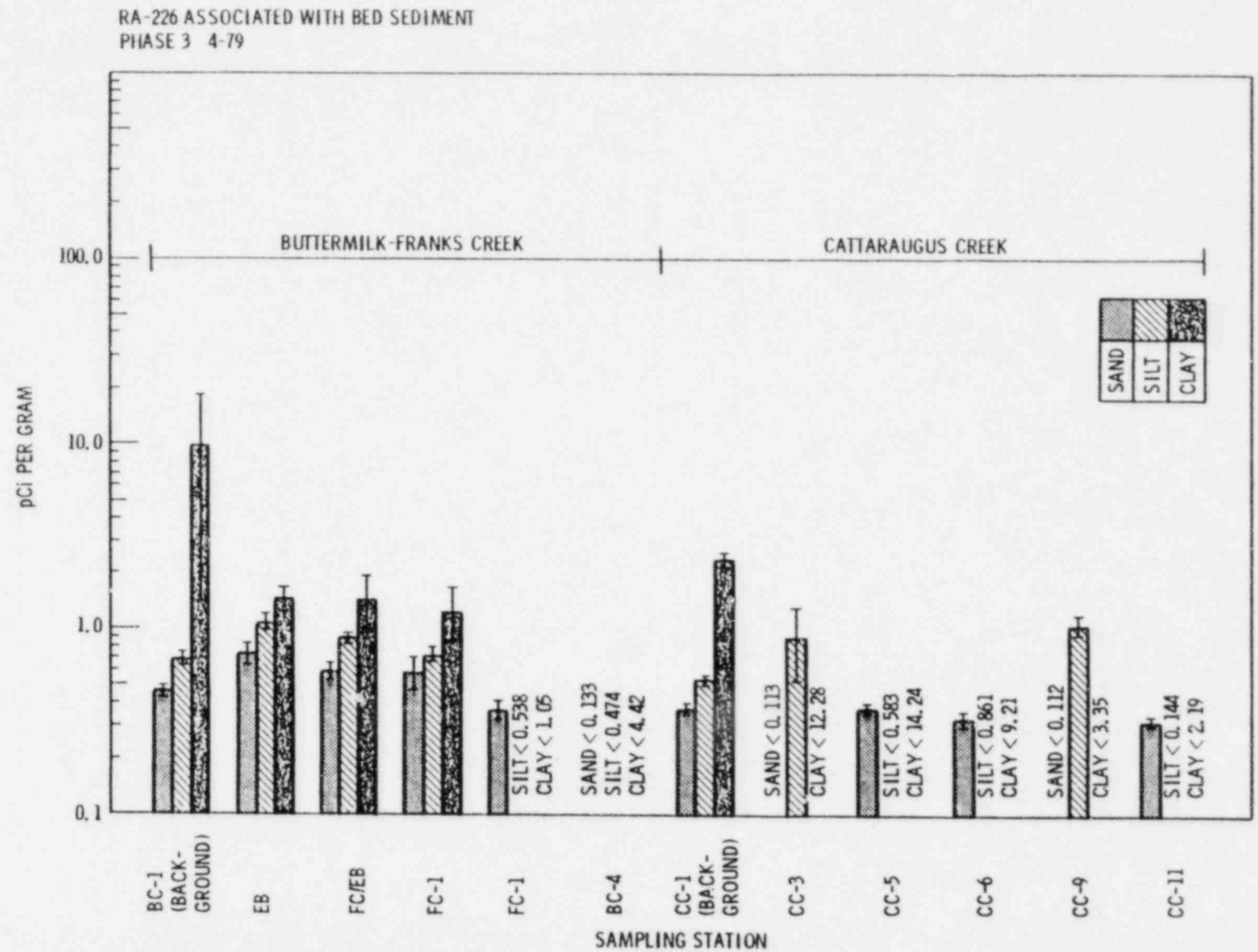

FIGURE 20. Radium-226 in Bed Sediment

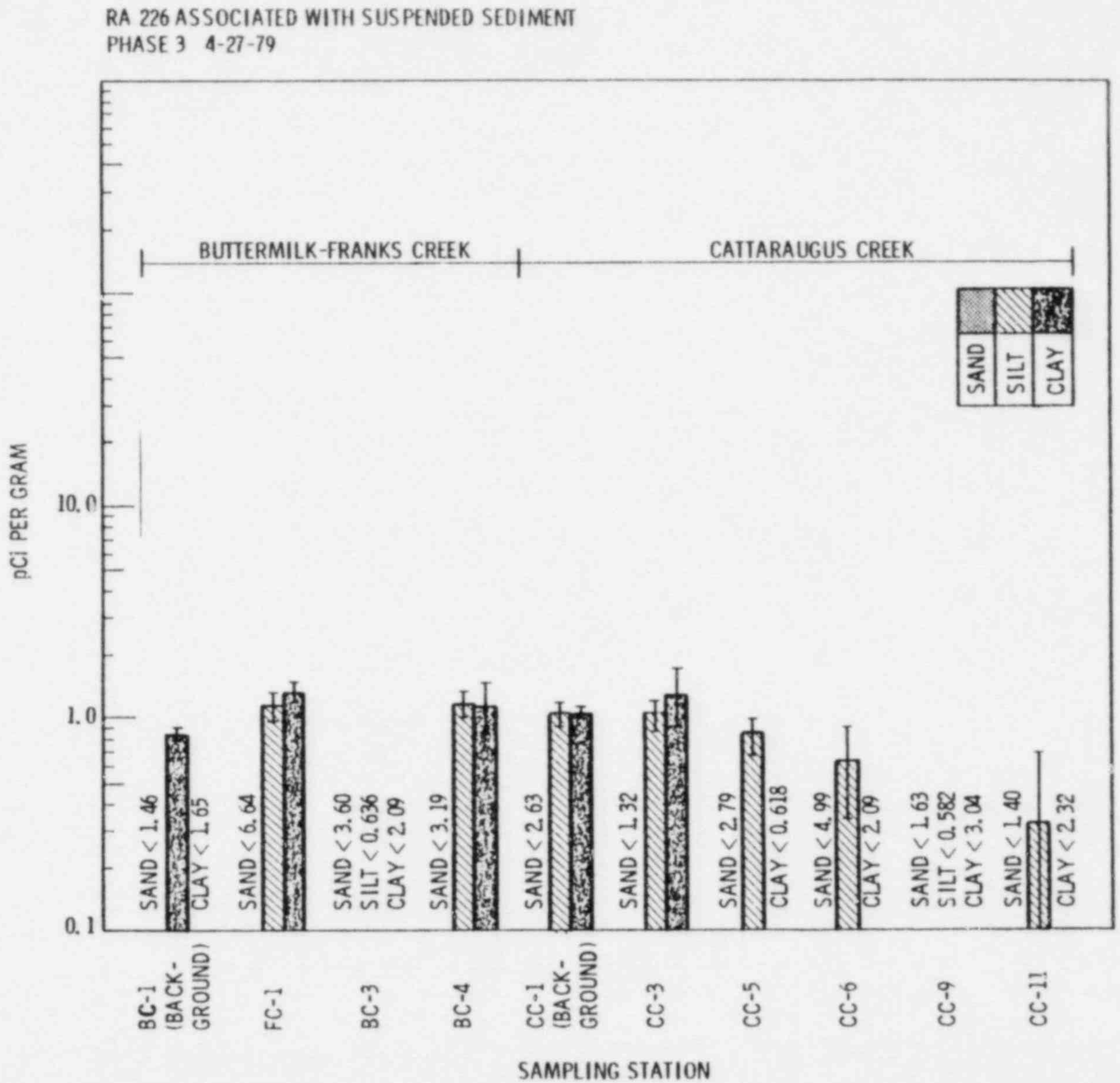

FIGURE 21. Radium-226 in Suspended Sediment

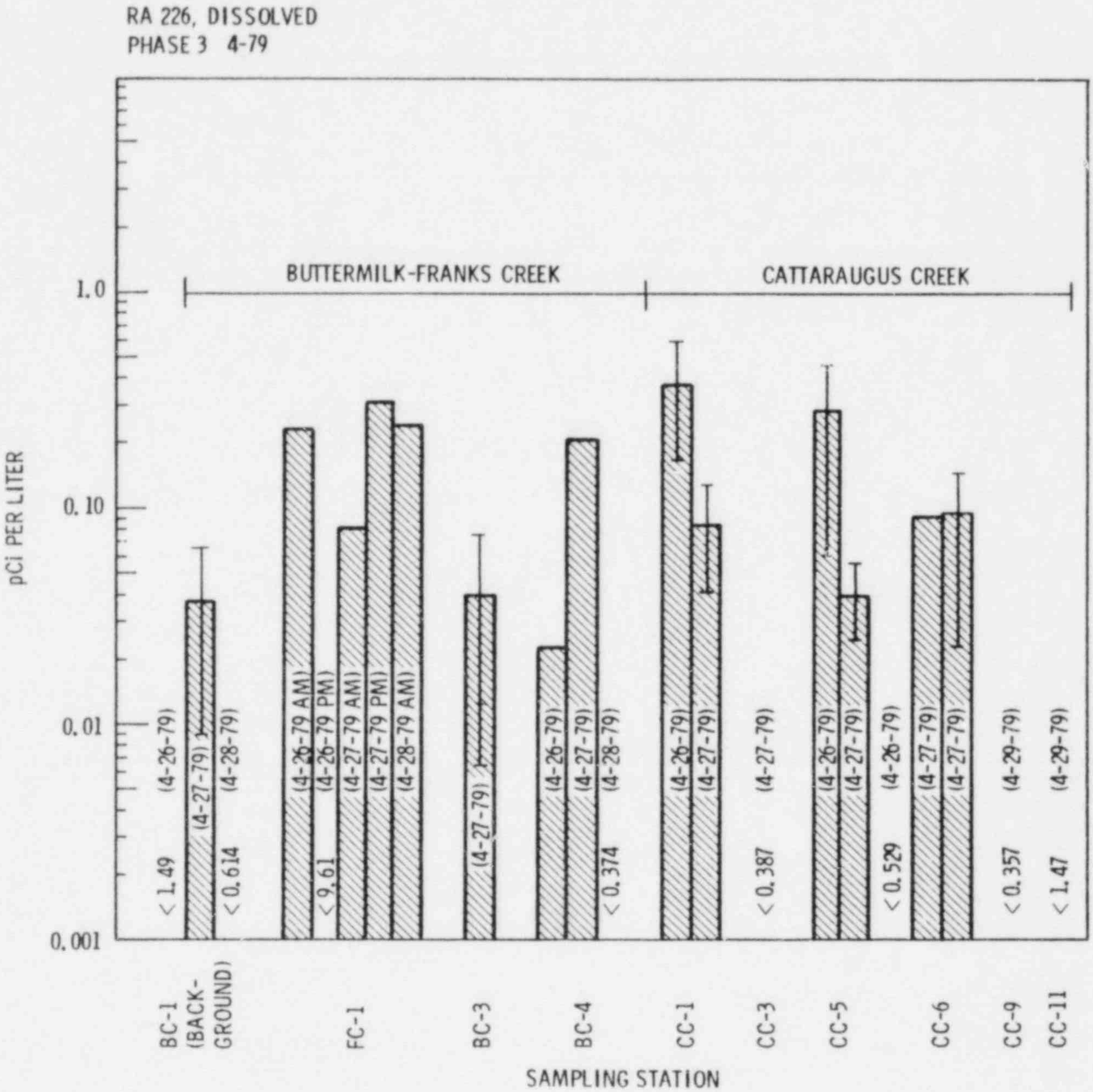

FIGURE 22. Radium-226 in Water

bed and suspended sediment samples at the upstream control stations on Cattaraugus and Buttermilk Creeks had the highest Th-228 concentrations. The clay size fractions generally had higher concentrations of Th-228. The background concentration in bed sediment (clay size fraction) at CC-1 was 3.37 $\pm$ 0.184 pCi/gm. This level was found in the clay size bed sediment of the

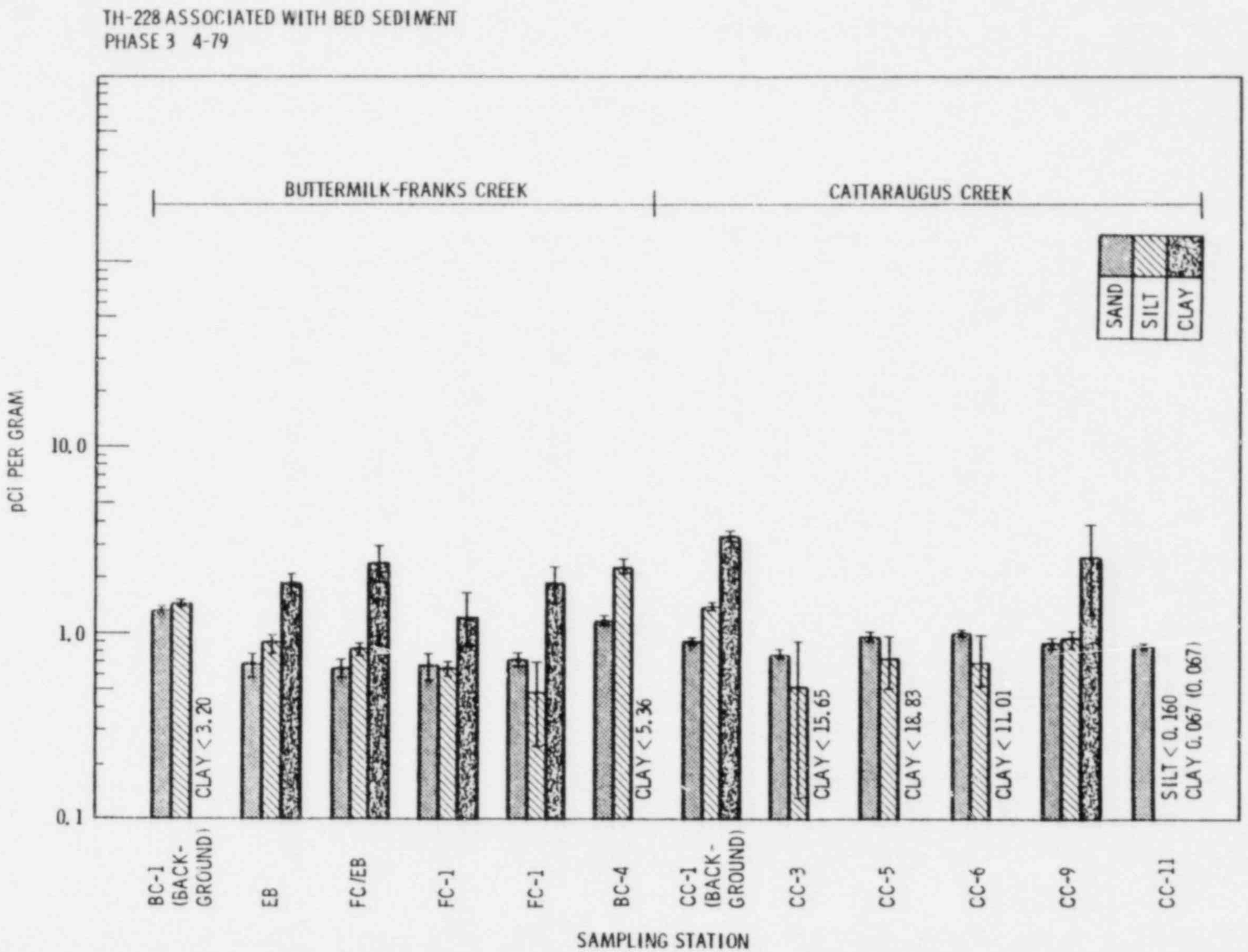

FIGURE 23. Thorium-228 in Bed Sediment

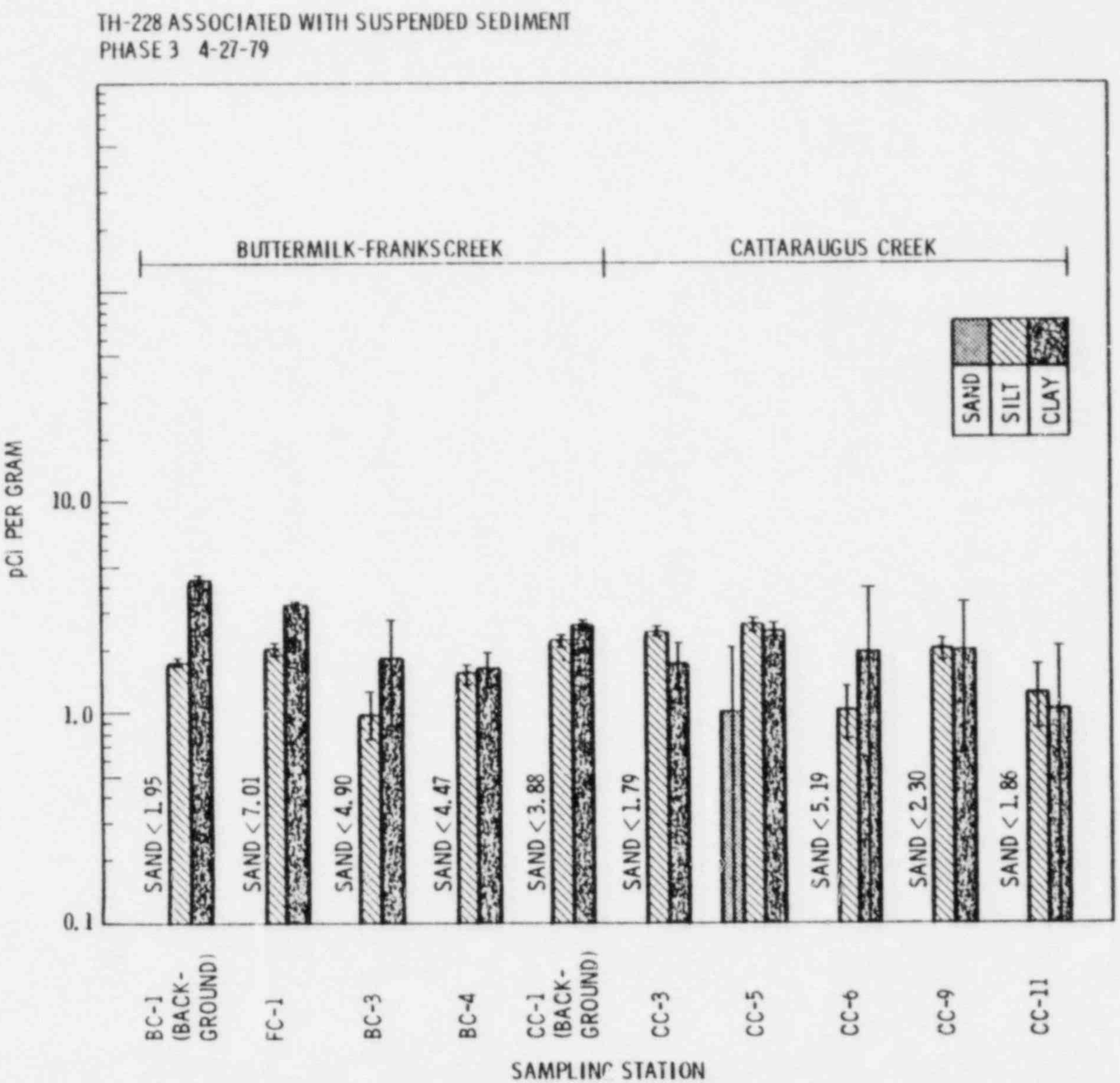

FIGURE 24. Thorium-228 in Suspended Sediment

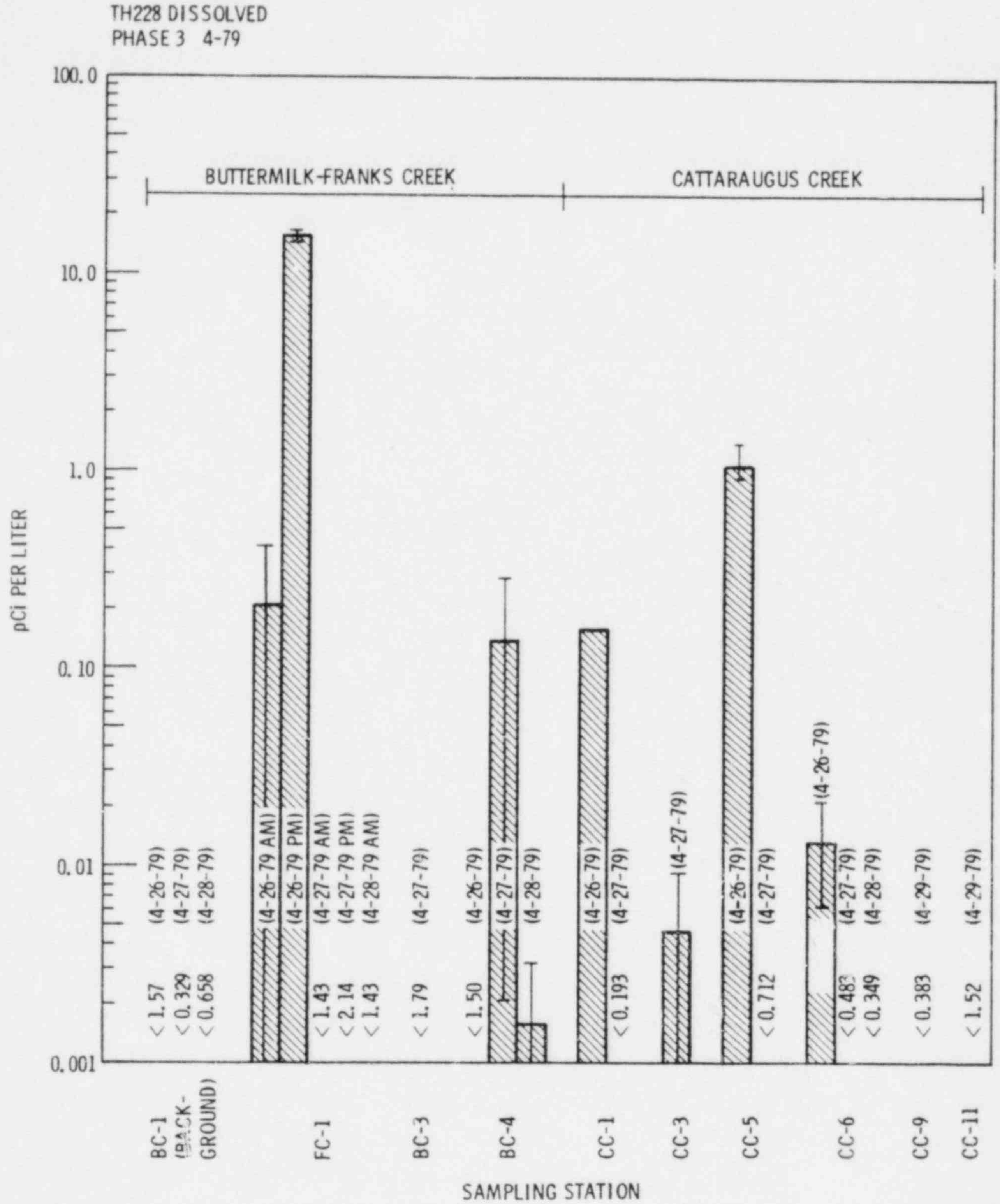

FIGURE 25. Thorium-228 in Water

small tributary about 1500 ft upstream of the CC-1 sampling station. Bed sediment activity levels downstream at CC-1 were below detection.

The background Th-228 level in water at CC-1 on April 26 was 0.154 pCi/l. Water samples from Franks Creek (FC-1) and Springville Reservoir (CC-5) exceeded the background concentration on April 26. The Th-228 concentration in water at FC-1 in the afternoon of April 26 was 15.71 pCi/l and at CC-5 the concentration was 1.06 pCi/l.

Uranium-238

Uranium-238 concentrations associated with bed and suspended sediment are shown on Figures 26 and 27. U-238 was not detected in any water samples during the Phase 3 sampling program. Uranium-238 was detected more frequently in the suspended sediment samples from Franks and Buttermilk Creeks. The radionuclide was found in sand, silt and clay with no apparent affinity for any one class of sediment. The maximum activity level of 33.56 $\pm$ 21.62 pCi/g associated with suspended sediment was found at CC-1 on April 26. It was detected much less frequently in the suspended sediment at the downstream stations on Cattaraugus Creek (CC-3 through CC-1').

The highest levels of U-238 in bed sediment were detected in the clay samples of CC-3 (36.72 $\pm$ 26.89 pCi/g) and CC-5 (35.23 $\pm$ 25.03 pCi/g). The isotope was detected intermittently in the sand, silt and clay at the stations upstream of Springville Reservoir. Levels at the stations downstream of the reservoir were mostly below detection.

Other Gamma Emitters

Detectable levels of Co-60 and Cs-134 were found in bed and suspended sediment of Franks Creek but were undetected in Cattaraugus and Buttermilk Creeks. Co-60 concentrations as high as 3.22 $\pm$ 0.26 pCi/gm were found in the bed clay size fraction in Franks Creek (FC-1). Co-60 was also found in some suspended sediment samples from Franks Creek. The highest concentration was found in the suspended clay fraction of FC-1 on the afternoon of April 27 with a concentration of 0.302 $\pm$ 0.071 pCi/gm. Cs-134 was also detectable in these same bed and suspended sediment samples from Franks Creek. The highest Cs-134 concentrations in bed and suspended sediment were 3.21 $\pm$ 0.27 pCi/gm and 0.458 $\pm$ 0.102 pCi/gm, respectively.

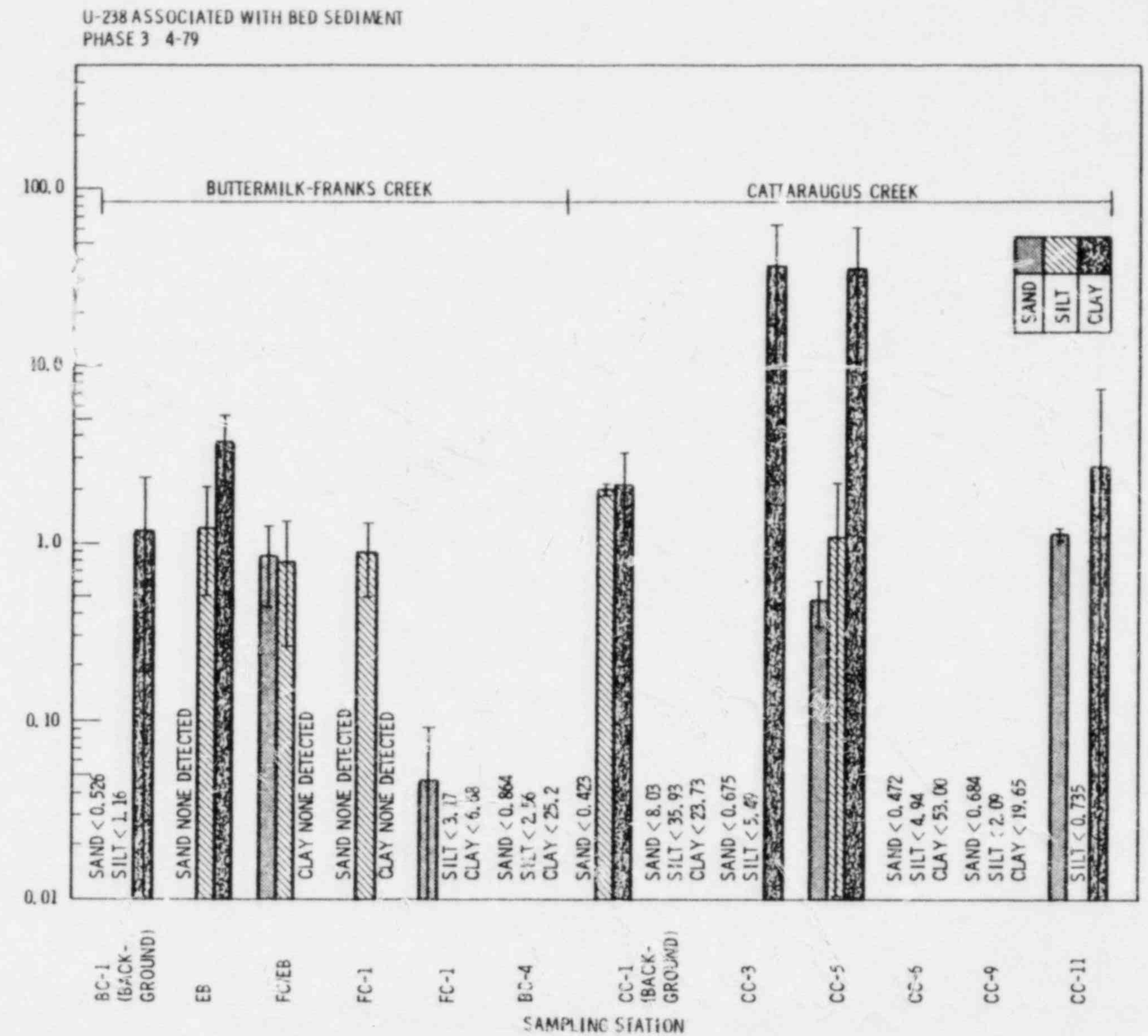

FIGURE 26. Uranium-238 in Bed Sediment

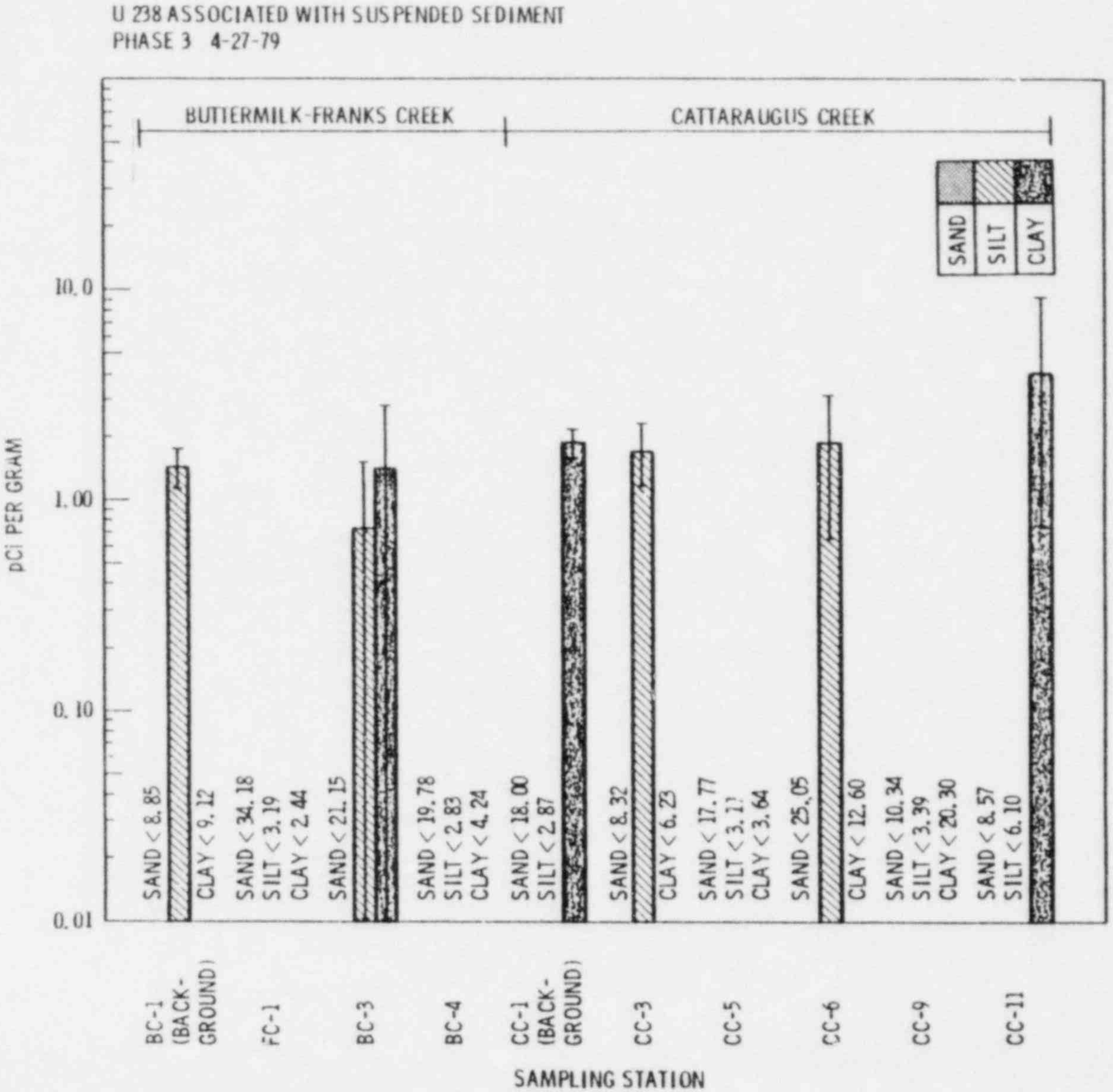

FIGURE 27. Uranium-238 in Suspended Sediment

Alpha/Beta Emitters

Radiochemical analyses were performed on the bed and suspended sediment and water samples to determine the activity levels of Sr-90, Pu-238, Pu-239,240, Am-241 and Cm-244. The results of the analyses of the bed sediment, suspended sediment and the waters of the Buttermilk-Cattaraugus Creek system are presented in Tables D.4, D.5 and D.6, respectively. Water samples from Franks, Buttermilk and Cattaraugus Creeks were analyzed for tritium. Selected dried sediment samples from stations CC-1 and FC-1 were analyzed for both tritium and C-14. The suspended sediment results from Table D.5 not plotted are footnoted in the table for each station.

Strontium-90

Sr-90 concentrations in bed sediment, suspended sediment and water are shown on Figures 28, 29, and 30. Background Sr-90 levels in bed sediment were below 1.0 pCi/gm except in one sample from CC-1 where the measured concentration in the bed clay fraction was 9.70 ± 6.21 pCi/gm. The weight of this sample, however, was only 0.12 gm and is probably not representative of the Sr-90 background levels. The highest background Sr-90 concentration in suspended sediment was found in the sand fraction of BC-1 with a concentration of 1.47 ± 0.688 pCi/gm collected on April 28.

The highest Sr-90 levels in bed sediment, with concentrations exceeding 1.0 pCi/gm were found in Erdmans Brook (EB), Franks Creek (FC-1 and FC/EB) and at Thomas Corners Bridge on Buttermilk Creek (BC-4). The bed clay fraction at FC-1 had a Sr-90 concentration of 7.44 ± 0.45 pCi/gm. In suspended sediment Sr-90 levels exceeded 1.0 pCi/gm in Franks Creek and Buttermilk Creek and at CC-6, CC-9, and CC-11 on Cattaraugus Creek.

Background Sr-90 levels in water varied from 0.144 pCi/l at CC-1 to 0.278 pCi/l at BC-1. All water samples on Franks Creek and Buttermilk Creek exceeded these background levels. The highest dissolved Sr-90 levels were found in Franks Creek where all samples exceeded 10 pCi/l and the highest concentration was 19.5 pCi/l. Sr-90 levels in water of Cattaraugus Creek varied between 2.0 and 5.0 pCi/l except at CC-3 where the Sr-90 concentration was less than 0.10 pCi/l.

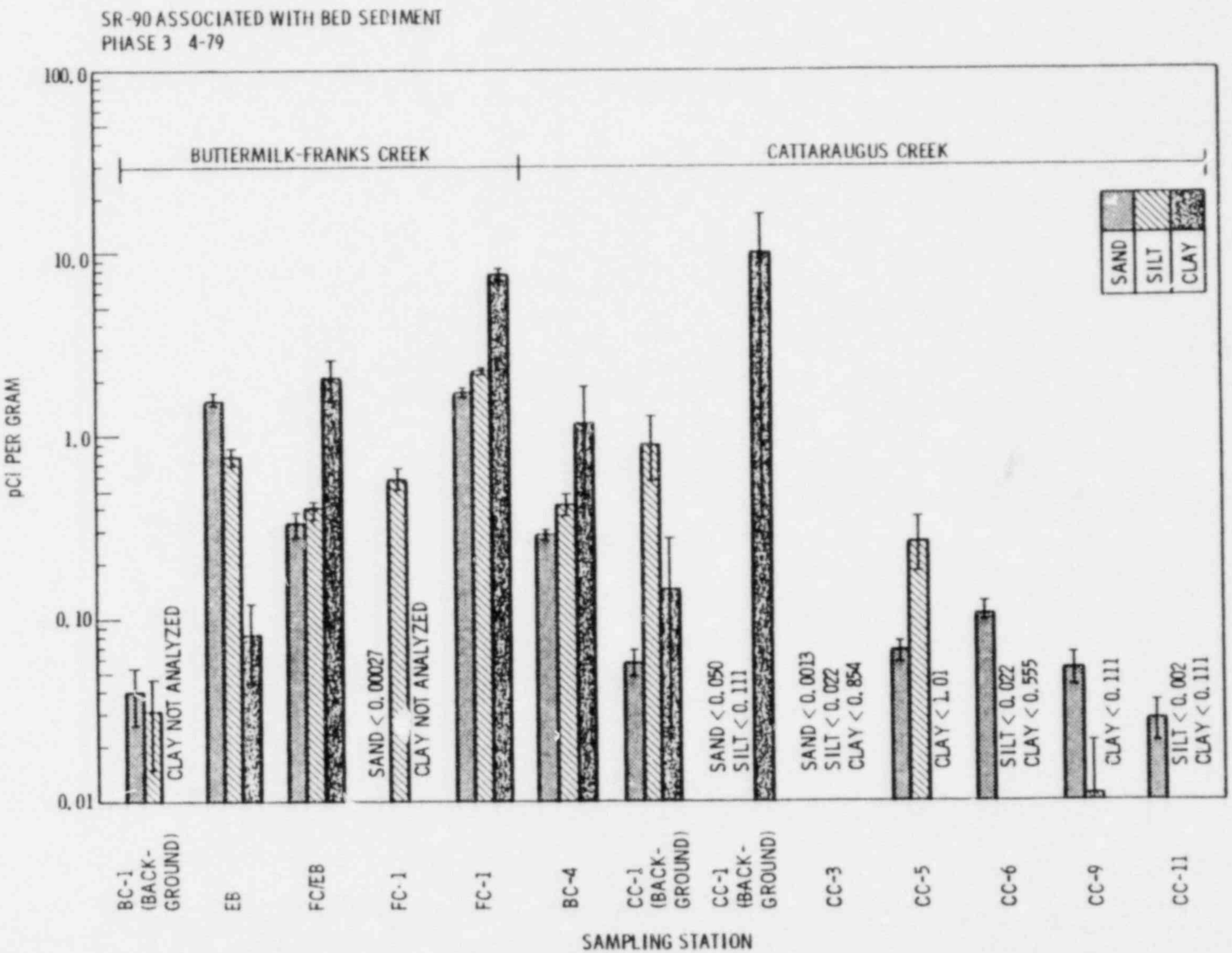

FIGURE 28. Strontium-90 in Bed Sediment

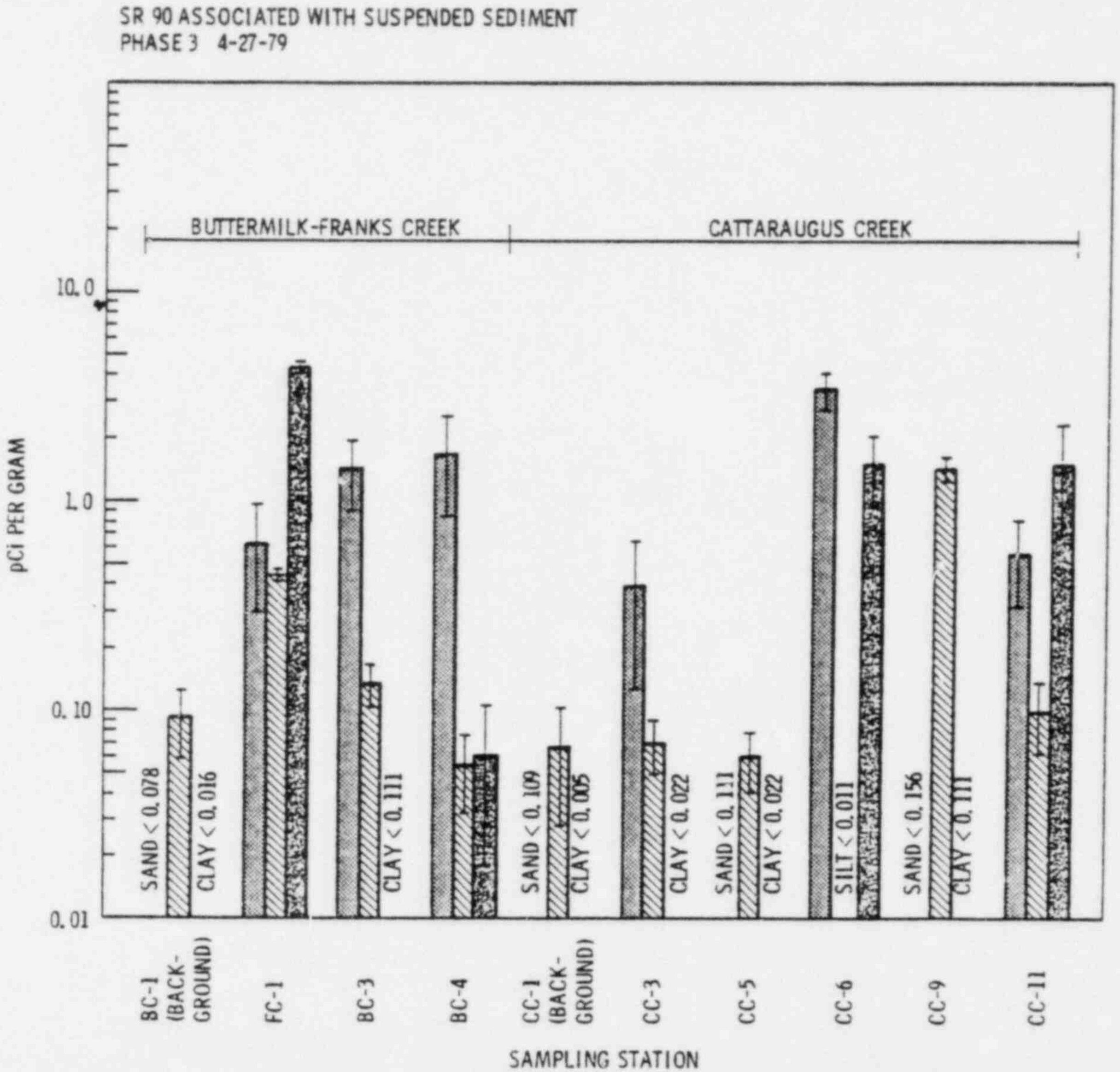

FIGURE 29. Strontium-90 in Suspended Sediment

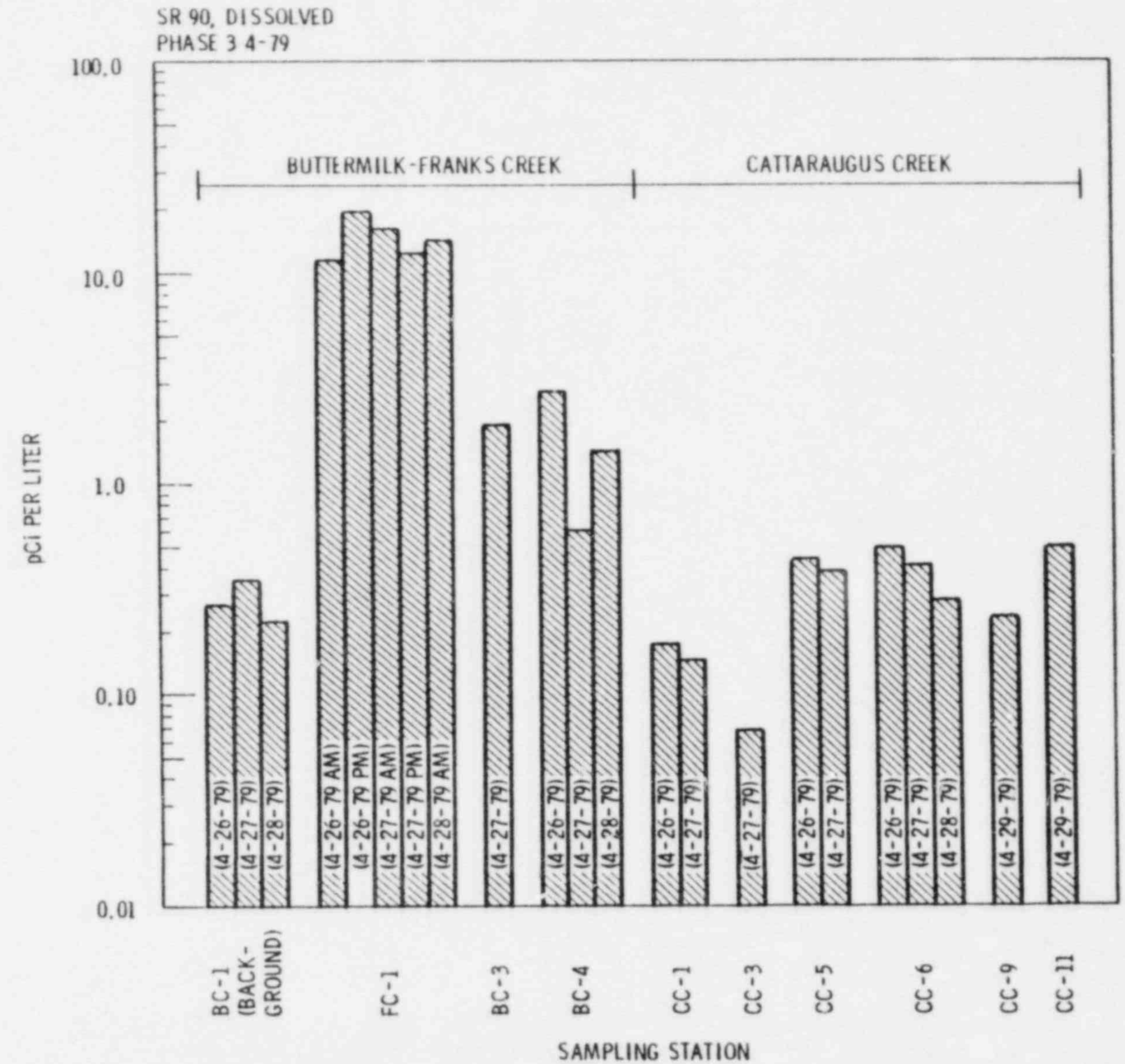

FIGURE 30. Strontium-90 in Water

Plutonium-238

Plutonium-238 concentrations in bed sediment, suspended sediment, and dissolved in water are shown on Figures 31, 32, and 33. The highest background Pu-238 levels in bed and suspended sediment were found at the upstream control station on Cattaraugus Creek (CC-1) with concentrations of 0.034 ± 0.020 pCi/gm (silt) and 0.043 ± 0.029 pCi/gm (sand), respectively. The Pu-238 concentration of 0.71 ± 0.105 pCi/g for the bed sediment sand sample at FC-1 was the only level above background. The station where activity levels of suspended sediment exceeded background were FC-1/1 (sand: 0.073 ± 0.063 pCi/g) on April 26, CC-6 (sand: 0.316 ± 0.137 pCi/g) on April 28, and CC-9 (clay: 0.085 ± 0.047 pCi/g) on April 29.

Pu-238 background concentrations detected in water varied from 0.00023 pCi/l to 0.00032 pCi/l at BC-1. The highest dissolved Pu-238 levels were found in Franks Creek (0.00183 pCi/l) and Buttermilk Creek at Thomas Corners Bridge (0.00231 pCi/l). Dissolved Pu-238 levels at CC-6, CC-9, and CC-11 in the lower reach of Cattaraugus Creek were above the levels at the upstream control stations.

Plutonium-239,240

Pu-239,240 concentrations in bed sediment suspended sediment, and dissolved in water are shown in Figures 34, 35, and 36. The highest background levels were found at CC-1. At the tributary station upstream of CC-1, the Pu-239,240 concentration in the bed clay fraction was 0.007 ± 0.002 pCi/gm. The concentration in the suspended clay fraction at CC-1 was 0.048 ± 0.008 pCi/gm which was the highest of the three sediment classes, and the concentration in water was 0.00011 pCi/l. Bed sediment and water samples from Franks Creek generally had higher Pu-239,240 levels than the levels at the upstream control stations. The highest concentration in the bed sediment was associated with the sand fraction of FC-1 with a concentration of 0.785 ± 0.113 pCi/gm. The highest dissolved Pu-239,240 concentration at FC-1 was 0.0008 pCi/l.

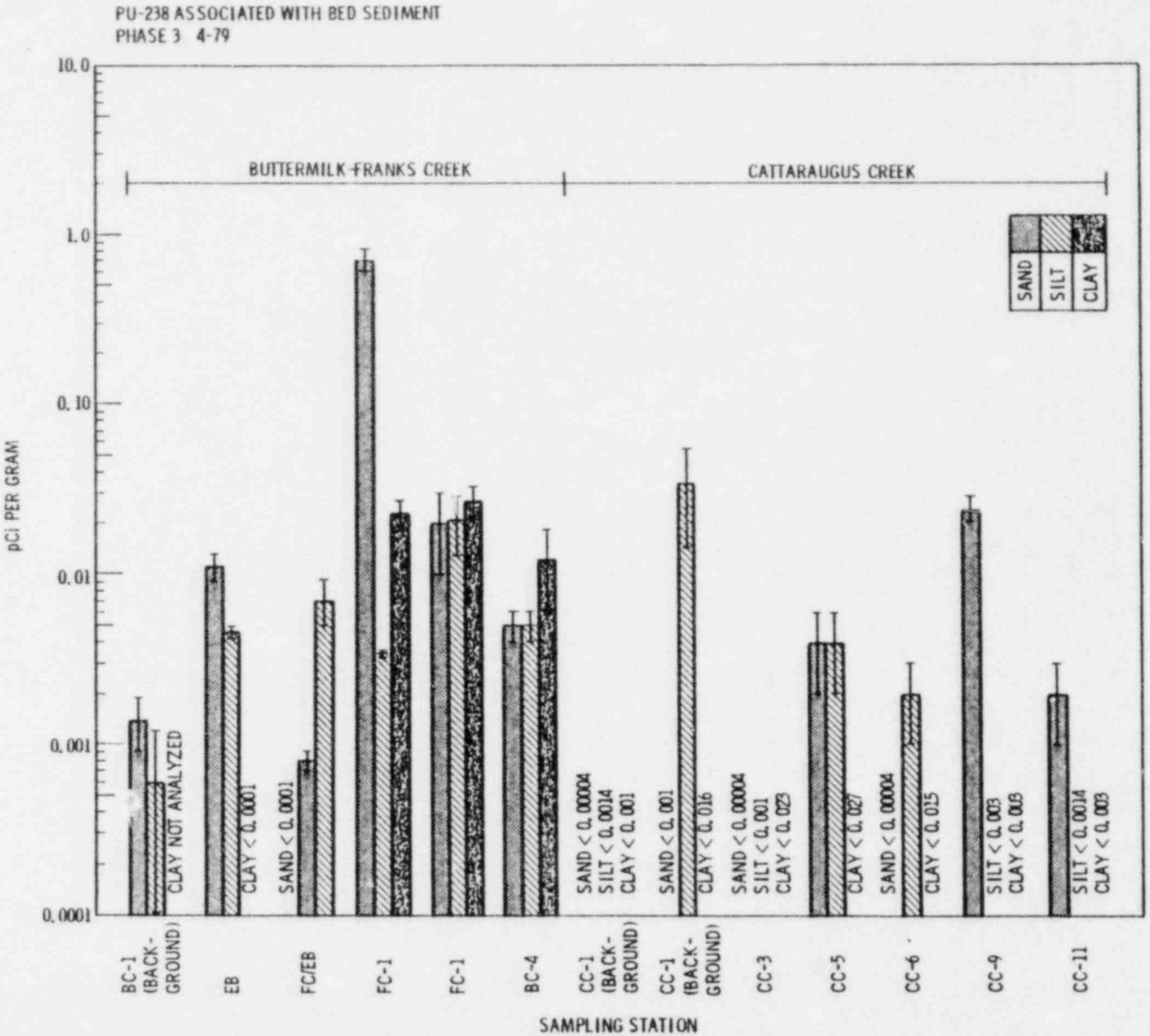

FIGURE 31. Plutonium-238 in Bed Sediment

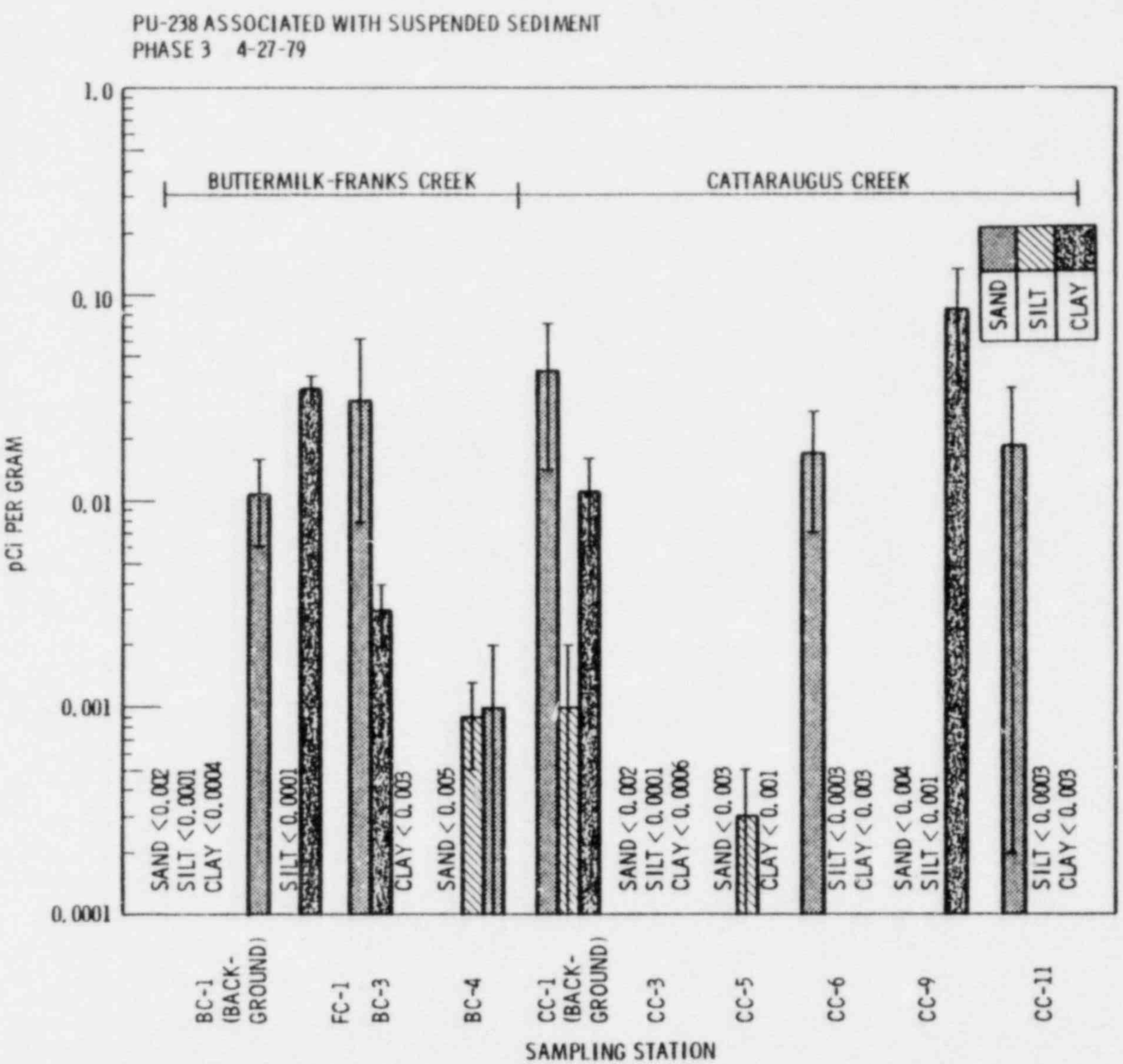

FIGURE 32. Plutonium-238 in Suspended Sediment

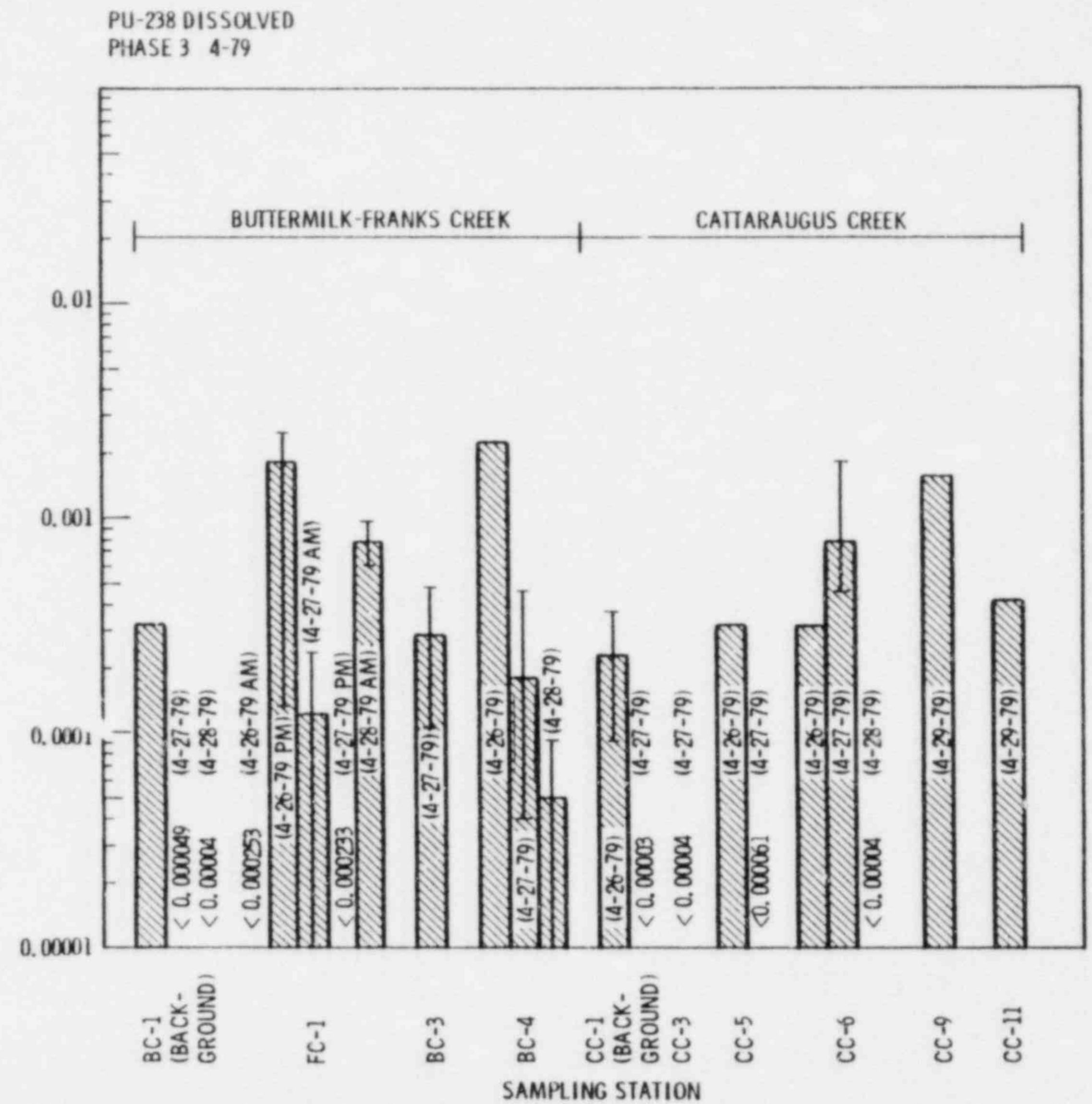

FIGURE 33. Plutonium-238 in Water

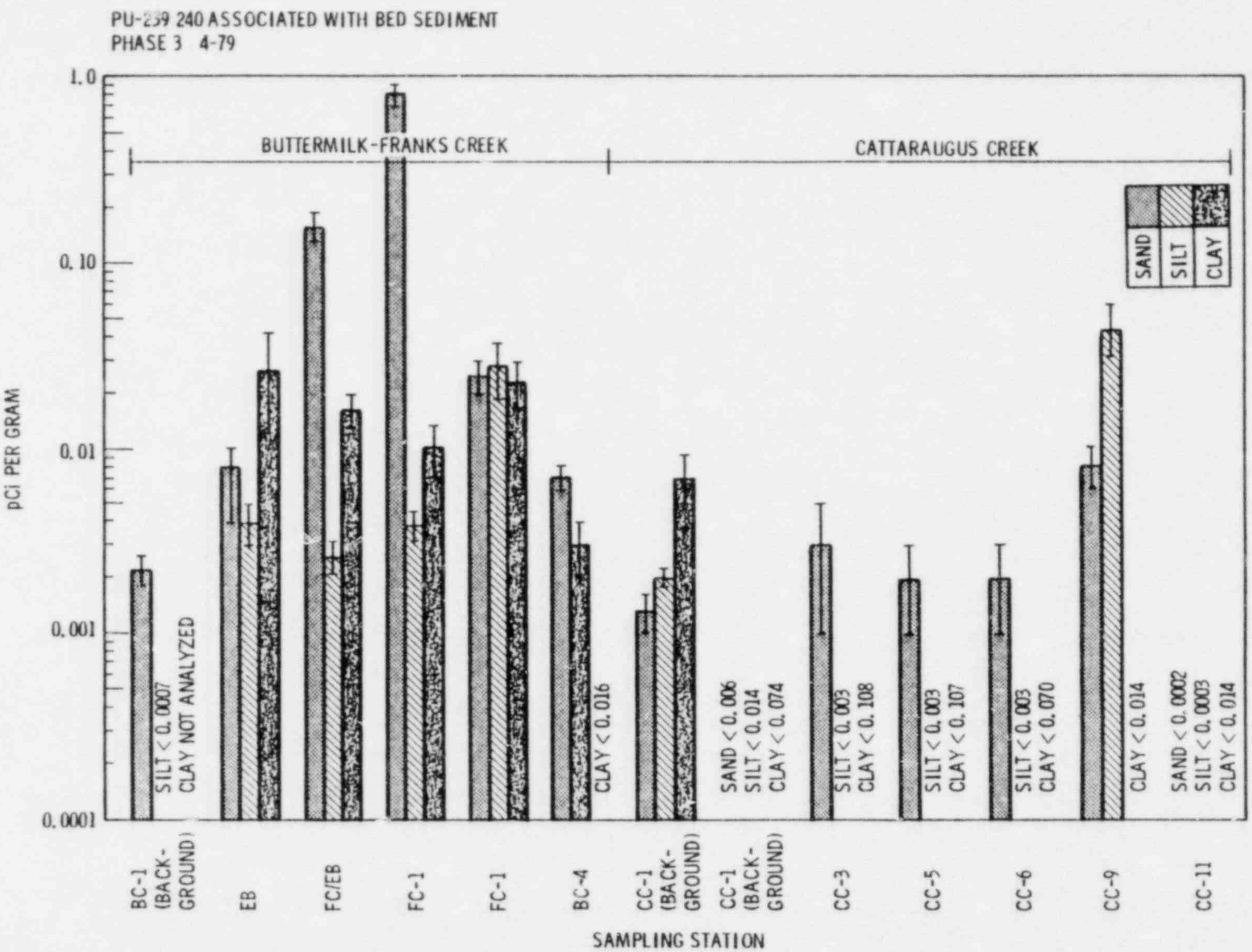

FIGURE 34. Plutonium-239,240 in Bed Sediment

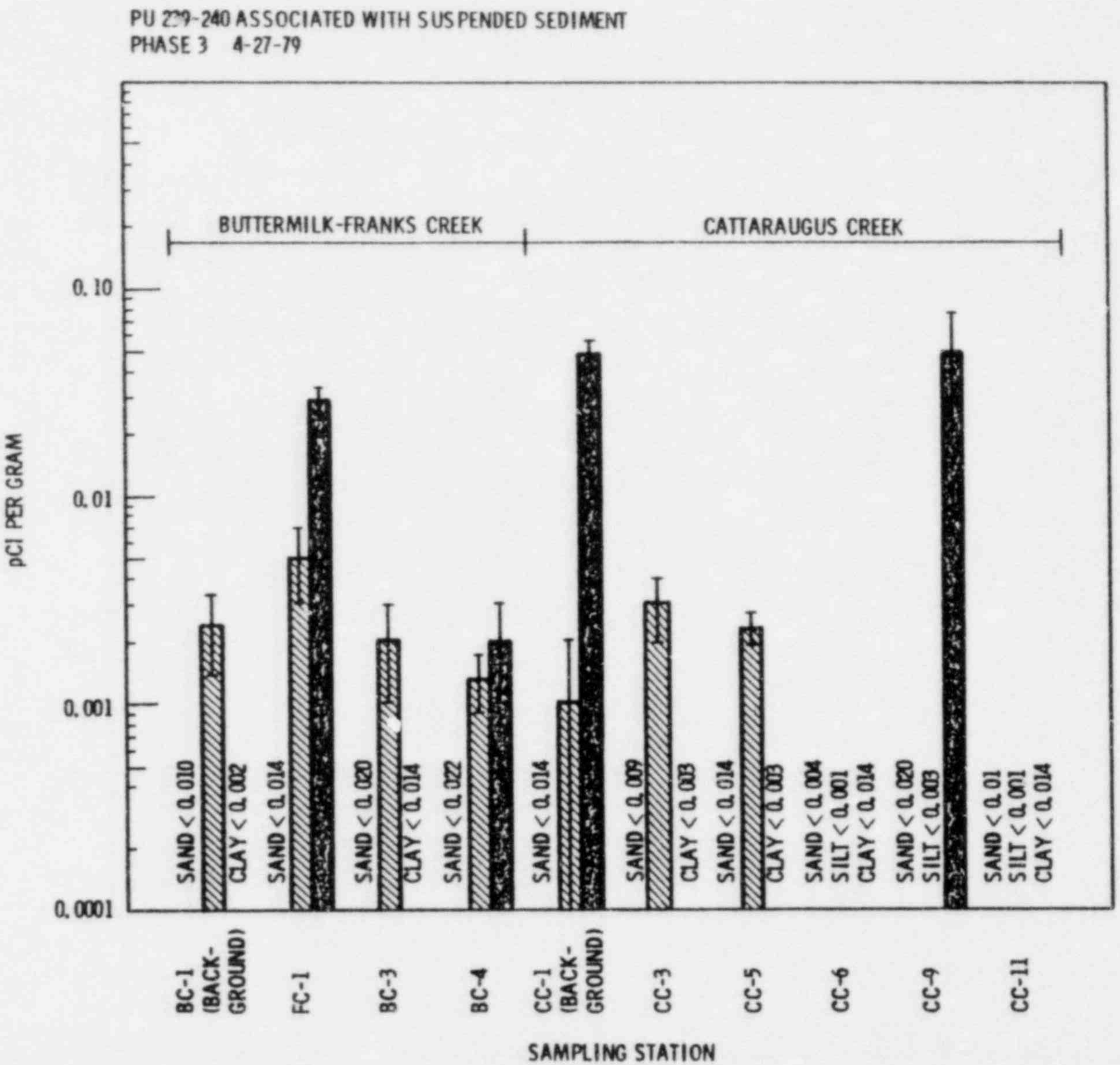

FIGURE 35. Plutonium-239,240 in Suspended Sediment

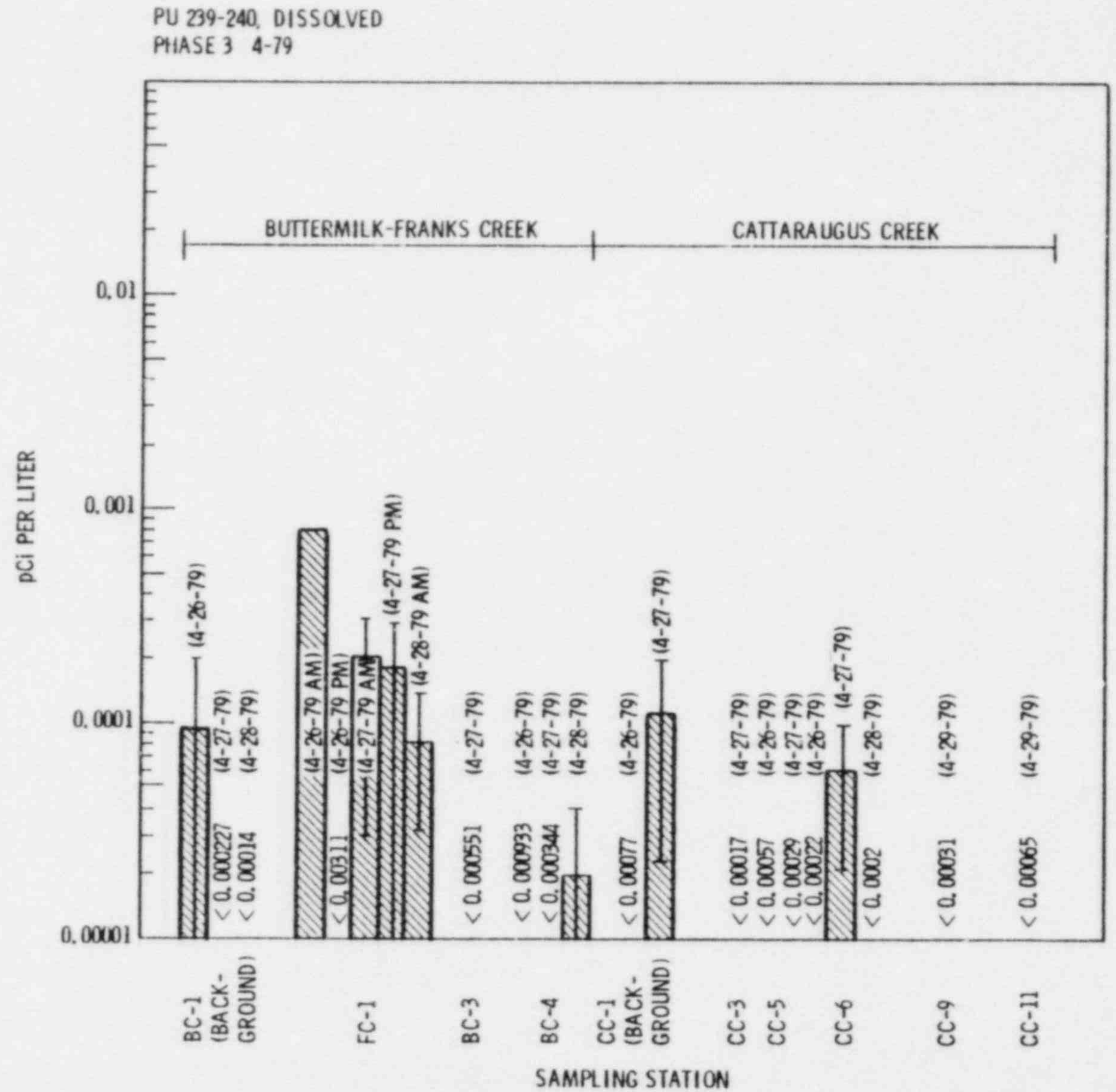

FIGURE 36. Plutonium-239,240 in Water

Americium-241

Figures 37, 38, and 39 show Am-241 concentrations in bed sediment, suspended sediment, and dissolved in water. The highest background level in bed sediment was detected at CC-1 in the sand sample (0.11 ± 0.056 pCi/g). Americium-241 was also found in the sand, silt, and clay of the CC-1 tributary station and varied from 0.0122 ± 0.0017 to 0.068 ± 0.03 pCi/g. Slightly higher levels of Am-241 were found in the bed sediment at FC-1 and FC/EB; however, the maximum level for any one sample was found downstream of Springville Reservoir at CC-6 (0.084 ± 0.24 pCi/g). The highest background levels of Am-241 in suspended sediment and water were detected at BC-1. The suspended sediment sample collected on April 28 at BC-1 contained a concentration of 12.06 ± 5.52 pCi/g for the clay fraction. The background levels for suspended sediment at BC-1 were not exceeded at any other stations. Dissolved Am-241 in water at BC-1 on April 26 was 0.0124 pCi/l. Only one water sample at FC-1 in the afternoon of April 27 exceeded the Am-241 background level. The concentration in this water sample was 0.0152 pCi/l.

Curium-244

Curium-244 concentrations in bed sediment, suspended sediment and water are shown on Figures 40, 41, and 42. The highest background levels in bed sediment, suspended sediment and water were found at BC-1 with concentrations of 0.0061 ± 0.0011 pCi/gm (sand), 1.16 ± 0.20 pCi/gm (silt) and 0.0020 pCi/l, respectively. Background levels in bed sediment were exceeded at EB, FC/EB, FC-1, CC-3 and CC-11. The highest bed sediment concentration was found in the bed sand fraction of FC/EB with a concentration of 0.077 ± 0.042 pCi/gm. The suspended sediment background level at BC-1 was exceeded only at station BC-4 on April 28 where the activity level for sand was 2.06 ± 1.18 pCi/g. Background Cm-244 concentrations in water were exceeded only at FC-1 where the highest concentration was found in the morning of April 27 with a concentration of 0.00613 pCi/l.

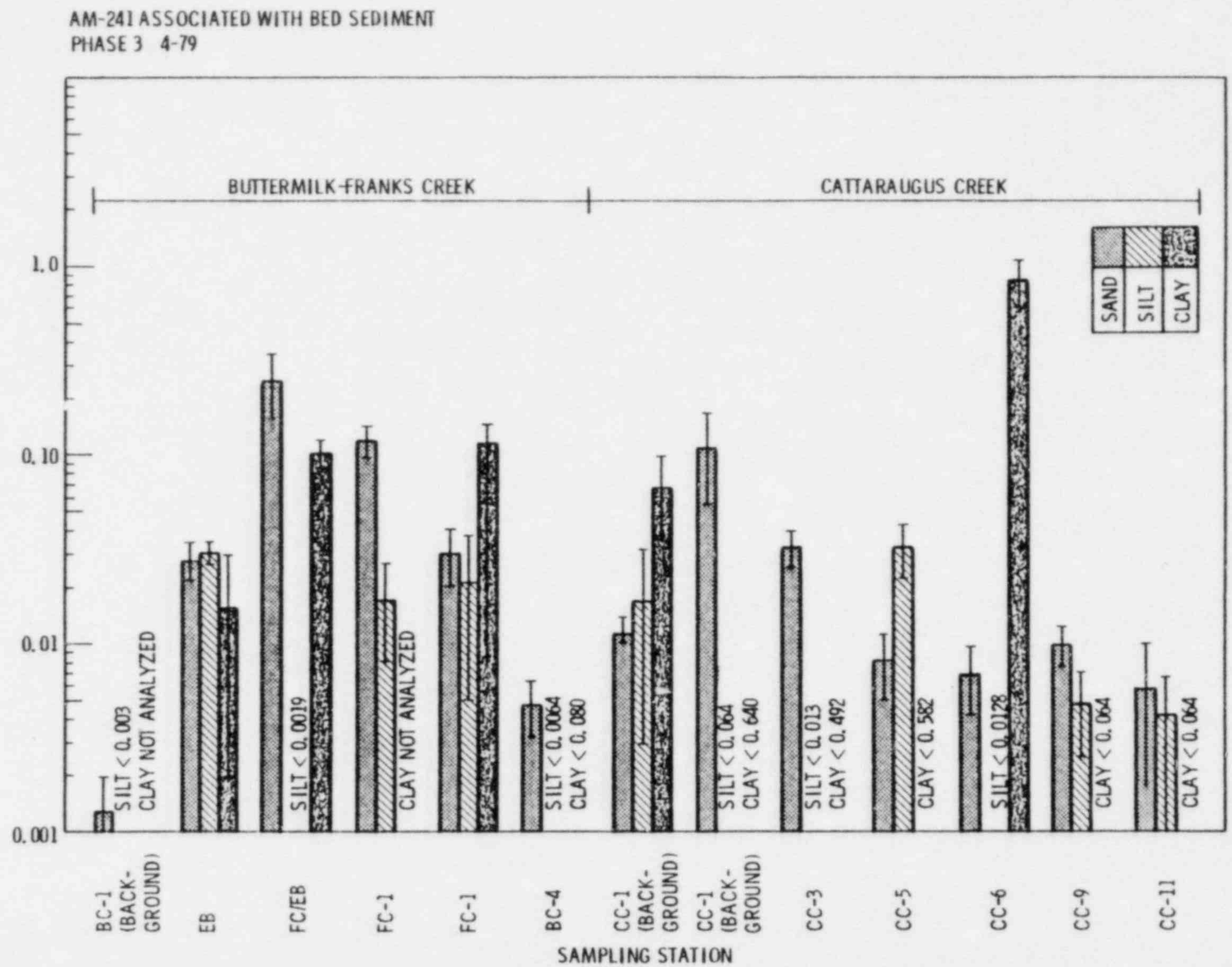

FIGURE 37. Americium-241 in Bed Sediment

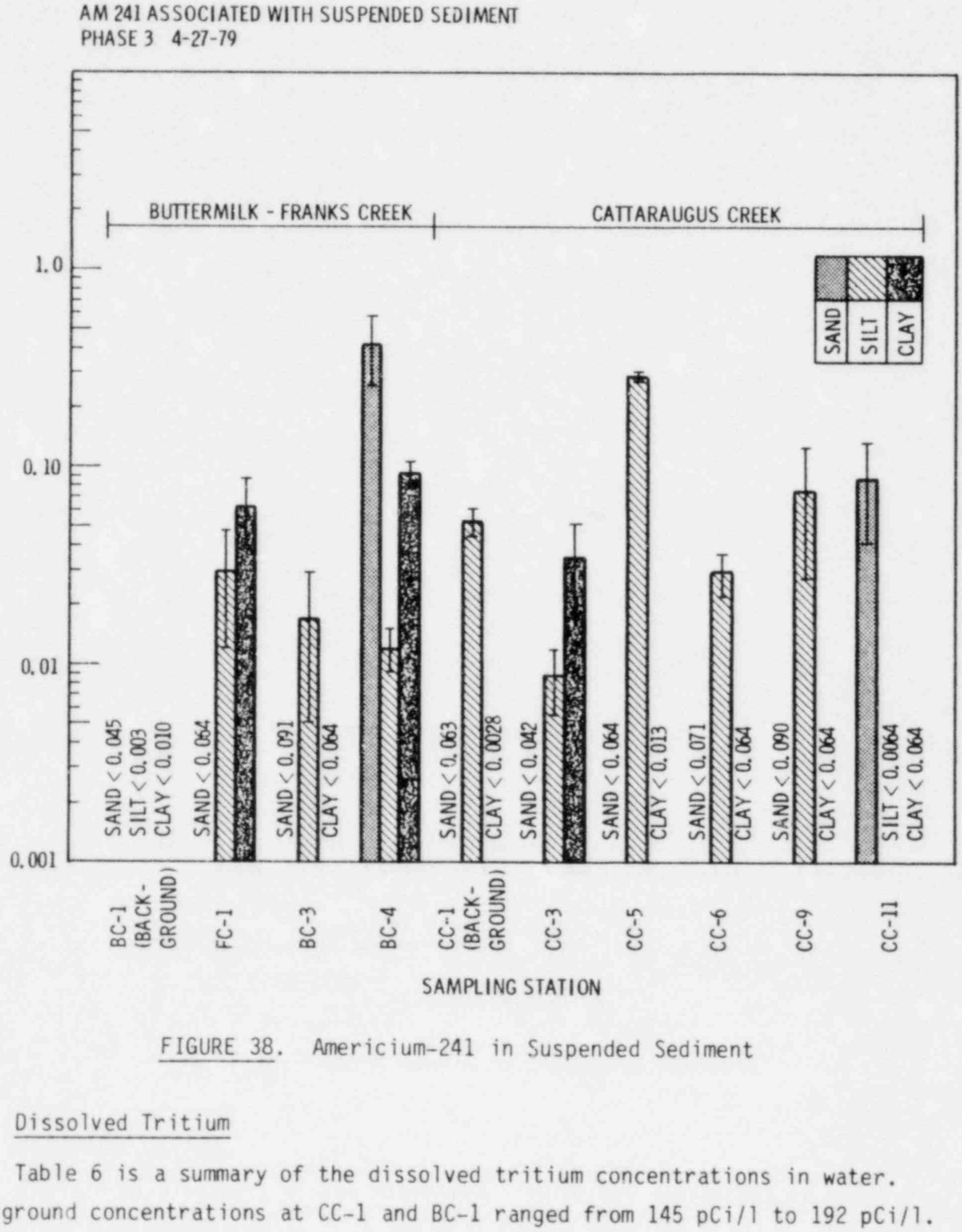

FIGURE 38. Americium-241 in Suspended Sediment

Dissolved Tritium

Table 6 is a summary of the dissolved tritium concentrations in water. Background concentrations at CC-1 and BC-1 ranged from 145 pCi/l to 192 pCi/l. In Franks Creek tritium concentrations ranged from 1038.71 ± 50.97 pCi/l to

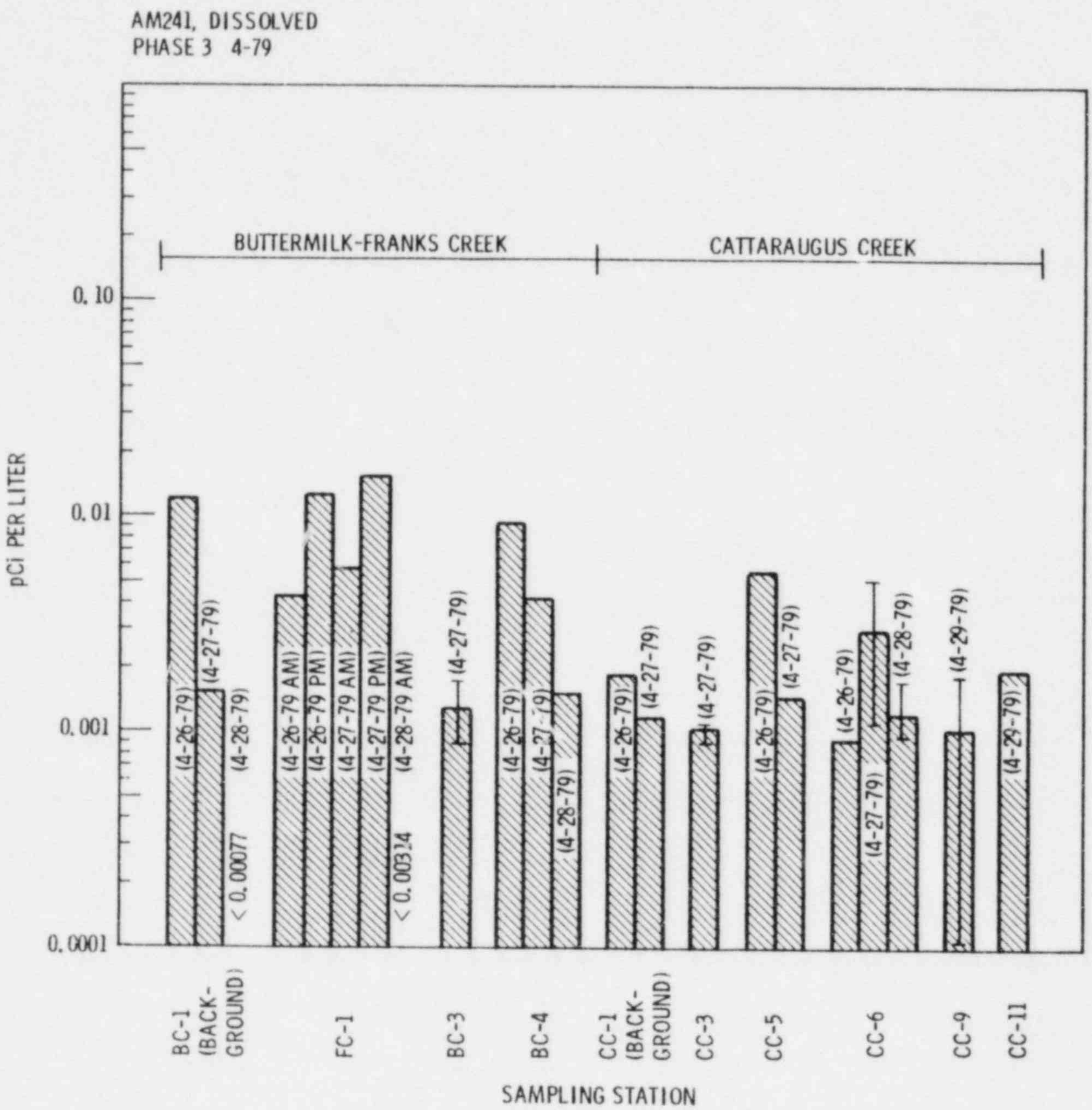

FIGURE 39. Americium-241 in Water

1788.31 ± 70.15 pCi/l. Tritium concentrations in Buttermilk Creek downstream of the confluence with Franks Creek were slightly elevated, with concentrations ranging from 211.84 ± 36.75 pCi/l to 315.20 ± 38.33 pCi/l. In Cattaraugus Creek the tritium concentrations ranged from background levels to slightly

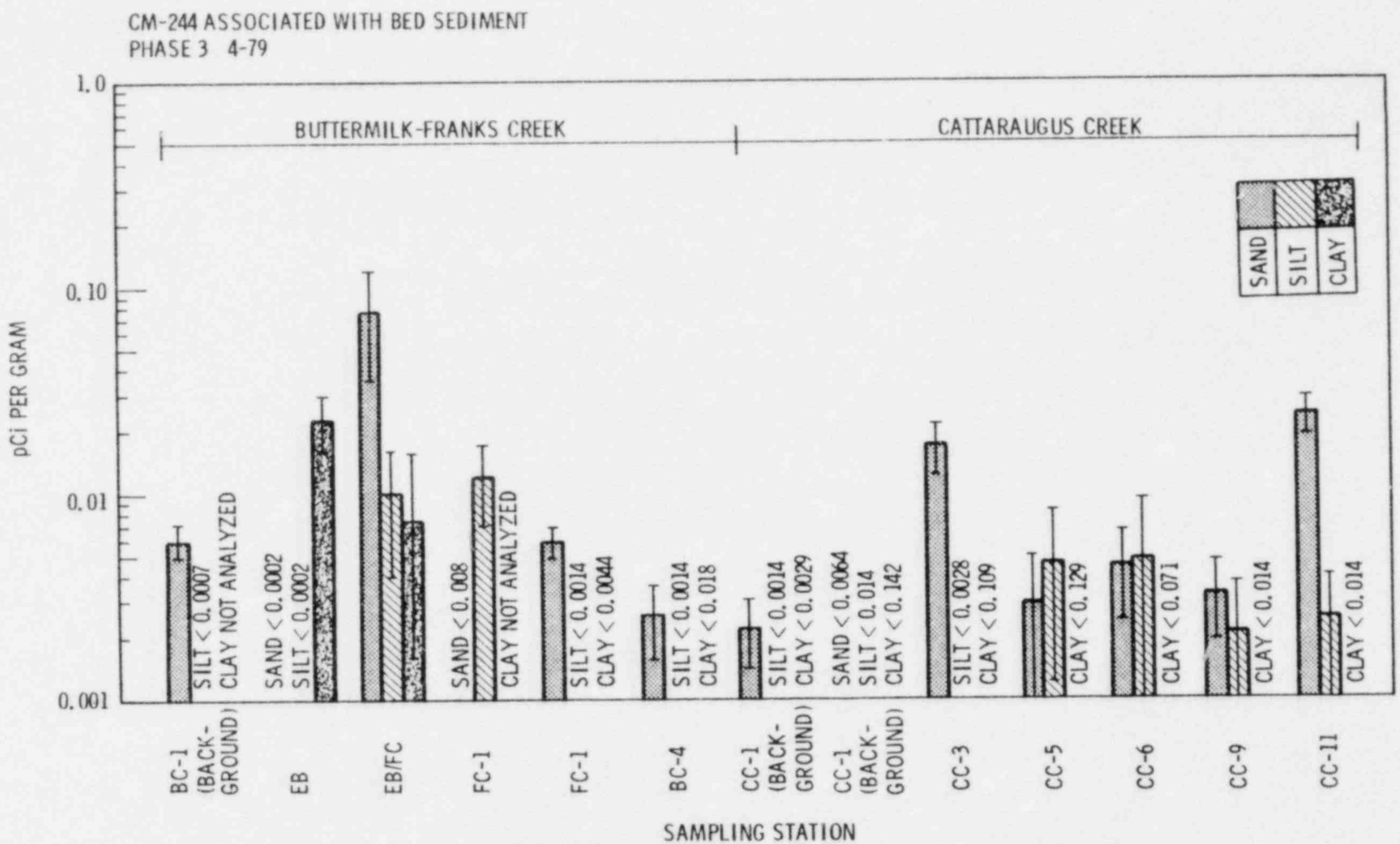

FIGURE 40. Curium-244 in Bed Sediment

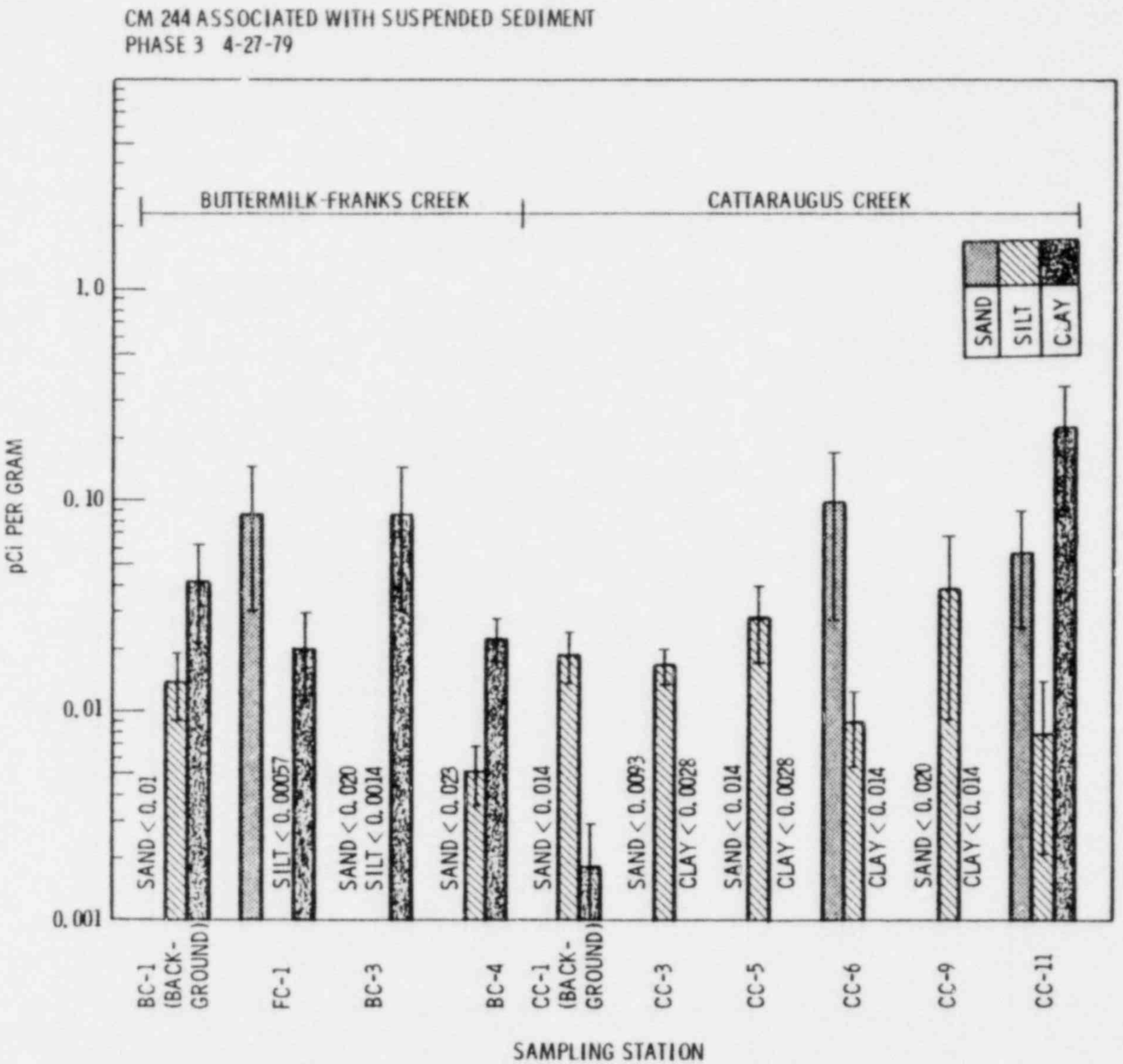

FIGURE 41. Curium-244 in Suspended Sediment

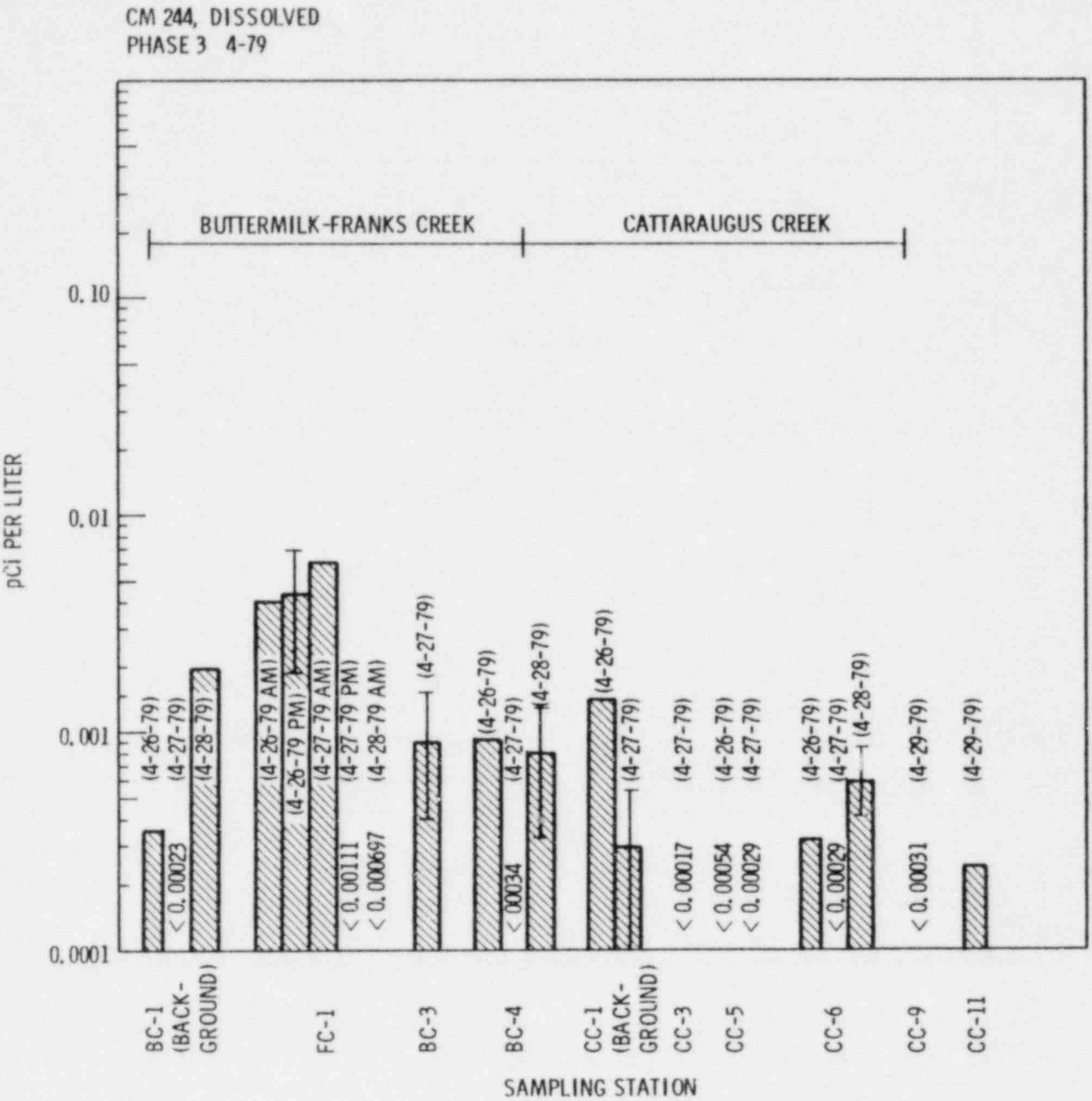

FIGURE 42. Curium-244 in Water

elevated levels. The highest concentration of 234.53 ± 37.07 pCi/l was found in Springville Reservoir (CC-5) on April 28.

Carbon-14 and Tritium in Sediment

Results of Carbon-14 and tritium analysis of dried sediment from CC-1 and FC-1 are shown in Table 7. Carbon-14 concentrations in Franks Creek were not significantly higher than at the upstream control station on Cattaraugus Creek (CC-1). The tritium content of dried sediment of Franks Creek are low, but significant. The concentration of tritium in dried sediment of Franks Creek ranged from 1.20 ± 0.19 pCi/gm to 2.85 ± 0.15 pCi/gm.

Lake Erie Core Samples

Results of gamma ray spectrometry analysis and alpha/beta analysis of Lake Erie core samples are shown in Tables 8 and 9. Detectable levels of K-40, Cs-137, Bi-214, Ra-226, R-228, Th-228, Sr-90, Pu-238, Pu-239,240, Am-241, and Cm-244 were found in the core samples, however; all the radionuclide concentrations were below the background levels found in bed and suspended sediment of Cattaraugus and Buttermilk Creeks.

TABLE 6. Tritium Concentrations in Water - Phase 3

Station	Date	Concentration pCi/l
BC-1	4-26-79	150.22 (35.82)
BC-1	4-27-79	144.78 (35.75)
BC-1	4-28-79	178.31 (36.23)
FC-1	4-27-79 (am)	1788.31 (70.15)
FC-1	4-27-79 (pm)	1038.71 (50.96)
BC-3	4-27-79	290.07 (41.45)
BC-4	4-27-79	211.84 (36.75)
BC-4	4-28-79	315.20 (38.33)
CC-1	4-26-79	177.86 (39.58)
CC-1	4-27-79	191.92 (36.43)
CC-3	4-27-79	210.04 (36.72)
CC-5	4-27-79	148.38 (35.78)
CC-5	4-28-79	234.53 (37.07)
CC-6	4-26-79	196.75 (44.96)
CC-6	4-27-79	215.48 (36.78)
CC-6	4-28-79	233.63 (37.07)

TABLE 7. Carbon-14 and Tritium in Dried Sediment - Phase 3

Station	Weight (gm)	Loss on Ignition (Δ)	Carbon-14 Soil (pCi/gm)	Carbon-14 Carbonates (pCi/gm)	Tritium Soil (pCi/gm)
CC-1					
Suspended Silt	2.628	8.01	1.72 (0.43)	20.1 (5.1)	0.55 (0.15)
Bed Silt	5.075	8.64	1.36 (0.34)	15.7 (3.9)	0.43 (0.08)
Bed Sand	5.203	3.91	0.21 (0.05)	5.4 (1.3)	0.08 (0.08)
FC-1					
Suspended Silt	2.245	9.24	1.1[illegible] (0.30)	12.8 (3.2)	1.20 (0.19)
Bed Silt	3.370	7.18	0.83 (0.21)	11.6 (2.9)	2.85 (0.15)
Bed Sand	4.956	6.40	0.35 (0.09)	5.5 (1.4)	2.62 (0.12)

TABLE 8. Results of Gamma Ray Spectrometry Analysis of Phase 3, Lake Erie Core Samples

	Sample Weight Analysis (g)	K-40	Co-60	Cs-134	Cs-137	Bi-214	Ra-226	Ra-228	Th-228	U-235	U-238	Am-241
Station 1												
Top 2 inches	79.1	8.91(0.377)	<0.052	<0.068	0.127(0.018)	0.496(0.036)	0.482(0.035)	0.785(0.090)	1.16(0.061)	<0.241	<0.763	<0.174
2nd 2 inches	73.0	8.40(0.259)	<0.037	<0.047	0.147(0.014)	0.607(0.025)	0.590(0.025)	0.900(0.070)	1.28(0.034)	<0.169	<0.535	<0.123
3rd 2 inches	80.4	9.35(0.268)	<0.036	<0.041	0.200(0.012)	<0.074	<0.072	0.467(0.057)	0.700(0.057)	<0.145	<0.446	<0.105
Station 2												
Top 2 inches	8.5	7.58(1.11)	<0.188	<0.234	<0.173	<0.381	<0.370	<0.929	1.11(0.156)	<0.778	<2.09	0.824(0.119)
2nd 2 inches	8.5	10.99(0.976)	<0.162	<0.197	<0.149	<0.306	<0.297	<0.784	0.368(0.126)	<0.639	<1.74	0.913(0.106)
3rd 2 inches	8.5	8.74(1.56)	<0.306	<0.320	<0.290	<0.519	<0.504	<1.35	<0.634	<1.12	<3.07	<0.543
Station 3												
Top 2 inches	8.5	8.84(1.79)	<0.389	<0.394	<0.349	<0.628	<0.609	<1.58	<0.780	<0.138	<3.64	<0.526
2nd 2 inches	8.5	10.76 (0.754)	<0.120	<0.138	0.437(0.038)	<0.217	<0.211	<0.519	2.14(0.098)	<0.445	<1.24	1.09(0.076)
3rd 2 inches	8.5	12.81(1.61)	<0.276	<0.3209	0.529(0.100)	<0.553	<0.537	<1.25	0.150(0.150)	<1.08	<3.02	0.974(0.168)
Station 4												
Top 2 inches	80.5	8.12(0.238)	<0.032	<0.039	0.156(0.011)	0.267(0.023)	0.259(0.022)	0.346(0.048)	0.650(0.026)	<0.139	<0.419	<0.097
2nd 2 inches	87.9	7.65(0.201)	<0.027	<0.031	0.148(0.010)	0.271(0.017)	0.263(0.016)	0.501(0.042)	0.592(0.023)	<0.112	<0.351	<0.081
3rd 2 inches	83.7	7.27(0.329)	<0.047	<0.059	0.136(0.019)	<0.105	<0.102	<0.266	0.682(0.038)	<0.199	<0.611	<0.144

TABLE 9. Results of Analysis of Phase 3 Lake Erie Core Samples for Alpha/Beta Emitters

	Sample Weight Analysis (g)	Sr-90	Pu-238	Pu-239,240	Am-241	Cm-244
Station 1						
Top 2 inches	79.1	0.019 (0.013)	<0.00004	0.003 (0.001)	<0.0008	<0.0002
2nd 2 inches	73.0	<0.0015	<0.0004	0.0005 (0.0004)	<0.0009	<0.0002
3rd 2 inches	80.43	0.021 (0.005)	<0.00004	0.003 (0.001)	0.0016 (0.0013)	0.0006 (0.0005)
Station 2						
Top 2 inches	8.5	0.118 (0.064)	<0.0003	<0.002	<0.0075	<0.0017
2nd 2 inches	8.5	0.262 (0.100)	<0.0003	<0.002	<0.0075	0.0053 (0.0028)
3rd 2 inches	8.5	<0.013	<0.0004	<0.002	0.0109 (0.0070)	0.0062 (0.0040)
Station 3						
Top 2 inches	8.5	0.174 (0.059)	<0.0004	0.007 (0.005)	0.025 (0.020)	<0.0017
2nd 2 inches	8.5	0.143 (0.044)	0.003 (0.002)	0.005 (0.002)	<0.0075	<0.0017
3rd 2 inches	8.5	0.067 (0.041)	<0.0004	0.004 (0.003)	<0.0075	0.0035 (0.0029)
Station 4						
Top 2 inches	80.5	0.017 (0.008)	<0.00004	0.0005 (0.0003)	0.0016 (0.0011)	<0.0002
2nd 2 inches	87.5	0.015 (0.008)	<0.00003	<0.0002	<0.0007	<0.0002
3rd 2 inches	83.75	0.023 (0.009)	0.0004 (0.0004)	<0.0002	0.0048 (0.0020)	0.0035 (0.0020)

CONCLUSIONS

Results of the Phase 3 sampling program conducted in April 1979 indicate that, of the detectable radionuclides in bed and suspended sediment and dissolved in water, the highest concentrations are generally found in Franks Creek. A summary of the background and nonbackground radionuclide concentrations found in bed sediment, suspended sediment and, dissolved in water of Franks Creek, Buttermilk Creek and Cattaraugus Creek during the Phase 3 sampling program is shown in Table 10. The values in the table are reported as the composite sample concentrations detected in the sand, silt and clay size fractions. Nonbackground concentrations of Cs-137 and Sr-90 were consistently higher than the background levels during the Phase 3 sampling program. Detectable levels of K-40, Cs-137, Bi-214, Ra-226, Ra-228, Th-228, Sr-90, Pu-238, Pu-239,240, Am-241, and Cm-244 were found in the sediments of Lake Erie near the mouth of Cattaraugus Creek, but were below the background concentrations found in bed and suspended sediment of Cattaraugus and Buttermilk Creeks.

The following conclusions are offered based on the evaluation of the results of the Phase 3 sampling program:

1. Gamma ray spectrometry analysis of bed sediment, suspended sediment and water samples indicate that the Nuclear Fuel Services (NFS) site at West Valley, New York is a possible source of Cesium-137. Based on the levels of Cobalt-60 and Cesium-134 levels in bed and suspended sediment of Franks Creek, the NFS site is also a possible source for these radionuclides. Cobalt-60 and Cesium-134, however, were not detected in the water samples from Franks Creek, nor were they found in bed and suspended sediment of Buttermilk and Cattaraugus Creeks during the Phase 3 sampling program.

2. Radiochemical analysis of bed and suspended sediment, and water indicates the NFS site is a possible source of Strontium-90. Elevated levels of Plutonium-238, Plutonium 239,240, Americium-241, Curium-244 and tritium were found in some bed sediment, suspended sediment and water samples. These elevated levels can possibly be attributed to the NFS site.

TABLE 10. Summary of Maximum Composite Background and Nonbackground Radionuclide Concentrations During Phase 3

Radio-nuclide	Bed Sediment Background pCi/gm	Bed Sediment Nonback-ground pCi/gm	Suspended Sediment Background pCi/gm	Suspended Sediment Nonback-ground pCi/gm	Dissolved Background pCi/l	Dissolved Nonback-ground pCi/l
K-40	BC-1 10.7(0.28)	FC-1 15.02(1.41)	BC-1 37.9(16.3)	FC-1 38.2(10.7)	CC-1 5.50	FC-1 17.27
Co-60	<	FC-1 1.02(0.08)	<	FC-1 0.09(0.02)	<	<
Cs-134	<	FC-1 0.681(0.021)	<	FC-1 0.14(0.03)	<	<
Cs-137	CC-1 3.29(0.78)	FC-1 69.18(0.34)	BC-1 0.95(0.44)	FC-1 15.94(0.66)	<	CC-5 4.50(0.183)
Ce-141	<	<	BC-1 0.10(0.09)	<	<	<
Bi-214	CC-1 0.50(0.02)	CC-5 0.38(0.02)	CC-1 1.06(0.14)	BC-4 1.17(0.19)	CC-1 0.088(0.046)	FC-1 0.162(0.08)
Ra-226	BC-1 0.49(0.04)	FC-1 0.62(0.11)	BC-1 1.38(0.23)	FC-1 1.7(0.72)	CC-1 0.381(0.215)	FC-1 0.308
Ra-228	BC-1 0.83(0.06)	BC-4 0.99(0.07)	BC-1 1.18(0.11)	FC-1 1.6(0.23)	<	<
Th-228	BC-1 1.32(0.04)	BC-4 1.23(0.06)	BC-1 2.42(0.22)	FC-1 3.51(1.97)	CC-1 0.154	FC-1 15.71(0.941)
U-235		FC-1 0.13(0.06)	BC-1 0.47(0.42)	<	<	<
U-238	CC-1 1.13(0.08)	CC-11 0.71(0.09)	CC-1 6.13(5.72)	FC-1 1.7(0.51)	<	<
Sr-90	CC-1 0.52(0.19)	FC-1 1.91(0.09)	BC-1 0.80(0.69)	FC-1 1.63(0.11)	BC-1 0.278	FC-1 19.50
Pu-238	CC-1 0.02(0.01)	FC-1 0.55(0.08)	BC-1 0.013(0.008)	CC-6 0.02(0.01)	BC-1 0.00032	BC-4 0.00231
Pu-239, 240	CC-1 0.002(0.001)	FC-1 0.61(0.09)	BC-1 0.018(0.007)	FC-1 0.01(0.003)	CC-1 0.00011 (0.00009)	FC-1 0.00080
Am-241	CC-1 0.06(0.03)	FC-1 0.09(0.02)	BC-1 4.13(1.59)	FC-1 0.23(0.03)	BC-1 0.0124	FC-1 0.0152
Cm-244	BC-1 0.006(0.001)	CC-3 0.017(0.005)	BC-1 0.84(0.15)	CC-6 0.07(0.03)	BC-1 0.002	FC-1 0.00614

< denotes levels below detection

3. The same dominant radionuclides found in the bed sediment of Buttermilk and Cattaraugus Creeks are found to be predominant in sediment of Lake Erie near the mouth of Cattaraugus Creek. The concentrations, however, were much lower, never exceeding the background levels measured in Buttermilk and Cattaraugus Creeks.
4. The clay size fraction of bed and suspended sediment samples generally have the highest activity levels, followed by the silt then sand fractions.
5. There was a large variability in activity levels in suspended sediment and water samples collected at the same station during unsteady flow conditions.

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APPENDIX A

BATTELLE LARGE VOLUME WATER SAMPLER (BLVWS)

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The BLVWS was developed at Battelle Northwest Laboratories (Silker et al. 1971) for the analysis of radionuclide concentration in seawater. The sampler has also been utilized to separate short-lived radionuclides from rainwater (Nielson and Wogman 1971) and analysis of Columbia River water for radionuclides discharged from the Hanford reactors (Robertson et al. 1973 and Perkins et al. 1976).

The BLVWS was designed as a field sampler to process as much as 4000 liters of water in about 3 hours. Water is forced through the sample by pumping and the rate recorded by a flow meter (Figure 2). The sorption beds are stacked in the sample column below a set of filters. The filters remove the particulate matter and then the water is passed through the series of sorption beds before being returned to the source. The principle of the BLVWS is based on the assumption that each sorption bed acts as a given number of theoretical plates and that the total concentration of the dissolved radionuclide can be determined by using the calculated collection efficiency between any two successive sorption beds.

An advantage of the BLVWS sampling system is that the sampler concentrates the elements in the field. This increases the amount of the element available for analysis and by-passes the need for handling large volume samples.

The BLVWS is applicable to flowing water as it takes an integrated sample over a 60 to 90 minute interval instead of an instantaneous sample. This would tend to dampen large variations in concentration due to moving water.

The total concentration of dissolved radionuclides is determined by the calculation of collection efficiency between any two sorption beds or more if desired. The method assumes that a fraction of the available solute is removed by each bed. When this approach is used the collection efficiency (E) between any two sorption beds can be determined by the following equation:

$$E_{(m,m+1)} = \frac{Nm - Nm+1}{Nm}$$

where

E(m,m+1) = collection efficiency of bed Nm (first bed)

Nm = concentration of radionuclide in the m^{th} bed

Nm+1 = concentration of radionuclide in the m+1 bed

The calculated efficiency can be used to determine the concentration of radionuclide in the soluble phase, C_2:

$$C_s = \frac{Nm}{E(m,m+1)} + \sum_{1}^{m-1} N_{(m-1)}$$

where

C_s = concentration of the radionuclide in the soluble fraction the water

$\sum_{1}^{m-1} N_{(m-1)}$ = sum of the concentrations of the radionuclide preceding bed m.

The total amount of radionuclide in the water, C_t, is the sum of the soluble fraction, C_s, and the particulate fraction, C_p, found on the millipore filters:

$$C_t = C_s + C_p.$$

APPENDIX B

HYDROLOGIC DATA COLLECTION PHASE 3 APRIL 1979

APPENDIX B

HYDROLOGIC DATA COLLECTION PHASE 3 APRIL 1979

PURPOSE OF MONITORING EFFORT

The purpose of the hydrological monitoring task is to provide input data of the actual flow conditions during the sampling period for unsteady state flow modeling. The results of the unsteady state flow computations will provide hydraulic input data for the sediment-contaminant model SERATRA. The collected hydrologic data include river stage readings versus time at temporary gage locations, vertical velocity measurements, channel cross-section surveys, and water surface slopes.

Certain sediment data are required as input to SERATRA and were collected simultaneously with the gage readings. These data are wash load concentrations (clay and silt fractions) and channel bed material samples (sand fractions). Wash load concentrations versus time are required at all primary channel network and tributary inflow points. Bed material samples are necessary for the determination of sand size fraction distribution.

The primary stream system under study consists of a length of Buttermilk Creek that extends from the mouth of Franks Creek at the NFS facilities to its confluence with Cattaraugas Creek which is about 12,500 feet of channel. The length of Cattaraugas extends 39 miles downstream to its outlet at Lake Erie. This is the assumed pathway of radionuclide migration for surface waters. In order to simplify model verification, a short reach of Buttermilk and Cattaraugas Creek system about 10 miles long was selected for detailed monitoring. The reach extends from just above the confluence with Buttermilk Creek to just upstream of Connoisarauley Creek. This reduces the number of tributaries that require monitoring to two which are Spring Brook and Spooner Creek.

Hydrographs of water discharge versus time are required at all significant inflow points of the selected reaches of Cattaraugas and Buttermilk Creeks. The channel geometry will be determined from the cross-sectional surveys and the channel slope measured from USGS topographic maps. Using these data the unsteady flow model will generate water depths and average cross-sectional velocities at specified points along the channel length for input into SERATRA. The wash load sediment concentration versus time and bed material size distribution data are not required for the unsteady flow modeling but will be input data for SERATRA.

CATTARAUGAS CREEK WATERSHED

Location

Cattaraugus Creek flows in a westerly direction through the Zoar Valley and empties into Lake Erie about 27 miles southwest of Buffalo, New York. The principal community on Cattaraugas Creek is Gowanda, New York which is located about 19 stream miles upstream from Lake Erie. The confluence of Buttermilk Creek is 20 miles further upstream from Gowanda. The total drainage area of the watershed is 564 square miles. The watershed area upstream of Buttermilk Creek includes 218 square miles and above Gowanda about 432 square miles.

Geomorphology

The Cattaraugas Creek watershed in Western New York lies within the Allegheny Plateau physiographic province. The pre-glacial erosional surface of the watershed was dissected upland with deeply incised valleys. Many of the valleys have been buried by a considerable volume of glacial deposits with the result that much of the present drainage is post-glacial and bedrock valleys which have depth and direction varying from the present valleys.

The present course of Buttermilk Creek is incised into glacial deposits and recent alluvium which fill a deep pre-glacial bedrock gorge. The channel pattern in the vicinity of its confluence with Franks Creek is that of a braided stream where at low flows there will be multiple channels.

At low flows Buttermilk Creek discharge follows a meandering underfit channel pattern among the alluvial islands within its narrow flood plain. At many locations the bankline is poorly defined and unstable. Evidence of very recent bank caving exists at some locations. Two primary causes generally assumed to be responsible for a braided condition are (1) a sediment load which exceeds the transport capacity of the stream, and (2) a steep channel slope, which tends to produce a wide shallow channel where bars and islands easily form.

At about the mid-point of the reach between the Franks Creek outlet and the confluence with Cattaraugas Creek the channel begins to establish a meandering plan geometry. Bendway development gives an S-shaped appearance which increases in size as the confluence with Cattaraugas Creek is approached. Meandering is a trading process of erosion and deposition. Material is eroded from the concave banklines of bendways and deposited on point bars (convex banklines) over a period of time. For easily erodible banks this process leads to a noticeable migration of the bendways over a period of years.

Cattaraugas Creek from the mouth of Buttermilk Creek to its outlet at Lake Erie has a meandering plan view geometry. There are reaches where alluvial islands and bars are present which cause a braided appearance at low flows. For the most part these multi-channeled reaches appear to have remained stable where the islands and bars tend to remain in their general location. Some islands lie adjacent to a bankline and have well-established vegetation. Many of the point bars are clear of established vegetation indicating prolonged inundation during the high water season or growth of the alluvial bar area. Both of these phenomena usually work in concert which is probably the case for Cattaraugas Creek.

Near Lake Erie the Cattaraugas Creek flood plain is much wider and terraces are prevalent. Numerous meander scrolls are evident in the cleared agricultural lands and can be determined by the difference in soil type and moisture content. Other cutoff bendways of more recent origin are in the form of oxbow lakes which may receive flow from the creek during spring floods. It is difficult to determine if the meandering process is very active without a sequence of aerial photos and mapping covering a sufficient time period, however, the presence of erosion control structures at a bridge near Gowanda indicates meandering may still be active enough to introduce significant quantities of sediment into the streamflow.

Hydrology

The Nuclear Fuels Service Center is located within an area that normally receives enough monthly precipitation to provide surplus water runoff throughout the year. Small quantitites of water that are withdrawn from the groundwater by farm, public, and private wells is replenished through natural percolation. Therefore, the natural water supply is more than adequate to supply the needs of the center and area. The water supply for the center is provided by surface runoff collected in two lakes in the southern portion of the center. These two lakes periodically release controlled water discharges to Buttermilk Creek at two separate inflow points about one-half mile apart and about two miles upstream from the Franks Creek confluence. The releases from these lakes superimpose a small wave disturbance on the stage hydrograph for time periods of 2 to 3 hours. A major portion of the water collected within the center will be returned to the drainage network and enter Lake Erie by way of Cattaraugus Creek. The extreme flow events for Buttermilk Creek are of short duration of hours or a few days. A report by Dana et al. (1979) discusses the USGS gage records on Buttermilk Creek from 1968 to 1973. They summarized the flow hydrograph characteristics for Buttermilk Creek as follows:

> "A hydrograph of daily discharge for water year 1962 is very "spikey" with high discharge flow events lasting only a day or two. Base-flow occurs from early summer to mid-fall and is approximately $0.3m^3$/sec or less. The fall and winter peaks represent discrete rainstorm or thaw events. Spring runoff from snow melt is punctuated by rainfall events. The mean monthly discharge is much less (maximum = $2.5m^3$/sec in May) than the summation of daily discharge that includes a rainfall peak ($14.5m^3$/sec, max.)."

The high discharge events are much higher than the mean daily flow which indicates that the high discharge events are on the order of several hours in duration. The highest discharge recorded for the period of record is $110.65m^3$/sec or 3896.5 cfs (Dana et al. 1979).

The only one gaging station on Cattaraugus Creek is located at Gowanda, New York. The watershed area upstream of the gage is 432 square miles. Annual peak discharge records received from the USGS Water Resources Division, Albany, New York, indicate that the maximum peak dishcarge of 34,600 cfs occurred on March 7, 1956 for the period of record from 1911 to 1975. The high discharges normally occur during the spring season from snowmelt coupled with rainfall.

HYDROLOGIC DATA COLLECTION

The routing of water and sediment through the Buttermilk-Cattaraugus Creek system will require monitoring the water discharge and suspended sediment concentrations at all significant inflow points. Because of the size (564 square miles) and complexity, including 16 significant tributaries from Buttermilk Creek to Lake Erie, a sub-basin area of the watershed in the immediate vicinity of NFS was selected for "more detailed" hydrologic monitoring. The area includes a 12,500 ft reach of Buttermilk Creek from just upstream of Franks Creek to its confluence with Cattaraugus Creek. The reach of Cattaraugus Creek is about 8 streamlength miles and begins at Bigelow Bridge upstream of the Buttermilk Creek confluence and extends downstream past Springville Dam to a point about 800 ft below Frye Bridge. A map of the study area and gage locations is shown in Figure B.1. Two tributaries, Spooner Creek and Spring Brook, have significant drainage areas and are included as inflow points for water and sediment. Springville Dam and reservoir are located about 2.5 miles downstream from the mouth of Buttermilk Creek and act as an intermediate control section. The reservoir serves only as pondage for the small hydroelectric plant at the dam but does trap large quantities of sediment. Flow depth over the spillway was monitored and total flow was measured at a section about 1500 ft downstream of the dam. The difference between the flow over the spillway and the total discharge measured downstream will provide an estimate of the water passing through the turbines.

An automatic water stage recorder has been established by the New York State Geological Survey at Thomas Corners Bridge over Buttermilk Creek. This gage provided continuous stage and time data for the monitoring period and serves as a check on upstream gage readings. Periodic surges of flow occur on Buttermilk Creek due to controlled reservoir releases upstream from the NFS ponds and last for about 2 to 3 hr. Because of the difficulty of minute by minute monitoring of the upstream inflow point on Buttermilk Creek by field

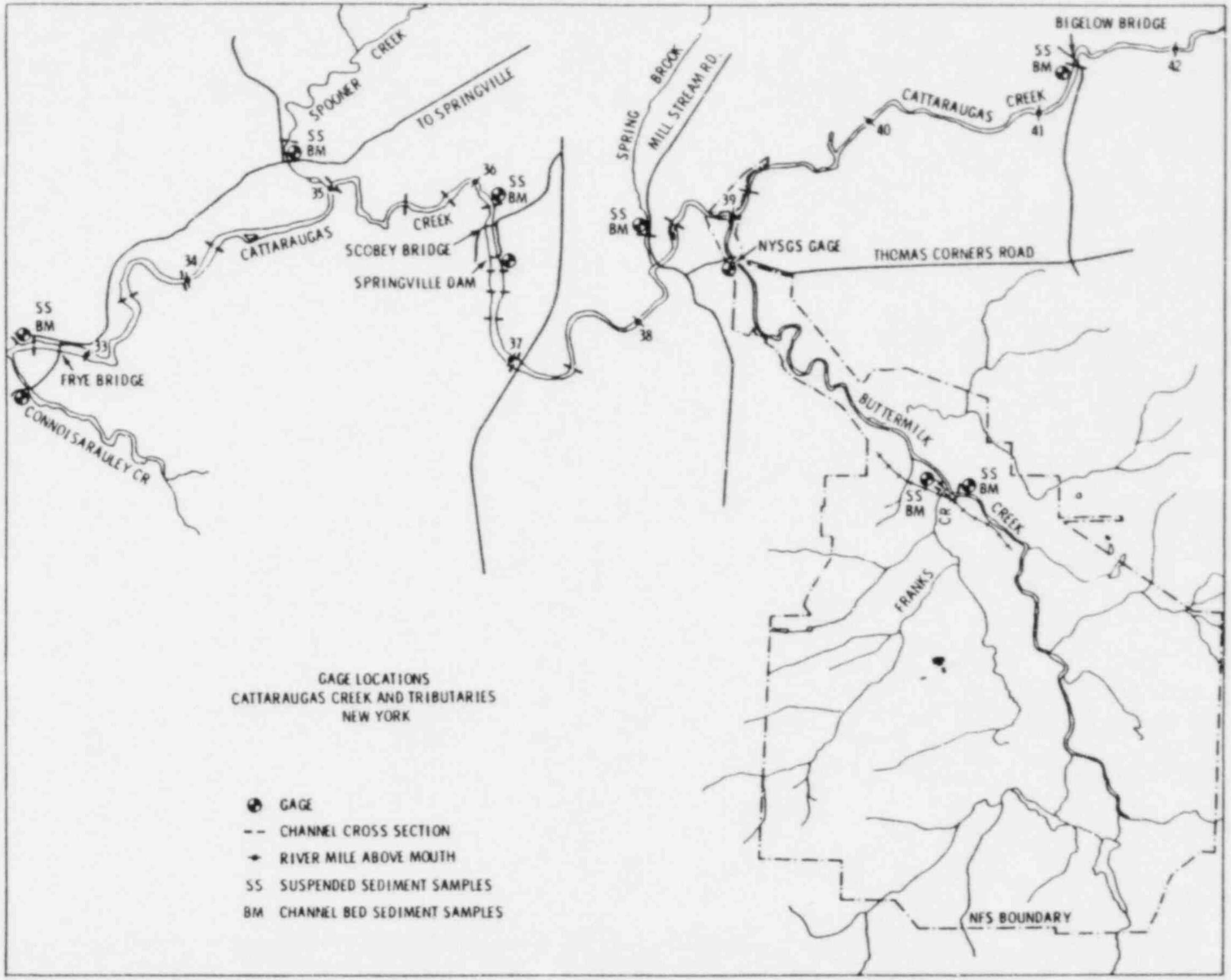

FIGURE B.1. Gage Locations of Cattaraugas Creek and Tributaries, New York personnel, the continuous record of the Thomas Corners Bridge gage was used to insure all surges were accounted for. During the monitoring period only one surge occurred and gage readings taken at the upstream inflow point corresponds very closely with those at Thomas Corners Bridge. An instream discharge measurement was also obtained at the peak of the surge.

Suspended sediment samples are required at all inflow points on Cattaraugus and Buttermilk Creeks. Samples were also taken immediately below the dam and at the outflow point below Frye Bridge as a check on the amount of sediment being transported through the system. Bed material samples are required at these locations to determine a size distribution of the sand available for transport. This information together with the water discharge will be used to compute channel bed material transport rates.

Stream Gage Network

Establishment of Gages

The staff gages were fabricated in the field using 3/4 in. galvanized pipe in lengths of 4 ft. One inch wide masking tape was used to outline 1 in. divisions with black and red spray paint as shown in Figure B.2. The painted pipe sections were driven into the stream bed about 2 ft and tied back with 1/8 in. cable or nylon rope for stability.

Monitoring of Gages

Beginning at 0730 on April 26, 1979 the reading of all gages in the study area commenced. The readings were taken by field personnel including the gage at Connoisarauley Creek which is very near the Frye Bridge gaging station. The auxiliary gage at South Branch Cattaraugus Creek proved to be too far downstream to effectively monitor, therefore, only two readings area available for that location. The gage readings are tabulated in Tables B.1 through B.9 for all monitored gages.

Water Discharge Measurements

Velocity measurements at specified intervals across the cross-section are required in order to determine the water discharge for the range of water

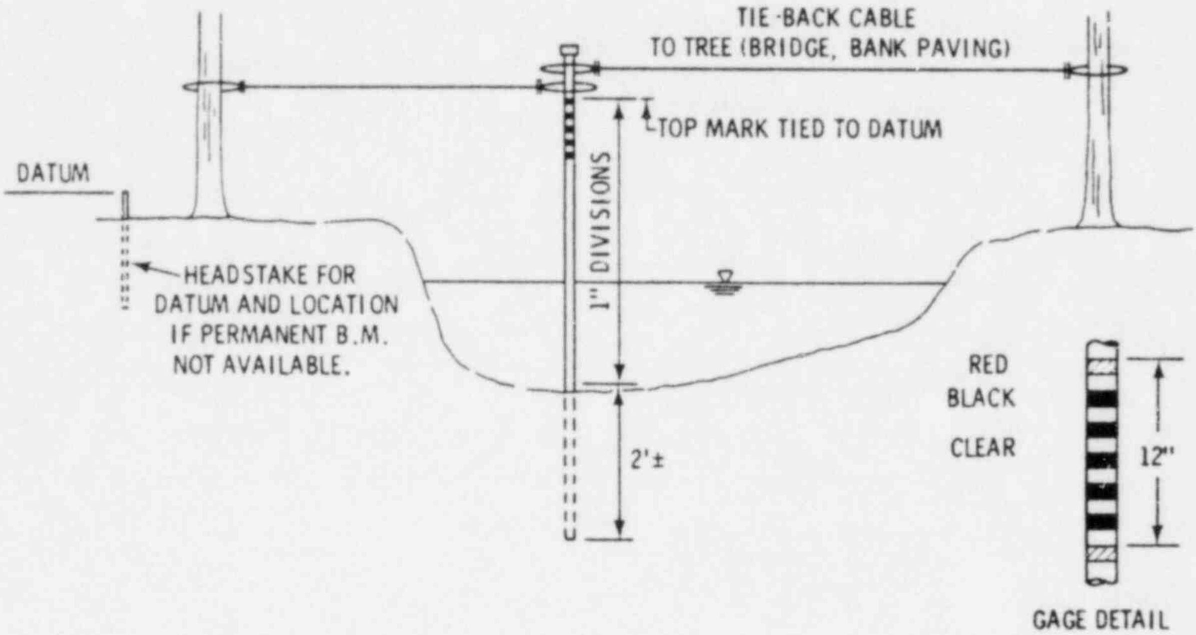

FIGURE B.2. Typical Staff Gage Installation for Recording Changes in Water Surface Elevation

surface elevations during the monitoring period. The velocity measurements together with the cross-sectional area and water surface slope will determine the water discharge and channel roughness. These data would then be used to develop discharge hydrographs for each gage location. The discharge hydrographs would be used as input at all inflow points for the unsteady state flow modeling.

Sediment Sampling

Five suspended sediment samples were collected in plastic 1 liter bottles at each inflow and outflow point and below the dam. The number of samples was limited by project costs but it is believed that enough samples were collected to determine the changes in sediment inflow. One bed material sample was collected at the sampling points by scooping materials from the bed at two or three locations along the discharge range. The wash load samples are tabulated in Table B.10. Table B.11 is a summary of collected data for all gage locations.

TABLE B.1. Water Surface Stages, Buttermilk Creek

Location: Gage at left bank about 150 ft upstream of Franks Creek and about 12,500 ft upstream of Cattaraugas Creek at station BC-1A.

Datum: Top of gage = 100.0 ft. (arbitrary)

Date	Time	Stage	Remarks
4/26/79	0930	95.71	
	1030	95.71	
	1100	95.71	
	1140	95.71	
	1205	95.71	
	1230	95.71	
	1300	95.71	
	1330	95.71	
	1400	95.71	
	1430	95.71	
	1500	95.71	
	1530	95.71	
	1600	95.71	
	1730	95.71	
	1830	95.71	
	1930	95.71	
	2030	95.71	Light rain
	2130	95.71	Intermittent rain
	2230	95.71	Heavy rain
	2330	95.71	Rain stopped
4/27/79	0030	95.71	
	0130	95.71	
	0230	95.71	
	0330	95.71	
	0350	no reading	Light rain
	0410	no reading	Rain stopped
	0430	95.75	Light rain
	0500	95.75	Light rain
	0530	95.75	Light rain
	0600	95.75	Light rain
	0630	95.75	Very light rain
	0945	95.92	Steady rain increased sediment load
	1100	95.92	
	1200	96.00	
	1300	96.00	
	1400	96.04	
	1505	96.04	
4/27/79	1600	96.04	
	1705	96.00	

TABLE B.1. Continued

Date	Time	Stage	Remarks
	1730	96.42	
	1737	96.50	
	1739	96.54	
	1741	96.58	
	1745	96.58	
	1758	96.50	
	1815	96.54	
	1830	96.54	
	1855	96.54	
	1917	96.54	
	1934	96.54	
	1955	96.04	
	2020	95.96	
	2110	95.87	
	2130	95.87	
	2200	95.87	
	2300	95.87	
4/28/79	0000	95.83	
	0100	95.83	
	0200	95.79	
	0300	95.79	
	0400	95.79	
	0500	95.79	
	0600	95.79	
	0700	95.79	
	0830	95.79	
	0925	95.79	
	1030	95.79	
	1128	95.79	
	1230	95.79	
	1330	95.79	Cloudy
	1430	95.79	
	1540	95.79	
	1630	95.79	Intermittent rain
	1730	95.79	Steady light rain
	1830	95.79	Rain continuing
	1930	95.79	Rain stopped
	2030	95.79	
	2130	95.79	
	2230	95.79	Cloud cover breaking up
	2330	95.79	
4/29/79	0030	95.79	
	0130	95.79	
	0200	95.79	
	0330	95.79	
	0602	95.79	

TABLE B.2. Water Surface Stages, Franks Creek

Location: Gage at left wall of railroad culvert barrel about 150 ft upstream of Buttermilk Creek at sampling station FC-1.

Datum: Top of gage = 100.0 ft. (arbitrary)

Date	Time	Stage	Remarks
4/26/79	0940	97.33	wind 5-10 mph (est.)
	1035	97.33	
	1135	97.33	
	1230	97.33	
	1330	97.33	
	1430	97.33	
	1500	97.33	
	1730	97.33	
	1830	97.33	
	1930	97.33	
	2030	97.33	Light rain
	2130	97.37	
	2230	97.33	Heavy rain
	2330	97.37	Rain stopped
4/27/79	0030	97.33	
	1030	97.33	
	0230	97.37	
	0330	97.33	
	0350	97.33	Light rain
	0410	97.33	Rain stopped
	0430	97.33	Light rain
	0500	97.33	Light rain
	0530	97.37	Light rain
	0600	97.37	Light rain
	0630	97.42	Steady rain increased sediment load
	0945	97.46	
	1100	97.46	
	1200	97.50	
	1300	97.50	
	1400	97.50	
	1505	97.50	
	1605	97.50	
	1707	97.50	
	1800	97.50	
	1900	97.46	
	1953	97.45	

TABLE B.2. Continued

Date	Time	Stage	Remarks
4/27/79	2110	97.46	
	2200	97.46	
	2300	97.42	
4/28/79	0000	97.42	
	0100	97.42	
	0200	97.42	
	0300	97.42	
	0400	97.42	
	0500	97.37	
	0600	97.37	
	0700	97.37	
	0827	97.37	Warm and sunny Light breeze
	0920	97.37	
	1035	97.37	
	1125	97.37	
	1225	97.37	Cloudy
	1325	97.37	
	1425	97.37	
	1530	97.37	
	1630	97.37	Intermittant rain
	1730	97.42	Steady light rain
	1830	97.42	Raining
	1930	97.42	Rain stopped
	2030	97.42	
	2130	97.42	
	2230	97.42	Cloud cover breaking up
	2330	97.42	
4/29/79	0030	97.42	
	0130	97.42	
	0200	97.42	
	0330	97.42	
	0600	97.42	

TABLE B.3. Water Surface Stages, Cattaraugas Creek at Bigelow Bridge

Location: Gage at right bank under bridge 41.3 miles upstream of Lake Erie at sampling station CC-1.

Datum: Top of gage = 100.0 ft. (arbitrary)

Date	Time	Stage	Remarks
4/26/69	0845	95.79	
	1150	95.79	
	1538	95.79	
	2125	95.79	Light rain
	2252	95.79	Light rain
4/27/79	0105	95.79	
	0225	95.79	
	0405	95.83	Light rain
	0530	95.83	Light rain
	0700	95.83	Light rain
	0835	95.87	
	1040	95.92	Light rain
	1223	95.96	
	1530	96.04	
	1710	96.04	
	2100	96.08	
	2227	96.12	
4/28/79	0015	96.12	
	0250	96.08	
	0437	96.04	
	0550	96.04	
	0825	96.00	
	1010	96.00	
	1200	95.96	
	1420	96.96	
	1845	95.87	Light rain
	2235	95.92	
	2250	95.92	
4/29/79	0200	95.96	
	0335	95.87	
	0523	95.87	
	0740	95.87	

TABLE B.4. Water Surface Stages, Spooner Creek

Location: Gage at left bank under Zoar Valley Road Bridge
0.5 miles upstream of Cattaraugas Creek

Datum: Top of gage = 100.0 ft. (arbitrary)

Date	Time	Stage	Remarks
4/26/79	0730	97.21	Wind 5-10 mph (est.)
	1053	97.21	Wind 0-5 mph (est.)
	1415	97.21	Wind 5-10 mph (est.)
	2000	97.17	Light rain
	2150	97.17	Light rain
	2335	97.21	Light rain
4/27/79	0125	97.21	
	0255	97.21	Light rain
	0440	97.21	Light rain
	0620	97.25	
	0755	97.29	
	0940	97.29	Light rain
	1056	97.25	
	1400	97.29	
	1615	97.25	
	1740	97.25	
	2120	97.25	
	2300	97.29	
4/28/79	0100	97.33	
	0320	97.29	
	0455	97.29	
	0730	97.25	
	0915	97.25	
	1105	97.25	
	1330	97.25	
	1730	97.21	Light rain
	2145	97.21	
	2250	97.25	
4/29/79	0050	97.29	
	0230	97.29	
	0430	97.29	
	0646	97.25	

TABLE B.5. Water Surface Stages. Springville Dam - Cattaraugas Creek

Location: Gage attached to steel ladder in forebay of power plant 36.4 miles upstream of Lake Erie near sampling station CC-5.

Datum: Top of gage = 0.0 ft. (level with spillway crest)

Date	Time	Stage	Remarks
4/26/69	0800	0.25	
	1117	0.25	
	1456	0.25	
	2040	0.25	Light rain
	2218	0.25	Light rain
4/27/79	0035	0.25	Light rain
	0330	0.21	
	0515	0.25	Light rain
	0640	0.33	Light rain
	0822	0.38	
	1005	0.29	
	1153	0.38	
	1445	0.50	
	1655	0.50	
	1845	0.50	
	2200	0.54	
	2335	0.50	
4/28/79	0155	0.58	
	0405	0.58	
	0525	0.54	
	0805	0.42	
	0905	0.42	
	1133	0.42	
	1402	0.42	
	1800	0.33	Light rain
	2215	0.38	
	2325	0.33	
4/29/79	0120	0.33	
	0300	0.33	
	0459	0.33	
	0715	0.21	

TABLE B.6. Water Surface Stages, Cattaraugas Creek at Scobey Bridge

Location: Gage at right bank about 500 ft downstream of Scobey Hill Road Bridge 36.15 miles upstream of Lake Erie

Datum: Top of gage = 100.0 ft. (arbitrary)

Date	Time	Stage	Remarks
4/26/79	0812	94.83	
	1126	94.83	
	1510	94.83	
	2045	94.83	
	2225	94.83	
4/27/79	0020	94.83	
	0155	94.83	
	0320	94.83	
	0505	94.87	Light rain
	0635	94.87	Light rain
	0816	94.92	
	1014	94.96	
	1201	95.04	Raining
	1500	95.21	
	1645	95.17	
	2150	95.21	
	2325	95.17	
4/28/79	0215	95.17	
	0415	94.17	
	0530	95.17	
	0755	95.12	
	0945	95.12	
	1130	95.08	
	1335	95.04	
	1815	95.00	Light rain
	2205	94.96	
	2320	94.92	
4/29/79	0125	94.96	
	0310	94.92	
	0506	94.96	
	0715	94.96	

TABLE B.7. Water Surface Stages, Spring Brook

Location: Gage at center of channel about 1000 ft upstream of Cattaraugas Creek

Datum: Top of gage = 100.0 ft. (arbitrary)

Date	Time	Stage	Remarks
4/26/79	0833	97.67	
	1142	97.67	
	1525	97.67	
	2100	97.62	Light rain
	2240	97.62	Light rain
4/27/79	0055	97.62	
	0215	97.67	
	0355	97.52	Light rain
	0520	97.67	Light rain
	0655	97.71	Light rain
	0820	97.71	
	1028	97.71	
	1215	97.75	
	1515	97.75	
	1704	97.71	
	2050	97.71	
	2215	97.71	
	2359	97.71	
4/28/79	0230	97.67	
	0425	97.67	
	0540	97.67	
	0815	97.67	
	1003	97.67	
	1145	97.67	
	1410	97.61	
	1830	96.67	Light rain
	2225	96.67	
	2340	97.61	
4/29/79	0135	97.67	
	0325	97.61	
	0515	97.67	
	0730	96.57	

TABLE B.8. Water Surface Stages Cattaraugus Creek at Frye Bridge

Location: Gage at righe bank about 900 ft downstream of Fry Bridge 32.7 miles upstream of Lake Erie.

Datum: Top of gage = 100.0 ft (arbitary)

Date	Time	Stage	Remarks
4/26/79	0740	94.83	debris on gage
	1059	94.83	
	1428	94.83	
	2015	94.79	light rain
	2200	94.79	light rain
	2322	94.79	light rain
4/27/79	0135	94.79	
	0300	94.83	
	0430	94.79	light rain
	0605	94.83	
	0745	94.87	
	0947	94.87	
	1103	94.87	light rain
	1410	95.04	
	1424	95.00	
	1748	95.04	
	2130	95.17	
	2310	95.12	
4/28/79	0135	95.17	
	0330	95.12	
	0503	95.12	
	0740	95.08	
	0925	95.04	
	1350	95.00	
	1745	94.96	light rain
	2145	94.92	
	2300	94.92	
4/29/79	0057	94.92	
	0240	94.92	
	0441	94.92	
	0653	94.87	

TABLE B.9. Water Surface Stages, Connoisarauley Creek

Location: Gage at left bank tied to bridge Wingwall about 0.4 miles upstream of Cattaraugas Creek

Datum: Top of gage = 100.0 ft. (arbitrary)

Date	Time	Stage	Remarks
4/26/79	0745	96.92	
	1102	96.92	
	1438	96.92	
	2020	96.92	Light rain
	2203	96.92	Light rain
	2325	96.92	Light rain
4/27/79	0140	96.92	
	0305	97.00	
	0435	96.96	Light rain
	0610	97.00	
	0748	97.04	
	0952	97.04	
	1108	97.13	
	1420	97.08	
	1626	97.08	
	1750	97.08	
	2137	97.04	
	2320	97.04	
4/28/79	0141	97.00	
	0335	97.00	
	0506	97.00	
	0745	97.00	
	0930	97.00	
	1110	97.00	
	1440	97.00	
	1750	96.96	Light rain
	2150	96.96	
	2310	96.96	
4/29/79	0100	97.00	
	0245	97.00	
	0444	96.96	
	0655	96.96	

TABLE B.10. Suspended Sediment Samples

(Wash Load Only)

Location	Sample No.	Date	Time	Stage	Concentration (mg/)
Franks Creek (FC-1)	1	4-26	1635	97.33	60.0
	2	4-27	1100	97.46	238.0
	3	4-28	0920	97.37	88.3
	4	4-28	1425	97.37	84.0
	5	4-29	0556	97.42	128.2
Buttermilk Creek (BC-1A)	1	4-26	1637	95.71	3.7
	2	4-27	1100	95.92	31.4
	3	4-28	0925	95.79	8.3
	4	4-28	1430	95.79	1.4
	5	4-29	0559	95.79	8.4
Cattaraugas Creek at Bigelow Bridge (CC-1)	1	4-26	1538	95.79	4.05
	2	4-27	1530	76.04	28.0
	3	4-28	0250	96.08	49.8
	4	4-28	1845	95.87	27.2
	5	4-29	0035	95.87	3.8
Cataraugas Creek at Scobey Bridge	1	4-26	1510	94.83	13.7
	2	4-27	1500	95.31	37.9
	3	4-28	0215	95.17	39.6
	4	4-28	1815	95.00	15.6
	5	4-29	0310	94.92	4.4
Cattaraugas Creek at Frye Bridge	1	4-26	1428	94.83	3.2
	2	4-27	1410	95.04	17.6
	3	4-28	0135	95.17	44.8
	4	4-28	1745	94.96	24.3
	5	4-29	0240	94.92	4.2

TABLE B.10. Continued

Location	Sample No.	Date	Time	Stage	Concentration (mg/)
Spring Brook	1	4-26	1525	94.67	127.2
	2	4-27	1515	97.75	199.8
	3	4-28	0230	97.67	212.1
	4	4-28	1820	97.67	191.8
	5	4-29	0325	97.61	132.4
Spooner Creek	1	4-26	1415	97.21	28.2
	2	4-27	1400	97.29	11.4
	3	4-28	0100	97.33	31.4
	4	4-28	1730	97.21	5.2
	5	4-29	0230	97.29	(a)

(a) sample container damaged in shipment

TABLE B.11. Data Summary

GAGE LOCATION	STAGE	VELOCITY	CROSS SECTION	WATER SURFACE SLOPE	SUSPENDED SEDIMENT	CHANNEL BED SEDIMENT	REMARKS
FRANKS CREEK	●	●	●		●	●	INFLOW
BUTTERMILK CREEK	●	●	●	●	●	●	INFLOW
THOMAS CORNERS BRIDGE	● (1)						INTERMEDIATE GAGE BUTTERMILK CREEK
BIGELOW BRIDGE	●	●	●	●	●	●	INFLOW
SPRINGVILLE DAM	● (2)						CONTROL SECTION AND RESERVOIR
SCOBEY BRIDGE	●	●	●	●	●	●	INTERMEDIATE GAGE DOWNSTREAM OF DAM
FRYE BRIDGE	●	●	●	●	●	●	OUTFLOW
SPRING BROOK	●	●	●	●	●	●	INFLOW
SPOONER CREEK	●	●	●	●	●	●	INFLOW
CONNOISARAULEY CREEK	●	●	●	●			INFLOW-AUXILIARY GAGE (3)
SOUTH BRANCH CATTARAUGAS CREEK	●	●	●	●			INFLOW-AUXILIARY GAGE (3)

1. NEW YORK STATE GEOLOGICAL SURVEY AUTOMATIC STAGE RECORDER.
2. DEPTH OF FLOW OVER SPILLWAY.
3. AUXILIARY GAGES TO MONITOR FLOW FROM TYPICAL LARGE TRIBUTARY BASINS.

APPENDIX C

UNIVERSITY OF WASHINGTON

LABORATORY OF RADIATION ECOLOGY

METHODS OF ANALYSIS

UNIVERSITY OF WASHINGTON
LABORATORY OF RADIATION ECOLOGY

SUMMARY OF QUALITY CONTROL RESULTS OF RADIONUCLIDE ANALYSIS

INTRODUCTION

During the time period 1971-1979 the Laboratory of Radiation Ecology (LRE) has participated in internal, external, national, and international programs to compare measurements of radionuclides and stable elements. Standards as well as environmental samples have been interchanged between several laboratories including LRE and the results are reported here.

We have measured and reported about 160 intercomparison samples on about 20 radionuclides. The analysis included: gamma radionuclides by Ge(Li) diode and NaI(Tℓ) crystal methods , alpha radionuclides (by alpha spectroscopy methods for $^{238,239}Pu$, ^{241}Am, ^{210}Pb, and ZnS screen and phototube counting for gross alpha radionuclides), beta radionuclides (by radiochemistry methods for ^{90}Sr, ^{131}I, by liquid scintillation method for tritium and by low background gas counting for gross beta radionuclides), and x-ray radionuclides (by radiochemistry methods for ^{55}Fe and x-ray proportional counting); measurements of trace elements have been made by NAA and AAS methods.

It has been our policy to treat the incoming standard samples identical to incoming normal environmental samples so that our internal reliability could also be checked. No special precautions have been taken in the measurement of the quality control samples.

MEASUREMENTS OF GAMMA-RAY EMITTING RADIONUCLIDES

Measurements of the concentrations of ^{241}Am and other gamma-emitting radionuclides in samples have been made using a 1 cm^2 Ge (intrinsic)[a] detector coupled to a 400-channel pulse height analyzer for ^{241}Am and two 7.3%[b] Ge(Li)[c] detector systems coupled to two 4096 channel pulse height analyzers with a PDP-5 computer data processing and reduction system. These detection systems have been cross calibrated with the two 5 x 5 Na(Tℓ) crystal detector systems which were used previously. In addition to the cross calibration between instruments, interlaboratory calibration of samples have been made continuously over the years to insure reliability in our measurements.

(a) Applied Detector Corporation, Menlo Park, California
(b) Absolute detection efficiency for 1.33 McV gamma rays relative to a 30% efficient NaI(Tℓ) detector
(c) Nuclear Diodes, Inc., Prairie View, Illinois (presently Edax International)

The absolute counting efficiency of each instrument was determined as a function of γ-ray energy by counting a series of standards prepared in the same geometry as that used to count the samples. Each standard was prepared and contained a known amount of a given radionuclide; these standard solutions were obtained from the N.B.S. or a commercial supplier, usually Amersham. An aliquot of each standard solution was added to an acrylic casting resin and homogenized by stirring until the resin set. Each encapsulated standard was thus uniformly distributed in the volume of the counting container (2' x 1/2", 2" x 1", 3" x 2") at a standard density of 1.1 g/cc and was a "permanent" standard for future calibration checks. The results of these calibrations are shown in Figure C.1 which shows the detector efficiencies as a function of gamma energy.

Since the cpm to dpm conversion factor, which was needed to calculate the absolute radionuclide concentrations of the sediment, biota and water samples from the counting data, was a function of several variables; (e.g., gamma-ray energy and bulk density) standards were prepared at a bulk density of 1.35 by adding NaCl to increase the density of the acrylic casting resin from 1.1 to cover the range normally found in our samples. The appropriate conversion factor for each sample (density) was then approximated by linear interpolation, between the values found for the 1.1 and 1.35 g/cc density standards.

The error that could result due to possible variation of the linear dependence assumption described above was estimated by considering the case where density changes gave logarithmic rather than linear changes in the correction factor. The maximum error that could result from a logarithmic instead of the assumed linear dependence was estimated by measuring the difference in the value of the two correction factors in samples which were at the extremes of sample densities encountered (0.6 and 1.6 g/cc). The difference found using the two correction factors was 7.3% for the sample geometry and density limit of the lowest energy radionuclide of ^{241}Am (most sensitive test). For radionuclide concentrations which were determined by using higher energy gamma-rays (>59.5 Kev) and for the majority of samples which were not at the extreme limits of the densities, the error which would arise due to this uncertainty was smaller than 7.3%.

The abundance of each γ-ray observed in the spectrum was used to calculate the concentration of the radionuclide present using a weighted mean concentration of each gamma peak and its associated error (Stevenson 1966). The error term associated with the counting are 2 S.D. errors based on propagated counting statistics.

The results of interlaboratory comparisons of concentration of the gamma-emitting radionuclides in the standards and environmental samples measured are shown in Table C.1.

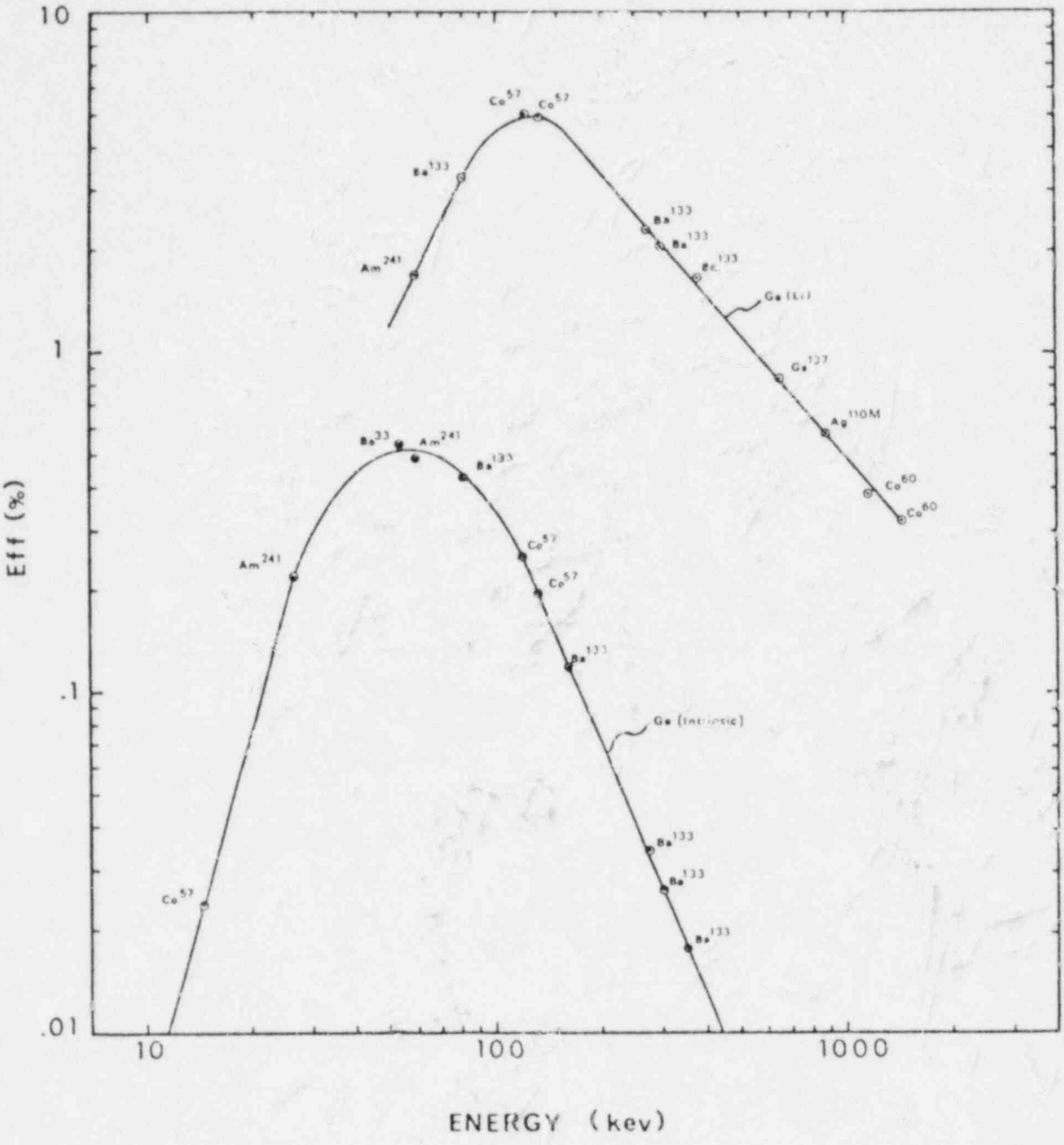

FIGURE C.1. Absolute Counting Efficiency of the Ge(Li) and Ge(Intrinsic) Detectors with Gamma-Ray Energy as Determined by Counting Radionuclide Standards Made to a Sample Density of 1.1 g/cc

TABLE C.1. Results of Interlaboratory Comparisons of Gamma and Beta Radionuclides in Samples

Sample	Type	Date	Lab	^{90}Sr	^{95}Zr-^{95}Nb	^{106}Ru	^{134}Cs	^{137}Cs
35065 MA B-1	Clam Homogenate	June 76	IAEA	7.4 ± .8		4.3 ± .6	.29 ± .06	16.24 ± .4
			LRE	6.5 ± .3		5 ± 1	.25 ± .07	18.0 ± .4
35066 MA B-2	Sea Hare	June 76	IAEA	.31 ± .09			3.0 ± 1.4	4.1 ± .3
			LRE					4.8 ± .3
[illegible] Milk A-9	Milk	June 76	IAEA	.49 ± .02				2.14 ± .09
			LRE	.48 ± .04				2.40 ± .3
35000 AG-I-1	Seaweed	May 72	IAEA	10.0 ± .1	2.5 ± .3	137 ± 6	10.3 ± .3	75 ± 1.
			LRE		2.21 ± .23	126 ± 4	8.5 ± .1	65.7 ± .2
35005 SD-B-1	Sediment	Jan 73	IAEA	13.8 ± .9		73 ± 2	9.6 ± .3	377 ± 6
			LRE			74.4 ± 1.2	9.6 ± .2	450 ± 2
35001 SW-I-1-19	Water	Jan 71	IAEA				1.7 ± .4	14.0 ± 2.0
			LRE				1.1 ± .5	16.6 ± 1.0
35002 SW-I-2-19	Water	Jan 71	IAEA			40 ± 5	26 3	195 ± 14
			LRE			25.0 ± 5	28.2 ± 1.1	232 ± 4
35083 W-1	Water	1975	IAEA	3.55 ± .07				8.15 ± .12
			LRE	3.89 ± .15				7.6 ± .4
35084 W-2	Water	1975	IAEA	52.0 ± 1.0				119.3 ± 1.8
			LRE	54.0 ± 5				131.6 ± 3.4
35139	Diet	18 Feb 77	EPA	55 ± 8				45 ± 15
			LRE	69 ± 6				51 ± 3
35128	Diet	26 Nov 76	EPA	96 ± 14				46 ± 15
			LRE	112 ± 19				50 ± 12
35118	Diet	27 Aug 76	EPA					
			LRE	108 ± 9				31 ± 5
35075	Diet	Dec 75	EPA	125 ± 19				101 ± 15
			LRE	114 ± 23				104 ± 11
35053	Diet	Aug 75	EPA	101 ± 15				121 ± 18
			LRE	88 ± 2				119 ± 3
35038	Diet	Apr 75	EPA	150 ± 23				150 ± 23
			LRE	142 ± 4				155 ± 8
35028	Diet	Dec 74	EPA	175 ± 26				176 ± 26
			LRE	176 ± 2				193 ± 6
35018	Diet	Aug 74	EPA	198 ± 30				205 ± 31
			LRE					243 ± 6
35125	Milk	Nov 76	EPA	16 ± 5				11 ± 5
			LRE					9 ± 1
35110	Milk	Jul 76	EPA	0				75 ± 15
			LRE	5.8 ± 1				78 ± 7
35090	Milk	Mar 76	EPA	50 ± 7				25 ± 15
			LRE	53 ± 5				22 ± 2
35072	Milk	Nov 75	EPA	75 ± 11				75 ± 15
			LRE	68 ± 6				85 ± 2
35035	Milk	Mar 75	EPA	50 ± 8				
			LRE	51 ± 7				
35046	Milk	Jul 75	EPA	97 ± 14				70 ± 15
			LRE	89 ± 8				78 ± 4
35022	Milk	27 Nov 74	EPA	102 ± 15				101 ± 15
			LRE	10.9 ± .6				95 ± 8
35138	Water	4 Feb 77	EPA			151 ± 23	76 ± 15	39 ± 15
			LRE			105 ± 17	50 ± 7	29 ± 3
35154	Water	3 Jun 77	EPA			* *	*	*
			LRE			61 ± 3	38 ± 1	32 ± 2
35086	Water	20 Feb 76	EPA			336 ± 50	230 ± 35	361 ± 54
			LRE			253 ± 17	209 ± 2	368 ± 5
35124	Water	10 Oct 76	EPA					
			LRE			75 ± 17	82 ± 10	37 ± 5
35106	Water	18 Jun 76	EPA			79 ± 15	106 ± 16	53 ± 15
			LRE			27.4 ± 9	79 ± 3	40 ± 2
35067	Water	Oct 75	EPA			247 ± 37	349 ± 52	274 ± 41
			LRE			217 ± 19	325 ± 4	270 ± 5
35042	Water	Jun 75	EPA			325 ± 49	303 ± 46	378 ± 57
			LRE			293 ± 6	267 ± 7	369 ± 4
35031	Water	Feb 75	EPA				422 ± 63	472 ± 71
			LRE			<20	315 ± 7	398 ± 4
35021	Water	Oct 74	EPA			0 ± 15	481 ± 72	0 ± 15
			LRE			30	485 ± 61	< 6
	Water	May 74	EPA			0 ± 15	0 ± 15	0 ± 15
			LRE			<1.9	.2	<.2

* EPA results not yet received

TABLE C.1. (contd)

^{144}Ce	^{40}K	^{154}Eu	^{155}Eu	^{60}Co	^{110}Ag	^{226}Ra	^{3}H
2.7 ± .5							
2.8 ± .5							
<2				166 ± 7			
				177 ± 2			
17.4 ± .9	39 ± 3						
14.7 ± 2.8	36 ± 1		1.5 ± .2	2.0 ± .1	1.5 ± .1		
		.11 ± .01	1.5 ± .1	1.8 ± .1	1.2 ± .1		
129 ± 5							
118 ± 4	11.2 1.5						
		.94 ± .15	4.44 ± .2				
				51.5 ± .8		3.64 ± .3	2.54 ± .09
				43.1 ± 1			
				2.53 ± .04		53.3 ± 4.5	45.3 ± 1.6
				2.30 ± .02			
	2670 ±401						
	2472 ± 83						
	2745 ±412						
	2583 ±237						
	2496 ±332						
	2414 ±362						
	2202 ±200						
	2352 ±353						
	1933 ±200						
	2216 ±333						
	2165 ±313						
	2619 ±393						
	2467 ±115						
	2389 ±358						
	2500 ±200						
	1510 ± 76						
	1403 ±106						
	1550 ±233						
	1356 ± 66						
	1529 ±229						
	1563 ±290						
	1549 ±233						
	1700 ±192						
	1514 ±228						
	1366 ±150						
	1495 ±224						
	1114 ±158						
				45 ± 15			
				39 ± 5			
				*			
				26 ± 1			
				209 ± 31			
				200 ± 4			
				24 ± 3			
				53 ± 15			
				48			
				271 ± 41			
				273 ±			
				350 ± 53			
				324 ± 12			
				437 ± 66			
				420 ± 14			
				0 ± 15			
				<6			
				0 ± 15			
				<.3			

TABLE C.1. (contd)

^{131}I	^{241}Am	^{125}Sb	^{140}Ba	^{51}Cr	^{65}Zn
		2.8 ± .5			
81 ± 15					
109 ± 24					
0			39 ± 15		
<30			72 ± 10		
115 ± 29			174 ± 31		
127 ± 19			0		
112 ± 19			<35		
0			145 ± 22		
<40			<200		
149 ± 22			0		
154 ± 2			<50		
175 ± 26			0 ± 15		
200 ± 10			<55		
216 ± 32			207 ± 31		
250 ± 10			173 ± 6		
85 ± 5			0		
84 ± 10			<20		
51 ± 15			0		
48 ± 2			<12		
75 ± 15			0		
70 ± 3			<26		
75 ± 15			0		
13 ± 5			<56		
76 ± 15			0		
116 ± 6			<20		
			0		
>.25			<38		
126 ± 19			0		
119 ± 10			< 2		
				202 ± 30	37 ± 15
				173 ± 11	37 ± 6
				*	*
				< 8	79 ± 4
				0	445 ± 67
				<18	472 ± 11
				<10	55 ± 9
				0	79 ± 15
				<8	75.1
				0	250 ± 38
				<18	277 ±
				0	327 ± 49
				<20	330 ± 6
				0	472 ± 71
				<30	487 ± 4
				0 ± 15	0 ± 15
				<90	<5
				349 ± 52	0 ± 15
				482 ± 30	<.1

MEASUREMENTS OF BETA EMITTING RADIONUCLIDES

The beta-emitting radionuclides are measured using gas flow and liquid scintillation counting. The radionuclides which are measured in samples using the gas flow counters are ^{90}Sr and ^{131}I; radicchemical procedures for sample preparation are required. The results of these interlaboratory comparisons are shown in Table C.1.

MEASUREMENTS OF TRITIUM

The measurements for tritium in samples have been made by liquid scintillation methods using Instagel (Packard Instrument Co.) and a low background (4.6 c/m) detection system (Packard Tricarb). The mixture of water: Instagel was 8 cc. H_2O: 12 cc Instagel; these procedures were adopted from Sauzay and Schell (1971). Table C.2 shows that our tritium values are consistently within the measurement errors stated by EPA.

ALPHA SPECTROSCOPY MEASUREMENTS

Instrumentation and calibrations: the measurement of radioactivity by alpha spectroscopy was made by using eight 300 mm^2 silicon surface barrier diodes. Each of the two counting systems available for use consisted of four diodes, preamplifiers and amplifiers routed through a router-mixer to each of four 128-channel quadrants of a 512-channel multichannel analyzer (MCA). The MCA memory was dumped into both tynwriter (digital) and graphical (analog) outputs after typical counting periods of 800 minutes. The detector amplifier gain was adjusted to 9 keV/channel. The resolution of the diodes (FWHM) was 20 keV or better. Background count rates of the four diodes used for plutonium and uranium analysis were 0-8 counts/800 minutes under each of the observed alpha peaks. Background count rates of the four diodes used for polonium analysis were typically 5 counts/800 minutes/peak.

The absolute disintegration rate of the isotopes of plutonium, uranium and ^{208}Po in the plated samples was determined by computing the ratio of the count rate observed for each isotope to the count rate for a secondary standard of known disintegration rate; corrections were made for background count rate, alpha particle branching ratios, and any impurities in the radiochemical spikes.

The disintegration rate of the secondary standards of plutonium was determined by similar calibrations with a standard ^{236}Pu solution supplied by the AEC Health and Safety Laboratories (HASL). The reliability of the plutonium calibration was verified by the agreement between the concentrations of plutonium found by this laboratory and those found by other laboratories in an interlaboratory standard solution of $^{239,240}Pu$ and ^{238}Pu concentrations measured by LRE in seaweed and sediment samples supplied by the International Atomic Energy Agency (IAEA) were also in agreement with the values recommended by the IAEA. The results of both these calibrations are shown in Table C.3.

TABLE C.2. Results of Interlaboratory Comparison of Tritium in Water Samples

Sample	Type	Date	Lab	^{3}H
35132	Water Cross Check	Dec. 76	EPA	2300 ± 1049
			LRE	2287 ± 65
---	Water Cross Check	Oct. 76	EPA	58 ± 5
			LRE	55 ± 9
---	Water Cross Check	Aug. 76	EPA	3100 ± 1080
			LRE	3200 ± 104
---	Water Cross Check	Apr. 76	EPA	1776 ± 1024
			LRE	1793 ± 42
35096	Water solution standard	May 76	EPA	No values available
			LRE	7.15 ± 0.26; 27.4 ± 0.08; 312.3 ± 0.14; 221.2 ± 3.1
35078	Water Cross Check	Dec. 75	EPA	1002 ± 972
			LRE	1000 ± 52
35050	Water Cross Check	Aug. 75	EPA	3200 ± 1083
			LRE	3337 ± 67
35036	Water Cross Check	Apr. 75	EPA	1499 ± 1002
			LRE	1540 ± 60
35026	Water Cross Check	Dec. 74	EPA	3395 ± 1095
			LRE	3449 ± 30
35017	Water Cross Check	Aug. 74	EPA	1438 ± 933
			LRE	1447 ± 74
---	Water Cross Check	May 74	EPA	2673 ± 1050
			PRE	2717 ± 38
35146	Water Cross Check	Apr. 77	EPA	1760 ± 1023
			LRE	1702 ± 41

TABLE C.3. Results of Interlaboratory Analysis of Samples for $^{239,240}Pu$

A. Standard Reference materials, solutions, soils

Sample	Type	Date	Laboratory	$^{239,240}Pu$	Comments
35005 SD-B-1	sediment	January 73	IAEA	960 ± 30	^{238}Pu 42 ± 4
			LRE	950 ± 70	^{238}Pu (N.D.)
35000 AG-I-1	seaweed	January 72	IAEA	27000 ± 100	Pu 3800 ± 100
			LRE	23400 ±1000	Pu 3100 ± 100
35083 W-1	water	1975	IAEA	3.21 ± 0.05	
			LRE	2.8 ± 0.3	
35149 R-2	water	March 77	EPA	1110 ± 100	Round robin study
			LRE	990 ± 44	
Soil - 2	soil	January 71	EPA(avg.)	0.30	Cross check study
			LRE	0.16 ± 0.18	
Soil - 3	soil	January 71	EPA(avg.)	2.24	Cross check study
			LRE	0.51 ± 0.13	"High fired" soil
Soil - 4	soil	April 71	EPA(avg.)	1735 ±1220	Cross check study
			LRE	1547 ± 955	Nevada test soil
Soil - 5	soil	May 71	EPA(avg)	208 ± 117	Cross check study
			LRE	96 ± 54	"High fired" soil
Soil - 6	soil	June 71	EPA(avg)	18164 ±2800	Cross check study
			LRE	21433 ± 306	Pacific Islands soil
35047 NBS #4350	river sediment	1975	NBS	.038 ± .003	
			LRE	.042 ± .018	
LLL #110	std. solution	1973	LLL	1303 ± 28	
			LLL	1320 ± 20	
			LLL	1265 ± 5	
			MCL	1255 ± 15	
			MCL	1272 ± 6	
			LFE	1330 ± 27	
			LRE	1273 ± 64	
			EIC	1207 ± 54	

TABLE C.3. (contd)

B. Collection on Joint Cruises.

Sample	Type	Laboratory	$^{239,240}Pu$ Particulate	$^{239,240}Pu$ Total	Avg.±S.D.	Dev. %
			Bikini Atoll - 1972			
Lagoon water - STA B-2	surface	LLL[a]	28 ± 2	107 ± 4	91.3±19	+17
		PRNC[a]		98 ± 7		+ 8
		LRE[b]	30 ± 2	69 ± 4		-24
" - STA B-15	surface	LLL	4.7 ± .6	66 ± 2	49.3±16	+34
		PRNC	--	49 ± 4		-.6
		LRE	3.1 ± .2	33 ± 5		-33
" - STA B-15	29m	LLL	5.6 ± .6	60 ± 3	57.0±21	+ 5
		PRNC	--	76 ± 7		+33
		LRE	6.4 ± .1	35 ± 2		-38
" - STA B-25	surface	LLL	9.7 ± .9	79 ± 3	73.0±8.5	+ 8
		PRNC	--	67 ± 4		- 8
		LRE	--	--		
" - STA B-25	50m	LLL	--	64 ± 3	95 ±44	-33
		PRNC		127 ± 9		+33
		LRE	--	--		
" - STA B-30	surface	LLL	--	--		
		PRNC		55 ± 3	42 ±18	+30
		LRE	2.5 ± .3	29 ± 3		-30

TABLE C.3. (contd)

B. Collection on Joint Cruises (cont'd.)

Sample	Type	Date	Laboratory	$^{239,240}Pu$ Particulate	Total	Avg.±S.D.	Dev. %
Bikini Atoll - 1972 (cont'd.)							
Lagoon water - STA B-30	45m		LLL	--	--		
			PRNC	--	81 ± 2		+15
			LRE	29 ± 1	60 ± 3		-15
Bomb Crater water - STA C-3	surface		LLL	10 ± 1	38 ± 1	44.0±16	-14
			PRNC	--	32 ± 1		-27
			LRE	13.6 ± .3	62 ± 2		+40
" - STA C-3	44m		LLL	22 ± 1	35 ± 2		+ 9
			PRNC	--	--	33 ± 3	
			LRE	24 ± 2	31 ± 3		- 9
" - STA C-8	surface	1972	LLL	--	47 ± 4	59 ±12	-13
			PRNC	--	68 ± 3		+25
			LRE	14.6 ± .6	48 ± 8		-11
Deep ocean water - STA D-1	300m		LLL	--	51 ± 6	28 ±32	+82
			PRNC	--	5 ± 1		-82
			LRE	--	--		
" - STA D-7	surface		LLL	--	3.5 ±0.2	3.45±.07	+ 1
			PRNC	--	--		
			LRE	0.13±0.06	3.4 ±1.2		- 1
Eniwetak Atoll - 1972							
Lagoon water ½ mi. off Leroy	Surface		LLL		18 ± .9	15 ± 4	+20
		½ flood ½ ebb	LRE	0.45 ±0.1	12 ± 3.5		-20
" Enewetak Dock	Surface	?	LLL	--	1.6 ± 0.2	1.43±.25	+12
		flood	LRE	0.47 ±0.1	1.25± 0.2		-12
" Japtan	Surface	?	LLL	--	2.8 ± 7		+30
	Surface	flood	LRE	0.62 ±0.1	1.5 ± 0.2	2.14±.65	-29
	Surface	ebb	LRE	1.15 ±0.2	2.14± 0.4		0

TABLE C.3. (contd)

B. Collection on Joint Cruises (cont'd.) Sample	Type	Date	Laboratory	239, 240Pu Particulate	239, 240Pu Total	Avg.±S.D.	Dev. %
Eniwetak Atoll - 1972 (cont'd.)							
Lagoon water - Runnit Dock	Surface	?	LLL	--	43.6 ± 1.4	} 57.1 ± 19	-23
		½ flood ½ ebb	}LRE	26.9 ±1.4	70.6 ± 6.6		+23
" - 200 yds off Runnit	15m	?	LLL		77.0 ± 3.1	} 69.1 ± 11	+11
		flood	LRE	34.3 ±0.9	61.1 ± 2.6		-11
Crater water - Mike Crater	33m	?	LLL	--	1510 ± 60	} 844 ±941	+79
		ebb	LRE	164 ±5	179 ± 6		-79
" " "	Surface		LLL	--	19.0 ± 0.8	} 20.0±1.5	-5
		flood	LRE	11.13 ±0.6	21.1 ± 5.6		+5
Washington Coastal Waters - 1976							
Coastal Water JDF-8 N 48° 27.1; W 124°45.2"	Surface		BNWL	0.14 ± .01)	(0.69±0.12)	- Sequim Bay	
			LRE	< .06	0.34±0.1		
			LRE		<0.59		
			LRE (batch)		0.5 ±0.25		
JDF-8 (50m) N 48° 30.0'; W 126° 46.0'	Surface		BNWL	0.09 ±0.01	0.12±0.04		
			LRE	<0.008	0.14±0.14		
			LRE	0.061±0.045	0.19±0.19		
			LRE (batch)		< .44		
HOH-5 mi. N 47°40'; W 124°33.6'	Surface		BNWL	0	0.18±0.05		
			LRE	0.03	0.26±0.26		
			LRE (batch)		< .4		

TABLE C.3. (contd)

C. Internal Comparisons of BLVWS and Batch Methods				$^{239,240}Pu$			
Sample	Type	Depth	Method	Particulate	Total	Avg.±S.D.	Dev. %
			Bikini Atoll - 1976				
Lagoon Water	STA B-3	Surface	Batch	--	55.1 ± 7.4	48.9 ± 9	+13
			BLVWS	16.7 ± 1.0	42.7 ± 2		-13
"	"	29 m	Batch	--	72.2 ± 8.2	67.5 ± 7	+ 7
			BLVWS	50.2 ± 3.6	62.9 ± 4		- 7
"	STA B-8	Surf	Batch	--	41.8 ± 9.7	34.7 ±10	+20
			BLVWS	< .3	27.7 ± 3.7		-20
"	"	17m	Batch	--	32.6 ± 6.0	31.7 ± 1.3	+ 3
			BLVWS	2.17 ± .17	30.8 ± 2.4		- 3
"	"	40m	Batch	--	28.3 ± 4.4	28.9 ± .9	- 2
			BLVWS	3.71 ± .5	29.5 ± 4.5		± 2
"	STA B-15	Surf	Batch	--	61.3 ± 22.4	37.5 ±20	+63
			BLVWS	1.6 ± .2	23.5 ± 1.4		-37
			BLVWS	1.9 ± .2	27.8 ± 1.4		-25
"	"	17m	Batch	--	36.2 ± 4.7	34.5 ± 3	+ 5
			BLVWS	1.7 ± .2	32.7 ± 3		- 5
"	"	37m	Batch	--	44.1 ± 9.3	41.3 ± 4	+ 7
			BLVWS	2.3 ± .2	38.4 ± 4.3		- 7
"	STA B-25	Surf	Batch	--	76.7 ± 9.7	59.7 ±24	+28
			BLVWS	2.17 ± .14	42.8 ± 5.7		-28
"	STA B-32	Surf	Batch	--	40.6 ± 9.4	32.9 ± 7	+18
			BLVWS	6.6 ± .4	28.2 ± 2		-14
			BLVWS	6.1 ± .5	29.9 ± 1		- 9
"	"	17m	Batch	--	45.6 ± 5	40.2 ± 8	+13
			BLVWS	5.0 ± .6	34.7 ± 3		-13
"	"	33m	Batch	--	44.6 ± 6	43.5 ± 1.6	+ 3
			BLVWS	10.2 ±1.6	42.4 ± 3		- 3

[a] Samples by LLL and PRNC were collected by the "Batch" method at a time which was usually before the long time BLVWS collections (continued)

[b] The LRE and BNWL samples were collected continuously over a time period at 2-4 hours using the BLVWS sampler which separated the particulate and soluble fractions; in 1972 two sorption beds of Al_2O_3 were used and in 1976 four Al_2O_3 beds were used.

[c] The LRE "Batch" collections were made during the BLVWS pumping to compare directly the two methods. The plutonium method of Wong et al. (1976) was employed.

The disintegration rate of the ^{232}U spike was determined by comparison of the activities of aliquots (in quadruplicate) of the ^{232}U spike and a ^{238}U standard solution electroplated simulatneously onto platinum discs. The ^{238}U solutions used for the standard were prepared by dissolving precisely weighted amounts of 99+% pure ^{238}U "D-38" metal supplied by the LLL.

The ^{208}Po spike was supplied as a radiochemical standard solution by the Amersham/Searle Corporation and has been calibrated several times between 1970-1975 by intercomparing the rdioactivity of plated samples with National Bureau of Standards (NBS), Battelle Northwest Laboratory (BNWL), and the LLL.

Replicate determinations of the plutonium concentration in a dissolved sediment (section 8-10 cm of core B-2) from Bikini Lagoon were performed to provide an estimate of the analytical precision of the radiochemical procedures used for plutonium analysis. The quantity of sediment (dry wt.) in each aliquote processed was 3.19 g. The chemical yield calculated from the counting data for these samples ranged from 22.6 to 40.8%. The precision for the $^{239,240}Pu$ determination was 5.3% of the mean concentration of 2. S.D. for the six analyses. The precision for ^{238}Pu measurement was 11% of the mean at 2. S.D. for the six analyses. The higher deviation about the mean for ^{239}Pu replicates is probably due to poorer counting statistics (average of 124 counts/800 minutes in the 238 peak vs. 5000 counts/800 minutes in the $^{239,240}Pu$ peak); all six ^{238}Pu concentrations found were within 2. S.D. counting errors of each other (Marshall 1975).

Quality control: problems of sample contamination were addressed by the inclusion of spiked reagent blanks with groups of samples. From several such reagent blanks, no significant contamination problem was detected. An evaluation was made of the interferences which might occur from natural and bomb-produced, alpha-emitting radionuclides in the Bikini Atoll samples.

In the plutonium and uranium procedures radium is removed along with the calcium in the chemical separation process. Isotopes of radon which might interfere are short-lived and, being gases, present no problems. Decontamination factors of greater than 1000 are reported by Butler (1968) for the removal of americium, thorium and neptunium from the final uranium samples, and similarly high decontamination factors are reported for the removal of curium and californium (Butler 1965), using TIOA separation procedures. Although Berkelium is unusual among the transamericium actinides, in that it can exist in the 4+ oxidation state (and therefore may not be separated from plutonium and uranium), it can not exist in the 4+ state in the 8 $\underline{M}$ HNO_3 - H_2O_2 solution which was used to maintain the oxidation states of $\overline{Pu}$ (VI) in the initial extraction step of the TIOA procedure (Keller 1971). The TIOA ion exchange method used in these separations provided high decontamination factors for the removal of uranium from the plutonium fraction (>300:1) and for the removal of plutonium from the uranium fraction (>1000:1) (Butler 1968).

Because no information was found concerning the plating efficiency of radionuclides which would interfere in the analysis of polonium by the plutonium procedures used in this work, solutions with known quantities of ^{241}Am, ^{242}Pu, ^{232}U, ^{228}Th, ^{224}Ra and ^{208}Po were prepared and plated as previously described.

Table C.3 shows the interlaboratory comparison results of plutonium analysis. Results of the January 1976 interlaboratory comparison of ^{210}Po in solution was Environmental Protection Agency (EPA) 164.4 $\pm$ 4.5, LRE 166 $\pm$ 5.4. The chemical procedures have been checked by the comparisons between duplicate standard samples re: IAEA, NBS, EPA. Interlaboratory comparisons between actual samples which have been exchanged are given for the results of the McClelland Laboratory (MCL) and L... data. Of the 17 biota samples which were measured as "duplicates" six results fell outside the estimated errors of the two laboratories. It is not clear as to which laboratory was correct or whether both laboratories were correct and inhomogeniety existed in the samples. Of the five soil samples analyzed in 1971, one value was clearly outside the estimated errors of the two laboratories; and one value had a large measurement error (Nervic and Ray 1973).

A comparison of actual water samples collected in 1972 by Puerto Rico Nuclear Center (PRNC), LLL, and LRE using difference collection and analysis methods is also shown in Table C.3. Discrete samples were collected at a single time (5-10 min) by LLL and PRNC, while LRE collected samples by continuous filtration over a time period of 2-4 hours. Noshkin (1974) has shown at Enewetak that variations in $^{239,240}Pu$ concentrations as great as a factor of 3 can exist at certain locations over one tidal cycle.

The samples measured at Bikini, where large changes in the concentrations of Pu at different locations have been observed, compared reasonably well between the three laboratories. Values are certainly within a factor of 2 at the concentration level of pCi/1000ℓ. In fact most of the values are within 30%. Comparisons can also be made between the values of the particulate fraction of the total measured by both LLL and LRE shown in Table C.3. Most of these values are within the reported counting errors.

The direct comparison of the Batch and BLVWS methods are shown by the internal LRE intercomparisons in Table C.3. The Batch method used in these comparisons was by Wong et al. (1976); the BLVWS method employed four sorption beds of Al_2O_3 whereas only two beds were used in 1972 at Bikini and Enewetak. The Batch method and BLVWS methods compared well (average about 13% difference) on most samples with the Batch method giving slightly higher values than the BLVWS method.

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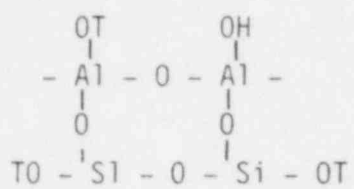
RESEARCH RESULTS

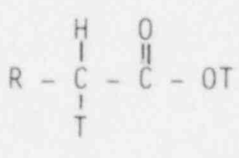
15 September 1981
W. R. Schell

PROJECT: New York Creek Samples
PRINCIPAL INVESTIGATOR: W. R. Schell
SUBJECT: Tritium and Carbon-14 Measurements in Sediment Samples

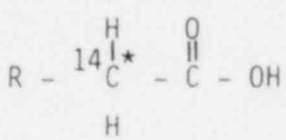
Possible contaminating radionuclides from the Nuclear Fuel Services Facilities at West Valley, New York, could be Carbon-14 and tritium. The tritium content in sediment could be a part of the mineral lattice as:



or as part of the organic fraction



the Carbon-14 content of sediment could also be part of the inorganic mineral as, for example, $Ca^{14}CO_3$ or as part of the organic fraction



To obtain an initial measurement of the concentrations of Carbon-14 and tritium in sediment samples, a procedure development program including the analysis of test samples was initiated. It was desirable that both Carbon-14 and tritium be measured in the same sample and that the totqal organic and inorganic fractions containing Carbon-14 and tritium be combined for the analysis of each radioisotope.

The methods developed to accomplish this required a vacuum line with controlled temperature heating of a combustion tube. Because of the possibilities of contamination due to different levels of radioisotope concentration, particular care was required to evaluate and to minimize the problems from contamination. The procedures developed included an initial combustion at 500°C with oxygen flowing through the system, and a second treatment by decomposition of carbonates upon heating under vacuum at 950°C. The CO_2 and Hd_2O produced were trapped at liquid nitrogen temperatures -198°C. The separation of CO_2 and water occurred by heating the glass collection trap to -30°C with He gas flowing through the system which ended in a trapping agent CO_2-Met (Packard Inst. Co.). After the CO_2 was volatilized from the glass trap and absorbed in the CO_2-Met, the combustion water was diluted with 10 ml tritium free water vacuum distilled by the toluene azeotrope mixture method and placed in a liquid scintillation vial with Instagel (Packard Instrument Company) for counting. The CO_2 was trapped using three CO_2-Met bubbler traps so that the trapping efficiency determination could be made. The CO_2-MET was suitable for liquid scintillation couting using Instagel.

The procedures were developed and tested using known amounts of $CaCO_3$ and $(NH_4)_2\ CO_3$ which had been "spiked" with Carbon-14 solutions and treated as described above.

The efficiency for trapping the CO_2 by the bubblers was 99+% for the first trap. In each of the spike experiments at different flow rates, no Carbon-14 was found in the second or third trap. The efficiency for decomposition of the carbonates at high tempertures is the most important error. The duplicate analysis of the loss on ignition gave values with differences of up to 25%. Since the total carbon dioxide produced depends on the amount which was decomposed, the final counting must reflect this error. With greater effort and more experience using the equipment, better error values could be obtained. The best estimate of the total analytical error of the samples is +25%. Counting errors and carbon dioxide trapping recovery errors were negligible (about 5%) compared to this variability in the decomposition. Table 1 gives the values for the six samples measured for total Carbon-14 content.

The results of these samples show that the concentrations of Carbon-14 downstream from the West Valley Nuclear Fuels SErvices Plant - Station FC-1, were not significantly higher than the concentrations found at the "control" station CC-1.

Upon reflection, it appears that by separating the organic from the inorganic fraction, additional information could be obtained which could shed more insight on the potential contaminants and their chemical form. If algae or other organic material took up the Carbon-14 present in the pond and was subsequently transported to the collection sites downstream, the organic fraction could be quite high in Carbon-14. The sediments contained a much larger fraction of carbonates than of organic matter, as observed first by the amount of CO_2 collected in the trap on combustion, and secondly by that collected on decomposition of the carbonates. The carbonates may have negligible Carbon-14 content and thus the total Carbon-14 in the sample would show this dilution. However, the studies show that the total samples do not contain high levels of Carbon-14.

The tritium content also shown in Table 1 clearly reflects the "contaminated station" compared to the control station. In each sample the concentrations are low but significant. It is apparent that excess tritium above the background levels are present in dried sediments downstream from the Nuclear Reprocessing Plant at West Valley, New York. It is not possible to separate the inorganic bound tritium from the organic bound tritium content of the sediments from the procedures used in this preliminary study. Additional sampling at various stages of the sample treatment and/or special treatment would be required to separate the tritium in the organic and inorganic fractions.

TABLE C.4. Carbon-14 and Tritium Content in Dried Sediments Collected Near the Nuclear Fuel Reprocessing Plant, West Valley, New York

Station	Number	Type	Weight (g)	Loss On Ignition (%)	Concentration - ^{14}C dpm/g Soil (± SD)	Concentration - ^{14}C dpm/g Carbonates (± SD)	Concentration - ^{3}H dpm/g Soil (± SD)	Concentration - ^{3}H TU/g Soil (± SD)
CC-1	40612	Susp Sed-Silt	2.62768 2.79782	8.01 8.40	3.81±0.95	45.4±11.3	1.21±0.34	21.3±5.1
CC-1	40694	Bed Sed-Silt	5.07504 3.06032	8.64 6.42	3.02±0.76	34.9± 8.7	0.96±0.18	16.7±3.1 9.8±5.5
CC-1	40072	Bed Sed-Sand	5.20279	3.91	0.46±0.12	11.9±2.9	0.18±0.18	5.0±5.0
FC-1	40626	Susp Sed-Silt	2.24541	9.24	2.63±0.66	28.5±7.1	2.67±0.42	46.3±7.5
FC-1	40087	Bed Sed-Silt	3.36951	7.18	1.85±0.46	25.8±6.4	6.33±0.34	110.0±6.0
FC-1	40080	Bed Sed-Sand	4.95610	6.40	0.77±0.19	12.1±3.0	5.82±0.26	101.0±4.1

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APPENDIX D

RESULTS OF RADIOLOGICAL ANALYSIS - PHASE 3

TABLE D.1. Concentration of Radionuclides in the Channel Bed Sediment of Buttermilk and Cattaraugus Creek Sampling Stations. Results of gamma-ray reasurements. Values in parentheses are two standard deviations of the propagated counting error for stations EB, FC/EB, and FC-1 (sand not separated into size fractions). Others are one standard deviation.

PHASE 3 - FIELD PROGRAM

STATION: BC-1 4/26/79

Radionuclide Concentration - Bed Sediment pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	82.0	19.61	0.76	
Sample Weight, Field (gms)	471.43	19.72	0.78	491.93
K-40	10.59(0.268)	12.88(0.566)	1.60(1.60)	10.7(0.28)
Co-60	<0.039	<0.083	<1.44	<0.044
Cs-134	<0.046	<0.096	<1.78	<0.051
Cs-137	2.65(0.031)	0.256(0.024)	2.92(0.437)	2.56(0.03)
Bi-214	0.480(0.025)	0.718(0.055)	<2.44	0.489(0.026)
Ra-226	0.466(0.025)	0.697(0.053)	9.97(8.56)	0.494(0.043)
Ra-228	0.824(0.057)	1.24(0.154)	<6.50	0.84(0.06)
Th-228	1.32(0.034)	1.45(0.055)	<3.20	1.32(0.04)
U-235	<0.172	<0.351	<5.77	<0.190
U-238	<0.526	<1.16	1.19(1.19)	0.002(0.002)
Am-241	<0.121	<0.191	<2.41	<0.128

TABLE D.1. (contd)

STATION: EB 4/29/79

Radionuclide Concentration - Bed Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	80.0	67.5	25.0	
Sample Weight, Field (gms)	*	*	*	
K-40	16.7(2.0)	17.2(2.3)	36.2(4.7)	
Co-60	0.46(0.07)	0.25(0.06)	0.51(0.14)	
Nb-95	0.14(0.09)			
Ru-103				
Ru-106	3.34(1.35)			
Rh-101				
Rh-102	0.22(0.08)			
Sb-125	0.46(0.08)	0.17(0.06)	0.54(0.15)	
Cs-134	0.46(0.06)	0.18(0.05)	0.56(0.11)	
Cs-137	34.0(0.51)	10.7(0.32)	34.3(0.82)	
Ce-144				
Eu-152				
Eu-155		0.16(0.13)		
Pb-210				
Bi-207		0.53(0.49)		
Ra-226	0.73(0.10)	1.09(0.10)	1.46(0.20)	
Th-228	0.67(0.10)	0.87(0.10)	1.85(0.22)	
Th-232		0.68(0.30)	1.42(0.65)	
U-235	0.14(0.07)	0.17(0.07)	0.17(0.15)	
U-238		1.22(0.82)	3.74(1.51)	
Am-241				

* Data missing.

TABLE D.1. (contd)

STATION: FC/EB 4/29/79

Radionuclide Concentration - Bed Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	85.5	67.5	7.5	
Sample Weight, Field (gms)	*	*	*	
K-40	4.7(1.5)	13.3(1.5)	33.7(11.6)	
Co-60	0.08(0.04)	0.08(0.03)		
Nb-95				
Ru-103				
Ru-106	1.15(0.73)			
Rh-101			0.16(0.14)	
Rh-102				
Sb-125	0.08(0.04)	0.03(0.03)		
Cs-134	0.08(0.03)	0.06(0.02)		
Cs-137	2.88(0.17)	1.91(0.10)	13.7(1.0)	
Ce-144				
Eu-152				
Eu-155	0.10(0.07)	0.11(0.07)		
Pb-210	1.89(1.33)			
Bi-207				
Ra-226	0.58(0.06)	0.89(0.06)	1.45(0.45)	
Th-228	0.64(0.07)	0.82(0.07)	2.38(0.52)	
Th-232	0.73(0.19)	0.87(0.15)	2.31(1.47)	
U-235	0.10(0.04)	0.12(0.04)		
U-238	0.85(0.42)	0.79(0.53)		
Am-241				

* Data missing.

TABLE D.1. (contd)

STATION: FC-1

Radionuclide Concentration - Bed Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	80	67.5	12.2	
Sample Weight, Field (gms)	566	155	12.1	733.2
K-40	6.6(1.6)	6.7(1.2)	19.4(6.1)	6.87(1.61)
Co-60	0.56(0.09)	0.34(0.05)	1.74(0.33)	0.54(0.09)
Nb-95				
Ru-103				
Ru-106	4.7(1.6)			3.6(1.2)
Rh-101	0.06(0.04)	0.04(0.02)	0.19(0.11)	0.06(0.04)
Rh-102				
Sb-125	0.54(0.09)	0.21(0.05)	0.89(0.33)	0.48(0.09)
Cs-134	0.60(0.07)	0.21(0.03)	1.13(0.25)	0.53(0.07)
Cs-137	44.1(0.66)	13.2(0.25)	91.9(2.2)	38.6(0.6)
Ce-144				
Eu-152				
Eu-155				
Pb-210				
Bi-207	0.12(0.07)	0.04(0.03)		0.10(0.06)
Ra-226	0.58(0.11)	0.73(0.06)	1.24(0.39)	0.62(0.11)
Th-228	0.67(0.11)	0.65(0.06)	1.24(0.40)	0.68(0.11)
Th-232	0.56(0.41)	0.48(0.19)		0.53(0.36)
U-235	0.13(0.07)	0.12(0.04)		0.13(0.06)
U-238		0.89(0.40)		0.19(0.08)
Am-241	0.24(0.17)	0.10(0.09)		0.21(0.15)

TABLE D.1. (contd)

PHASE 3 - FIELD PROGRAM

STATION: FC-1 4/29/79

Radionuclide Concentration - Bed Sediment
pCi/gm

	Coarse Sand	Medium Sand	Fine Sand	Sand Composite	Silt	Clay	Sample Composite
Sample Weight, Analysis (gms)	88.78	8.5	1.75		10.0	3.2	
Sample Weight, Field (gms)	180.7	58.0	8.02	246.72	32.91	3.19	282.82
K-40	14.17(0.398)	14.25(1.96)	3.97(3.97)	13.88(0.88)	20.97(1.40)	43.72(2.81)	15.02(1.41)
Co-60	0.969(0.036)	0.758(0.174)	<1.31	0.889(0.068)	1.83(0.121)	3.22(0.262)	1.02(0.08)
Cs-134	0.834(0.041)	<0.605	<1.31	0.609(0.010)	0.989(0.133)	3.21(0.273)	0.681(0.027)
Cs-137	73.29(0.204)	53.81(0.587)	32.41(0.887)	67.39(0.32)	66.57(0.437)	244.8(1.07)	69.18(0.34)
Bi-214	0.520(0.048)	<0.729	<1.70	0.380(0.035)	<0.554	<1.08	0.331(0.031)
Ra-226	0.505(0.047)	<0.708	<1.65	0.369(0.034)	<0.538	<1.05	0.322(0.030)
Ra-228	<0.345	<1.70	<4.68	<0.800	<1.25	<2.19	<0.867
Th-228	1.00(0.095)	<0.976	<2.45	0.73(0.07)	0.477(0.230)	1.85(0.405)	0.712(0.091)
U-235	<0.581	<1.70	<4.28	<0.961	<1.31	<2.67	<1.019
U-238	<1.47	<4.35	1.54(1.54)	0.046(0.046)	<3.17	<6.68	0.040(0.040)
Am-241	<0.365	<0.773	<1.90	<0.509	<0.622	2.87(0.315)	0.032(0.003)

TABLE D.1. (contd)

PHASE 3 - FIELD PROGRAM

STATION: BC-4 4/26/79

Radionuclide Concentration - Bed Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	85.5	10.0	0.80	
Sample Weight, Field (gms)	383.20	15.34	0.83	399.37
K-40	11.26(0.386)	11.60(1.30)	1.50(1.50)	11.25(0.002)
Co-60	<0.074	<0.258	<2.68	<0.086
Cs-134	<0.082	<0.289	<2.96	<0.096
Cs-137	10.34(0.082)	13.57(0.206)	46.51(1.63)	10.54(0.09)
Bi-214	<0.136	<0.488	<4.56	<0.158
Ra-226	<0.133	<0.474	<4.42	<0.155
Ra-228	1.03(0.077)	<1.10	<10.97	0.99(0.07)
Th-228	1.19(0.051)	2.28(0.203)	<5.36	1.23(0.06)
U-235	<0.30	<0.985	<9.62	<0.345
U-238	<0.864	<2.56	<25.20	<0.977
Am-241	<0.207	1.95(0.163)	<4.04	0.07(0.006)

TABLE D.1. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-1* 4/28/79

Radionuclide Concentration - Bed Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	76.2	71.2	4.8	
Sample Weight, Field (gms)	441.5	554.8	14.7	1011.0
K-40	10.40(0.246)	9.15(0.215)	27.16(1.94)	9.9(0.25)
Co-60	<0.032	<0.028	<0.289	<0.032
Cs-134	<0.038	<0.036	<0.312	<0.040
Cs-137	0.066(0.009)	0.074(0.009)	0.764(0.089)	0.08(0.01)
Bi-214	0.386(0.021)	0.552(0.021)	2.43(0.175)	0.5(0.02)
Ra-226	0.374(0.020)	0.536(0.020)	2.36(0.170)	0.48(0.02)
Ra-228	0.639(0.048)	0.770(0.054)	2.51(0.440)	0.73(0.06)
Th-228	0.902(0.027)	1.40(0.028)	3.37(0.184)	1.2(0.03)
U-235	<0.138	<0.126	<1.11	<0.141
U-238	<0.423	2.01(0.127)	2.17(0.996)	1.13(0.08)
Am-241	<0.098	<0.092	2.01(0.11)	0.02(0.001)

* Sample collected in tributary of Cattaraugus Creek located about 1500 ft upstream from CC-1

TABLE D.1. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-1 4/29/79

Radionuclide Concentration - Bed Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	2.2	1.0	0.10	
Sample Weight, Field (gms)	2.25	2.01	0.12	4.38
K-40	<15.12	<112.8	<204.4	<65.73
Co-60	<0.685	<4.71	<11.16	<2.85
Cs-134	<1.04	<5.07	<11.75	<3.22
Cs-137	<0.940	5.67(1.49)	22.74(3.26)	3.29(0.78)
Bi-214	<1.36	<7.49	<17.68	<4.67
Ra-226	<1.32	<7.27	<17.17	<4.53
Ra-228	<3.99	<19.22	<43.55	<12.18
Th-228	<1.84	<7.14	<20.98	<4.85
U-235	<3.10	<16.86	<41.74	<10.59
U-238	<8.03	<35.93	<103.5	<23.73
Am-241	<1.38	<6.45	<17.43	<4.19

TABLE D.1. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-3 4/27/79

Radionuclide Concentration - Bed Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	83.22	5.0	0.13	
Sample Weight, Field (gms)	524.37	5.2	0.14	529.71
K-40	8.74(0.381)	19.46(5.36)	<146.1	8.84(0.43)
Co-60	<0.049	<0.651	<7.81	<0.057
Cs-134	<0.066	<0.756	<8.74	<0.075
Cs-137	0.621(0.027)	1.49(0.189)	8.41(2.03)	0.63(0.03)
Bi-214	<0.116	0.951(0.399)	<12.64	0.009(0.004)
Ra-226	<0.113	0.924(0.388)	<12.28	0.009(0.004)
Ra-228	<0.303	1.12(1.09)	<33.94	0.01(0.011)
Th-228	0.781(0.042)	0.526(0.391)	<15.65	0.78(0.05)
U-235	<0.220	<2.51	<30.59	<0.252
U-238	<0.675	<5.49	36.72(26.89)	0.01(0.008)
Am-241	<0.160	<0.923	<13.29	<0.171

TABLE D.1. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-5 4/28/79

Radionuclide Concentration - Bed Sediment
pCi/gm

	Coarse Sand	Medium Sand	Fine Sand	Sand Composite	Silt	Clay	Sample Composite
Sample Weight, Analysis (gms)	80.5	72.9	3.2		5.0	0.11	
Sample Weight, Field (gms)	596.25	101.9	3.36	701.51	6.12	0.12	707.75
K-40	9.26(0.237)	10.05(0.411)	5.40(5.40)	9.36(0.29)	11.56(1.82)	13.0(13.0)	9.38(0.30)
Co-60	<0.036	<0.055	<1.01	<0.044	<0.334	<10.09	<0.048
Cs-134	<0.040	<0.065	<1.13	<0.049	<0.392	<11.24	<0.054
Cs-137	1.38(0.020)	0.875(0.029)	3.77(0.284)	1.32(0.02)	4.65(0.161)	59.15(4.16)	1.36(0.022)
Bi-214	0.404(0.020)	0.283(0.032)	0.509(0.509)	0.39(0.02)	<0.601	<14.66	0.39(0.02)
Ra-226	0.392(0.019)	0.275(0.031)	0.495(0.495)	0.38(0.02)	<0.583	<14.24	0.38(0.02)
Ra-228	0.724(0.051)	<0.277	<4.32	0.62(0.04)	0.757(0.453)	<41.06	0.62(0.04)
Th-228	1.04(0.029)	0.634(0.049)	0.234(0.234)	0.98(0.03)	0.737(0.230)	<18.83	0.98(0.03)
U-235	<0.139	<0.235	<3.82	<0.171	<1.26	<37.23	<0.188
U-238	0.563(0.153)	<0.715	<8.62	0.48(0.13)	1.09(1.09)	35.23(25.03)	0.49(0.14)
Am-241	<0.099	<0.166	<1.43	<0.115	2.14(0.136)	<15.76	0.02(0.001)

TABLE D.1. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-6 4/26/79

Radionuclide Concentration - Bed Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	82.1	5.0	0.2	
Sample Weight, Field (gms)	510.88	7.16	0.21	518.25
K-40	9.20(0.259)	11.03(2.44)	<104.7	9.22(0.29)
Co-60	<0.034	<0.433	<5.92	<0.042
Cs-134	<0.044	<0.391	<6.78	<0.063
Cs-137	0.558(0.018)	0.771(0.151)	<4.78	0.56(0.02)
Bi-214	<0.078	<0.887	<9.49	<0.093
Ra-226	0.332(0.022)	<0.861	<9.21	0.33(0.02)
Ra-228	0.783(0.055)	<1.82	<21.40	0.77(0.05)
Th-228	1.01(0.030)	0.746(0.230)	<11.01	1.01(0.03)
U-235	<0.149	<1.83	<21.43	<0.181
U-238	<0.472	<4.94	<53.00	<0.555
Am-241	<0.106	1.17(0.276)	<8.92	0.02(0.004)

TABLE D.1. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-9 4/29/79

Radionuclide Concentration - Bed Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	79.5	50.0	1.0	
Sample Weight, Field (gms)	1168.1	68.2	1.46	1237.76
K-40	10.01(0.378)	11.63(1.30)	4.63(4.63)	10.09(0.43)
Co-60	<0.053	<0.237	<1.87	<0.065
Cs-134	<0.061	<0.248	<2.10	<0.073
Cs-137	0.202(0.016)	0.291(0.051)	2.73(0.517)	0.21(0.02)
Bi-214	<0.115	<0.417	<3.45	<0.135
Ra-226	<0.112	1.09(0.117)	<3.35	0.06(0.006)
Ra-228	0.564(0.079)	1.11(0.284)	<7.79	0.59(0.09)
Th-228	0.879(0.051)	0.929(0.103)	2.55(1.27)	0.88(0.06)
U-235	<0.219	<0.917	<7.49	<0.265
U-238	<0.684	<2.09	<19.65	<0.780
Am-241	<0.153	<0.425	<3.05	<0.171

TABLE D.1. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-11 4/29/79

Radionuclide Concentration - Bed Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	79.3	50.0	1.0	
Sample Weight, Field (gms)	520.24	340.3	5.26	865.8
K-40	10.46(0.174)	<1.77	24.67(7.42)	6.52(0.18)
Co-60	<0.021	<0.069	<1.26	<0.052
Cs-134	<0.027	<0.085	<1.52	<0.065
Cs-137	0.223(0.008)	0.028(0.019)	1.55(0.420)	0.16(0.02)
Bi-214	0.336(0.013)	<0.148	<2.26	0.2(0.01)
Ra-226	0.326(0.013)	<0.144	<2.19	0.2(0.01)
Ra-228	0.555(0.034)	<0.358	<5.76	0.33(0.02)
Th-228	0.857(0.019)	<0.160	0.067(0.067)	0.52(0.01)
U-235	<0.090	<0.272	<5.01	<0.210
U-238	1.12(0.091)	<0.735	3.68(3.68)	0.71(0.09)
Am-241	<0.065	<0.157	<2.07	<0.121

TABLE D.2. Concentration of Radionuclides in the Suspended Sediment of Buttermilk and Cattaraugus Creek Sampling Stations. Results of gamma-ray measurements. Values in parentheses are one standard deviation of the propagated counting error.

PHASE 3 - FIELD PROGRAM

STATION: BC-1* 4/26/79

Radionuclide Concentration - Suspended Sediment pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.03	2.56	0.28	
Sample Weight, Field (gms)	0.05	2.62	0.32	2.99
K-40	862.6(675.3)	21.81(3.24)	38.63(18.85)	37.9(16.34)
Co-60	<80.52	<0.527	<2.54	<2.10
Cs-134	<89.70	<0.594	<3.04	<2.37
Cs-137	47.07(18.57)	0.168(0.143)	<2.10	0.95(0.44)
Ce-139				
Ce-141			0.910(0.802)	0.10(0.09)
Bi-214	40.37(40.37)	<0.947	<4.24	0.69(0.69)
Ra-226	<121.6	<0.920	<4.12	<3.31
Ra-228	<342.8	<2.29	4.05(4.05)	0.43(0.43)
Th-228	<124.1	1.30(0.333)	0.375(0.375)	1.18(0.33)
U-235	<297.0	<2.25	4.41(3.89)	0.47(0.42)
U-238	<652.1	4.24(2.21)	12.95(12.95)	5.1(3.32)
Am-241	<109.7	<1.19	<5.71	<3.52

* Data not presented graphically.

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: BC-1 4/27/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	1.43	25.0	7.0	
Sample Weight, Field (gms)	2.89	50.12	7.12	60.13
K-40	5.13(4.99)	21.95(0.636)	42.88(6.30)	23.62(1.53)
Co-60	<0.833	<0.082	<1.02	<0.232
Cs-134	<1.15	<0.089	<1.15	<0.269
Cs-137	<0.742	0.160(0.020)	<0.802	0.13(0.02)
Ce-139				
Ce-141				
Bi-214	<1.50	0.859(0.052)	<0.170	0.71(0.04)
Ra-226	<1.46	0.834(0.051)	<1.65	0.69(0.042)
Ra-228	<4.04	1.42(0.134)	<4.26	1.18(0.11)
Th-228	<1.95	1.73(0.052)	4.27(0.506)	1.95(0.10)
U-235	<3.53	<0.322	<4.04	<0.929
U-238	<8.85	1.44(0.302)	<9.12	1.2(0.25)
Am-241	<1.46	<0.177	<1.74	<0.429

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: BC-1* 4/28/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.61	13.12	4.62	
Sample Weight, Field (gms)	0.65	13.22	4.72	18.59
K-40	6.36(6.36)	27.42(1.83)	51.22(6.40)	32.73(3.15)
Co-60	<1.58	<0.250	<0.868	<0.399
Cs-134	<1.91	<0.248	<0.920	<0.477
Cs-137	<1.29	0.567(0.083)	1.58(0.173)	0.80(0.103)
Ce-139				
Ce-141				
Bi-214	<3.02	1.10(0.127)	<1.39	0.78(0.09)
Ra-226	<2.93	1.07(0.123)	2.44(0.541)	1.38(0.23)
Ra-228	<7.13	1.24(0.412)	<3.42	0.88(0.29)
Th-228	<3.54	2.01(0.135)	3.89(0.470)	2.42(0.22)
U-235	<6.85	<0.988	<3.32	<1.79
U-238	7.52(5.29)	1.75(0.895)	<7.51	1.51(0.82)
Am-241	<2.99	<0.525	<1.46	<0.849

* Data not presented graphically.

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: FC-1/1* 4/26/79 (AM)

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.49	25.0	25.0	
Sample Weight, Field (gms)	0.66	71.95	26.22	98.83
K-40	15.35(15.35)	22.74(0.661)	43.36(2.26)	28.15(1.19)
Co-60	<3.53	0.061(0.029)	<0.421	0.044(0.021)
Cs-134	<4.52	0.124(0.031)	<0.423	0.09(0.023)
Cs-137	<3.40	4.98(0.067)	12.43(0.188)	6.92(0.10)
Ce-139				
Ce-141				
Bi-214	<6.02	0.889(0.047)	1.07(0.189)	0.93(0.08)
Ra-226	<5.84	0.863(0.046)	1.04(0.183)	0.90(0.08)
Ra-228	<16.42	1.57(0.139)	1.74(0.467)	1.6(0.23)
Th-228	<7.44	1.59(0.054)	2.96(0.140)	1.94(0.08)
U-235	<14.81	<0.361	<0.143	0.404
U-238	<36.55	1.44(0.333)	<3.37	1.05(0.24)
Am-241	<6.11	<0.20	<0.671	<0.366

* Data not presented graphically.

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: FC-1/2* 4/2[illegible]/79 (PM)

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.91	12.12	1.0	
Sample Weight, Field (gms)	0.91	12.37	3.97	17.25
K-40	<68.31	13.72(7.02)	25.39(12.68)	15.72(8.0)
Co-60	<3.19	<1.25	<2.39	<1.61
Cs-134	<3.41	<1.24	<2.61	<1.66
Cs-137	10.40(0.804)	11.76(0.479)	24.81(1.18)	14.7(0.66)
Ce-139				
Ce-141				
Bi-214	<4.91	<1.83	<3.60	<2.39
Ra-226	<4.77	0.725(0.568)	<3.50	0.52(0.41)
Ra-228	<12.10	<4.59	<9.09	<6.00
Th-228	<4.96	2.77(0.629)	6.58(6.58)	3.51(1.97)
U-235	<11.16	<4.33	<8.35	<5.04
U-238	<23.83	<9.88	<21.52	<13.25
Am-241	8.92(1.25)	<2.00	<3.52	0.45(0.06)

* Data not presented graphically.

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: FC-1/3* 4/27/79 (AM)

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.40	25.5	22.5	
Sample Weight, Field (gms)	0.49	55.30	22.81	78.60
K-40	<51.05	23.64(2.08)	42.78(0.942)	29.0(1.[illegible])
Co-60	<2.43	<0.405	<0.141	<0.349
Cs-134	<3.29	<0.380	0.347(0.043)	0.10(0.01)
Cs-137	9.53(0.770)	6.25(0.139)	14.95(0.121)	8.81(0.14)
Ce-139				
Ce-141				
Bi-214	<4.05	<0.623	0.999(0.056)	0.29(0.02)
Ra-226	<3.94	0.998(0.162)	0.970(0.055)	0.98(0.13)
Ra-228	<10.74	<1.53	2.10(0.206)	0.61(0.06)
Th-228	<5.47	2.31(0.173)	2.55(0.070)	2.36(0.14)
U-235	<10.15	<1.36	<0.484	<1.194
U-238	17.36(9.07)	<3.25	<1.45	0.17(0.09)
Am-241	<4.36	<0.617	<0.257	<0.55

* Data not presented graphically.

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: FC-1/4 4/27/79 (PM)

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	1.0	25.0	20.8	
Sample Weight, Field (gms)	0.99	48.86	21.23	71.08
K-40	68.22(30.25)	23.16(2.04)	38.38(1.77)	28.18(2.24)
Co-60	<4.28	<0.390	0.302(0.071)	0.09(0.02)
Cs-134	<4.92	<0.375	0.458(0.102)	0.14(0.03)
Cs-137	7.50(1.33)	5.88(0.134)	13.17(0.127)	8.08(0.14)
Ce-139				
Ce-141				
Bi-214	<6.84	<0.630	1.35(0.133)	0.41(0.04)
Ra-226	<6.64	1.13(0.172)	1.31(0.129)	1.17(0.16)
Ra-228	<16.95	1.07(0.416)	1.59(0.373)	1.22(0.40)
Th-228	<7.01	2.00(0.132)	3.22(0.117)	2.35(0.13)
U-235	<16.13	<1.35	<1.02	<1.40
U-238	<34.18	<3.19	<2.44	<3.27
Am-241	<6.32	<0.618	<0.469	<0.63

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: FC-1/5* 4/28/79 (AM)

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.08	5.69	3.3	
Sample Weight, Field (gms)	0.06	6.11	3.28	9.45
K-40	419.9(318.3)	34.75(12.45)	37.99(2.16)	38.19(10.71)
Co-60	<48.18	<2.25	<0.331	<1.86
Cs-134	<52.77	<2.53	<0.372	<2.08
Cs-137	<33.23	14.48(0.898)	18.95(0.230)	15.94(0.66)
Ce-139				
Ce-141				
Bi-214	20.84(20.84)	<0.395	1.59(0.169)	0.68(0.18)
Ra-226	<70.84	1.80(1.03)	1.54(0.164)	1.7(0.72)
Ra-228	<182.9	<9.38	1.74(0.505)	0.6(0.18)
Th-228	<71.98	<3.68	2.04(0.224)	0.71(0.08)
U-235	<174.9	<9.32	<1.36	<7.55
U-238	<396.9	<20.69	4.91(1.46)	1.7(0.51)
Am-241	<72.05	<4.05	<0.698	<3.29

* Data not presented graphically.

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: BC-3 4/27/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.70	10.0	1.0	
Sample Weight, Field (gms)	0.71	14.07	2.82	17.60
K-40	<41.96	20.68(2.04)	23.46(7.29)	20.3(2.8)
Co-60	<2.26	<0.361	<1.27	<0.58
Cs-134	<2.60	<0.411	<1.49	<0.671
Cs-137	4.99(0.832)	4.79(0.20)	7.86(0.521)	5.29(0.28)
Ce-139				
Ce-141				
Bi-214	<3.71	<0.655	<2.15	<1.016
Ra-226	<3.60	<0.636	<2.09	<0.987
Ra-228	<9.70	1.11(0.549)	<5.24	0.89(0.44)
Th-228	<4.90	0.996(0.272)	1.82(0.942)	1.09(0.37)
U-235	<8.45	<0.40	<4.81	<1.43
U-238	<21.15	0.762(0.762)	1.44(1.44)	0.84(0.84)
Am-241	<3.57	1.73(0.153)	<2.03	1.38(0.12)

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: BC-4* 4/26/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay**	Composite
Sample Weight, Analysis (gms)	0.18	16.81		
Sample Weight, Field (gms)	0.16	16.95		17.11
K-40	<118.6	24.40(0.788)		24.16(0.78)
Co-60	<6.38	<0.110		<0.17
Cs-134	<7.20	<0.124		<0.195
Cs-137	<5.40	2.51(0.055)		2.48(0.05)
Ce-139				
Ce-141				
Bi-214	<9.59	<0.232		<0.326
Ra-226	<9.31	0.867(0.059)		0.86(0.06)
Ra-228	<23.86	1.40(0.152)		1.39(0.15)
Th-228	<12.58	1.86(0.066)		1.84(0.07)
U-235	<23.83	<0.425		<0.659
U-238	<57.95	1.15(0.393)		1.14(0.39)
Am-241	<9.54	<0.231		<0.324

* Data not presented graphically.
** Clay sample lost during shipment.

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: BC-4 4/27/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.63	25.0	10.0	
Sample Weight, Field (gms)	0.65	57.2	14.66	72.51
K-40	5.75(5.75)	25.59(1.89)	37.72(3.88)	27.82(2.33)
Co-60	<2.07	<0.326	<0.534	<0.385
Cs-134	<2.38	<0.336	<0.583	<0.406
Cs-137	<2.01	2.31(0.92)	4.12(0.171)	2.65(0.76)
Ce-139				
Ce-141				
Bi-214	<3.28	1.19(0.163)	1.17(0.313)	1.17(0.19)
Ra-226	<3.19	1.16(0.159)	1.14(0.304)	1.14(0.19)
Ra-228	<8.57	<1.30	3.60(0.751)	0.72(0.15)
Th-228	<4.47	1.52(0.135)	1.61(0.307)	1.52(0.17)
U-235	<7.90	<1.20	<1.89	<1.41
U-238	<19.78	<2.83	<4.24	<3.28
Am-241	<3.3	<0.536	<0.730	<0.603

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: BC-4* 4/28/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.10	10.0	1.00	
Sample Weight, Field (gms)	0.17	11.96	3.45	15.58
K-40	<434.6	24.95(5.24)	22.78(6.49)	24.22(5.46)
Co-60	<49.24	<0.801	<1.20	<1.373
Cs-134	<52.77	<0.884	<1.50	<1.538
Cs-137	<33.23	2.89(0.267)	3.98(0.345)	3.1(0.28)
Ce-139				
Ce-141				
Bi-214	<69.84	0.486(0.410)	<1.92	0.37(0.32)
Ra-226	<70.84	0.472(0.398)	<1.87	0.36(0.31)
Ra-228	<182.9	<3.42	<5.36	<5.64
Th-228	<71.98	1.26(0.467)	0.440(0.440)	1.07(0.46)
U-235	<174.9	<2.92	<4.56	<5.00
U-238	<396.9	<6.86	0.80(0.80)	0.18(0.18)
Am-241	<72.05	<1.20	<1.95	<2.07

* Data not presented graphically.

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-1* 4/26/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.15	1.00	0.21	
Sample Weight, Field (gms)	0.15	4.11	0.23	4.49
K-40	<131.9	12.33(12.33)	<53.78	11.34(11.34)
Co-60	<7.34	<2.03	<2.70	<2.22
Cs-134	<7.76	<2.43	<3.20	<2.63
Cs-137	<5.73	<1.72	<2.13	<1.86
Ce-139				
Ce-141	1.41(1.41)			0.04(0.04)
Bi-214	<11.21	<3.46	<4.38	<3.74
Ra-226	<10.88	<3.36	<4.26	<3.63
Ra-228	<30.03	<8.53	<11.89	<9.34
Th-228	<14.10	<4.00	<5.47	<4.38
U-235	6.82(6.82)	<7.50	<10.69	0.20(0.20)
U-238	33.56(21.62)	4.89(4.89)	12.57(11.25)	6.13(5.71)
Am-241	<11.46	<3.20	<4.59	<3.52

* Data not presented graphically.

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-1 4/27/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	1.02	25.0	22.51	
Sample Weight, Field (gms)	1.64	89.25	22.70	113.59
K-40	<33.22	23.04(1.89)	41.52(0.806)	26.51(1.65)
Co-60	<1.71	<0.342	<0.104	<0.308
Cs-134	<2.03	<0.343	<0.116	<0.314
Cs-137	<1.55	0.316(0.061)	0.981(0.036)	0.45(0.06)
Ce-139				
Ce-141				
Bi-214	<2.71	1.07(0.153)	1.07(0.075)	1.06(0.14)
Ra-226	<2.63	1.04(0.148)	1.04(0.073)	1.03(0.13)
Ra-228	<8.11	<1.30	2.55(0.160)	0.51(0.03)
Th-228	<3.88	2.19(0.124)	2.64(0.060)	2.26(0.11)
U-235	<7.02	<1.20	<0.366	<1.09
U-238	<18.00	<2.87	1.92(0.322)	0.38(0.06)
Am-241	<2.87	<0.552	<0.206	<0.506

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-3 4/27/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	1.52	25.0	5.0	
Sample Weight, Field (gms)	2.36	36.25	8.29	46.90
K-40	2.74(2.74)	21.58(1.97)	34.88(5.78)	23.03(2.69)
Co-60	<0.895	<0.322	<0.763	<0.43
Cs-134	<1.00	<0.357	<0.832	<0.475
Cs-137	1.13(0.261)	1.67(0.070)	4.44(0.251)	2.14(0.11)
Ce-139				
Ce-141				
Bi-214	<1.36	<0.560	1.33(0.410)	0.24(0.07)
Ra-226	<1.32	1.02(0.165)	1.29(0.398)	1.02(0.20)
Ra-228	<3.55	0.899(0.394)	2.63(1.14)	1.17(0.51)
Th-228	<1.79	2.42(0.123)	1.71(0.424)	2.17(0.17)
U-235	<3.16	<1.24	<2.70	<1.60
U-238	<8.32	1.76(0.583)	<6.23	1.36(0.45)
Am-241	<1.34	<0.554	<1.02	<0.677

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-5* 4/26/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.40	21.78	5.0	
Sample Weight, Field (gms)	0.40	21.98	5.45	27.83
K-40	59.32(58.37)	21.88(2.23)	35.84(1.91)	25.05(2.73)
Co-60	<7.17	<0.389	<0.288	<0.437
Cs-134	<7.98	<0.425	<0.335	<0.483
Cs-137	<5.42	0.763(0.079)	1.99(0.109)	1.0(0.8)
Ce-139				
Ce-141				
Bi-214	<11.53	1.18(0.208)	1.15(0.172)	1.16(0.20)
Ra-226	<11.20	1.14(0.202)	1.12(0.167)	1.12(0.19)
Ra-228	<29.59	0.713(0.583)	2.45(0.428)	1.05(0.55)
Th-228	<11.78	2.01(0.134)	2.58(0.180)	2.1(0.14)
U-235	<26.58	<1.47	<1.11	<1.65
U-238	<57.34	<3.44	1.87(1.02)	0.37(0.20)
Am-241	<10.45	<0.662	1.99(0.11)	0.40(0.02)

* Data not presented graphically.

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-5 4/27/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	1.0	25.0	5.0	
Sample Weight, Field (gms)	1.16	30.8	5.55	37.51
K-40	<35.39	22.44(2.05)	35.06(2.22)	23.66(2.01)
Co-60	<2.06	<0.368	<0.385	<0.978
Cs-134	<2.10	<0.376	<0.414	<0.433
Cs-137	<1.57	0.877(0.081)	1.65(0.118)	0.97(0.08)
Ce-139				
Ce-140				
Bi-214	<2.87	0.842(0.161)	<0.637	0.69(0.13)
Ra-226	<2.79	0.818(0.156)	<0.618	0.67(0.13)
Ra-228	<7.89	0.493(0.444)	1.81(0.557)	0.68(0.45)
Th-228	1.01(0.01)	2.62(0.181)	2.46(0.197)	2.55(0.21)
U-235	<6.98	<1.32	<1.28	<1.48
U-238	<17.77	<3.11	<3.64	<3.63
Am-241	<2.91	<0.592	2.13(0.220)	0.32(0.03)

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-5 4/28/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.81	10.0	1.0	
Sample Weight, Field (gms)	1.02	10.62	1.33	12.97
K-40	37.44(22.85)	20.03(2.25)	34.48(26.48)	22.87(6.32)
Co-60	<2.33	<0.494	<3.92	<0.983
Cs-134	<2.51	<0.468	<4.14	<0.999
Cs-137	<1.67	0.966(0.122)	<2.88	0.79(0.10)
Ce-139				
Ce-141				
Bi-214	3.14(1.65)	<0.707	<5.82	0.25(0.13)
Ra-226	3.05(1.60)	<0.686	<5.65	0.24(0.13)
Ra-228	<9.22	<1.75	<15.01	<3.67
Th-228o	<3.58	1.25(0.249)	<5.97	1.03(0.20)
U-235	<8.32	<1.49	<13.66	<3.25
U-238	<17.56	<4.13	<29.15	<7.71
Am-241	8.02(0.869)	1.25(0.223)	<5.48	1.67(0.25)

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-6* 4/26/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.35	44.4	10.0	
Sample Weight, Field (gms)	0.51	44.95	13.28	58.74
K-40	<72.82	27.06(1.37)	34.90(3.95)	28.59(1.94)
Co-60	<2.34	<0.161	<0.473	<0.251
Cs-134	<1.15	<0.148	<0.564	<0.251
Cs-137	<2.98	0.736(0.054)	2.87(0.146)	1.2(0.07)
Ce-139				
Ce-141				
Bi-214	<6.28	0.983(0.108)	1.50(0.288)	1.09(0.15)
Ra-226	<6.10	0.954(0.105)	1.46(0.280)	1.06(0.14)
Ra-228	<10.68	0.889(0.225)	2.20(0.718)	1.18(0.33)
Th-228	<1.91	1.26(0.062)	2.91(0.269)	1.62(0.11)
U-235	<14.82	<0.729	<1.88	<1.116
U-238	<37.28	2.16(0.515)	<4.23	1.65(0.394)
Am-241	<6.04	<0.399	<0.727	<0.524

* Data not presented graphically.

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-6 4/27/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.90	10.0	1.0	
Sample Weight, Field (gms)	1.18	16.36	2.08	19.62
K-40	40.43(26.50)	28.06(3.64)	23.47(7.88)	28.3(5.48)
Co-60	<3.37	<0.448	<1.16	<0.702
Cs-134	<3.66	<0.506	<1.44	<0.798
Cs-137	<2.35	1.42(0.143)	1.35(0.366)	1.33(0.16)
Ce-139				
Ce-141				
Bi-214	2.06(1.78)	0.637(0.290)	<2.16	0.65(0.35)
Ra-226	<4.99	0.618(0.282)	<2.09	0.51(0.23)
Ra-228	<12.90	<2.02	<5.17	<1.88
Th-228	<5.19	1.03(0.292)	1.97(1.97)	1.07(0.46)
U-235	<11.80	<1.76	<4.82	<2.70
U-238	<25.05	1.94(1.27)	<12.60	1.61(1.05)
Am-241	8.67(1.25)	<0.678	<2.05	0.52(0.08)

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-6* 4/28/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.96	10.0	1.0	
Sample Weight, Field (gms)	1.03	11.89	2.52	15.44
K-40	<26.01	34.76(3.67)	18.06(13.44)	29.65(4.98)
Co-60	<1.26	<0.461	<2.14	<0.786
Cs-134	<1.54	<0.509	<2.06	<0.829
Cs-137	<1.14	0.580(0.105)	<1.70	0.45(0.08)
Ce-139				
Ce-141				
Bi-214	<2.07	<0.796	<3.57	<1.329
Ra-226	<2.01	0.889(0.261)	<3.46	0.68(0.20)
Ra-228	<5.36	1.59(0.688)	<8.91	1.22(C.53)
Th-228	<2.73	1.00(0.301)	<4.08	0.77(0.23)
U-235	<5.03	<1.75	<7.39	<2.88
U-238	8.38(3.09)	<3.89	<19.30	0.59(0.22)
Am-241	<2.16	<0.674	<3.11	<1.168

* Data not presented graphically.

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-9 4/29/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.71	5.0	1.0	
Sample Weight, Field (gms)	0.83	5.59	1.08	7.5
K-40	<20.17	20.14(1.92)	20.90(11.86)	18.03(3.1)
Co-60	<1.13	<3.39	<2.0	<2.95
Cs-134	<1.29	<0.388	<2.41	<0.770
Cs-137	2.33(0.306)	2.26(0.131)	2.78(0.698)	2.34(0.23)
Ce-139				
Ce-141				
Bi-214	<1.68	<0.60	<3.13	<1.07
Ra-226	<1.63	<0.582	<3.04	<1.041
Ra-228	<4.61	1.48(0.504)	<8.65	1.11(0.38)
Th-228	<2.30	2.01(0.238)	2.0(1.35)	1.79(0.37)
U-235	<4.04	<1.25	<7.17	<2.386
U-238	<10.34	<3.39	<20.30	<6.52
Am-241	<1.71	2.47(0.210)	<3.29	1.85(0.16)

TABLE D.2. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-11 4/29/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	1.36	10.0	1.0	
Sample Weight, Field (gms)	3.71	13.37	1.84	18.92
K-40	0.256(0.256)	25.67(4.81)	22.87(7.85)	20.42(4.2)
Co-60	<0.859	<0.702	<1.48	<0.808
Cs-134	<0.970	<0.828	<1.61	<0.932
Cs-137	1.17(0.314)	2.89(0.231)	6.16(0.692)	2.87(0.29)
Ce-139				
Ce-141				
Bi-214	<1.44	<1.23	<2.39	<1.384
Ra-226	<1.40	0.317(0.317)	<2.32	0.224(0.224)
Ra-228	<3.72	<3.02	<6.32	<3.48
Th-228	<1.86	1.27(0.424)	1.09(0.988)	1.00(0.40)
U-235	<3.35	<2.74	<5.39	<3.12
U-238	<8.57	<6.10	5.15(4.37)	0.5(0.42)
Am-241	<1.40	0.871(0.255)	<2.28	0.62(0.18)

TABLE D.3. Concentration of Radionuclides in the Water of Buttermilk and Cattaraugus Creek Sampling Stations. Results of gamma-ray measurements. Values in parentheses are one standard deviation of the propagated counting error.

STATION: BC-1 4/26/79 PHASE 3 Water Volume Filtered: 325.5 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample						Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
		Aluminum Oxide Beds			Resin Beds				
		1st	2nd	3rd	1st	2nd	3rd		
Sample Wt., Analysis (g)	12.87	50.0	50.0	50.0	49.0	43.6	41.49		
Sample Wt., Field (g)	12.87	526.0	434.0	442.0	173.6	148.8	183.0		
K-40	254.83(46.07)	<1709.50	<3228.96	112.27(112.27)	246.51(124.64)	<113.68	<237.90	1.10*	1.89*
Co-60	<5.70	<72.59	<141.92	<35.80	<15.80	<6.70	<12.26	<0.88	<0.893
Cs-134	<7.23	<81.00	<162.3	<43.76	<18.58	<7.44	<13.54	<1.00	<1.03
Cs-137	<4.89	<51.02	<112.0	<30.06	<12.33	<5.06	<10.80	<0.68	<0.695
Bi-214	5.06(3.51)	<124.14	<241.30	<63.65	4.86(4.86)	<10.56	<22.33	0.0149(0.0149)	0.0305*
Ra-226	<10.40	<120.45	<234.36	<61.88	<26.73	<10.27	<21.59	<1.46	<1.49
Ra-228	<25.61	<297.72	<590.24	<159.12	<65.79	<25.15	<52.52	<3.66	<3.74
Th-228	<11.27	<119.93	<237.40	<68.07	<28.99	<14.14	<30.74	<1.53	<1.57
U-235	<26.00	<292.98	<611.94	<161.33	<67.01	<28.42	<57.28	<3.74	<3.82
U-238	<62.42	<699.58	<1297.66	<158.32	<158.32	<77.82	<160.31	<7.84	<8.03
Am-241	<12.82	<144.12	<268.65	<79.56	<32.98	<15.18	<30.56	<1.75	<1.79

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

PHASE 3

STATION: DC-1 4/27/79 Water Volume Filtered: 325.9 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	14.59	50.0			49.42				
Sample Wt., Field (g)	14.59	409.0			161.4				
K-40	271.37(57.34)	50.72(50.72)			605.25(117.18)			2.01*	2.85*
Co-60	<7.69	<37.22			<14.85			<0.160	<0.184
Cs-134	<8.91	<40.08			<18.56			<0.180	<0.207
Cs-137	<6.57	<28.22			<11.62			<0.122	<0.142
Bi-214	<13.25	<61.35			12.43(9.36)			0.038(0.03)	0.038(0.03)
Ra-226	<12.87	<59.71			11.94(9.04)			0.037(0.028)	0.037(0.028)
Ra-228	<31.66	<148.47			<65.04			<0.655	<0.752
Th-228	<13.89	<65.44			<27.76			<0.286	<0.329
U-235	<32.10	<152.97			<64.56			<0.667	<0.765
U-238	<76.16	<369.33			<148.97			<1.59	<1.82
Am-241	<16.19	<75.67			<31.15			<0.328	<0.378

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

PHASE 3

STATION: BC-1 4/28/79 Water Volume Filtered: 465.6 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	13.64	50.0			50.0				
Sample Wt., Field (g)	13.64	808.0			177.8				
K-40	303.22(37.78)	<3644.08			134.95(40.72)			0.290(0.088)	0.941*
Co-60	<5.03	<175.34			<7.11			<0.392	<0.403
Cs-134	<5.47	<193.11			<8.18			<0.432	<0.444
Cs-137	<4.05	<134.13			<6.40			<0.302	<0.311
Bi-214	<8.12	<274.72			<11.73			0.615	<0.633
Ra-226	<7.88	<266.64			<11.38			<0.597	<0.614
Ra-228	<20.05	<686.80			<30.23			<1.54	<1.58
Th-228	<8.81	<281.18			<16.54			<0.639	<0.658
U-235	<20.19	<711.04			<32.36			<1.60	<1.64
U-238	<48.69	<1527.12			<91.57			<3.48	<3.58
Am-241	<9.94	<326.43			<17.25			<0.738	<0.760

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

PHASE 3

STATION: FC-1/1 4/26/79 (AM) Water Volume Filtered: 181.7 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	16.53	50.0	50.0	50.0	50.0	47.6	46.91		
Sample Wt., Field (g)	16.53	482.0	425.55	442.0	162.2	184.1	182.5		
K-40	450.77(65.79)	<1903.90	15.75(15.75)	<1622.14	266.01(163.82)	132.0(132.0)	229.95(136.51)	3.54*	6.02*
Co-60	<11.52	<90.13	<143.41	<78.23	<23.68	<25.77	<17.52	<2.08	<2.15
Cs-134	<12.68	<107.5	<154.9	<87.52	<27.74	<31.48	<21.35	<2.37	<2.44
Cs-137	85.63(3.69)	<70.85	<109.4	<60.55	<18.33	<21.17	<14.78	<1.62	0.47(0.020)
Bi-214	<18.35	<147.49	<221.71	<128.18	<40.55	<44.55	<30.66	<3.37	<3.48
Ra-226	8.15(5.07)	<143.15	<215.33	33.59(33.59)	<39.41	<43.26	<29.75	0.185(0.185)	0.230*
Ra-228	<45.95	<352.82	<514.92	<311.61	<99.59	<106.23	<74.10	<8.03	<8.28
Th-228	<18.68	37.11(37.11)	<219.16	<123.32	<41.85	<47.50	<32.67	0.204(0.204)	0.204(0.204)
U-235	<45.62	<379.33	<570.24	<315.15	<100.08	<108.99	<76.10	<8.53	<8.78
U-238	<98.35	<804.94	<1246.86	<680.68	<231.95	<257.74	<180.49	<18.73	<19.27
Am-241	<20.99	<168.70	<253.20	<145.42	<48.98	<54.49	<36.87	<3.90	<4.01

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

PHASE 3

STATION: FC-1/2 4/26/79 (PM) Water Volume Filtered: 45.4 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	12.86	50.0	50.0		49.6	45.7			
Sample Wt., Field (g)	12.86	398.0	436.0		157.2	174.8			
K-40	353.26(50.41)	<2610.88	<1927.12		130.32(130.32)	300.66(136.52)		9.49	17.27*
Co-60	<7.29	<128.95	<93.30		<36.31	<46.32		<6.72	<6.88
Cs-134	<7.77	<140.5	<99.41		<41.34	<47.37		<7.24	<7.41
Cs-137	<5.49	29.05(29.05)	<71.94		<27.35	<66.60		0.64(0.64)	0.64(0.64)
Bi-214	5.38(3.41)	<200.19	<149.55		<59.11	<28.67		<9.64	0.12(0.075)
Ra-226	<11.57	<194.22	<145.19		<57.38	<27.79		<9.35	<9.61
Ra-228	<28.29	<469.64	<362.75		<138.81	<158.02		<24.86	<25.49
Th-228	<12.77	<200.59	688.88(42.73)		<57.85	<66.95		15.71(0.941)	15.71(0.941)
U-235	<28.42	<513.42	<373.65		<146.51	<72.37		<24.36	<24.99
U-238	<69.06	<1094.50	<797.88		<304.97	<172.18		<52.19	<53.71
Am-241	<13.89	<234.02	<166.55		<63.67	<37.14		<11.04	<11.35

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

PHASE 3

STATION: FC-1/3   4/27/79 (AM)   Water Volume Filtered: 212.0 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	16.0	50.0	50.0		50.0	50.0			
Sample Wt., Field (g)	16.0	432.0	405.6		185.0	156.0			
K-40	457.12(38.72)	<1974.24	257.56(257.56)		229.40(125.80)	198.12(113.10)		3.23*	5.39*
Co-60	<5.14	<97.2	<52.73		<16.10	<14.98		<0.854	<0.878
Cs-134	<5.97	<107.1	<60.43		<18.69	<16.38		<0.956	<0.98
Cs-137	44.8(1.68)	<72.14	17.04(10.95)		7.59(3.89)	<12.01		0.116*	0.327*
Bi-214	7.07(3.04)	<156.38	<88.02		<27.20	<25.27		<1.40	0.033(0.014)
Ra-226	6.88(2.94)	<152.06	<85.58		<26.27	10.14(8.27)		0.048(0.039)	0.080*
Ra-228	<2.03	<373.68	<206.86		<64.57	<61.62		<3.33	<3.34
Th-228	<8.90	<152.06	<85.99		<29.23	<26.21		<1.38	<1.43
U-235	<20.0	<388.80	<221.05		<68.64	<60.84		<3.49	<3.58
U-238	<48.8	<851.05	<474.55		<162.43	<144.30		<7.70	<7.93
Am-241	<10.0	<196.99	<105.86		<33.30	<29.33		<1.72	<1.77

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

PHASE 3

STATION: FC-1/4 4/27/79 (PM) Water Volume Filtered: 120.4 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	14.78	50.0	50.0		48.36	50.0			
Sample Wt., Field (g)	14.78	345.0	465.0		165.4	152.4			
K-40	427.73(38.13)	290.84(290.84)	<1315.95		373.80(119.25)	<426.72		5.52*	9.07*
Co-60	<38.13	<48.30	<59.52		<15.38	<58.06		<1.51	<1.55
Cs-134	<5.41	<23.81	<68.82		<18.69	<66.75		<1.48	<1.52
Cs-137	8.84(1.17)	<55.89	<47.90		14.39(3.47)	<43.43		0.120(0.029)	0.193*
Bi-214	<8.04	<125.24	<101.84		19.52(9.59)	<88.85		0.162(0.080)	0.162(0.080)
Ra-226	4.55(2.66)	<121.44	13.49(13.49)		19.02(9.26)	<86.26		<0.270*	0.308*
Ra-228	<19.81	<215.97	<246.45		<67.15	<187.45		<5.96	<6.12
Th-228	<8.45	<31.40	<98.58		<28.12	<91.59		<2.07	<2.14
U-235	<19.51	<328.10	<256.22		<66.99	<230.12		<7.32	<7.48
U-238	<45.56	<693.45	<544.05		<157.96	<495.30		<15.70	<16.09
Am-241	<9.47	<145.25	<113.46		<32.42	<102.72		<3.27	<3.35

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

PHASE 3

STATION: FC-1/5 4/28/79 (AM) Water Volume Filtered: 189.3 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	13.67	50.0	50.0		49.6	49.5			
Sample Wt., Field (g)	13.67	427.0	469.9		161.8	147.0			
K-40	358.84(38.00)	362.95(362.95)	<1024.38		318.17(203.87)	191.10(86.29)		4.61*	6.51*
Co-60	<4.43	<76.43	<39.00		<36.89	<8.23		<0.848	<0.872
Cs-134	<5.15	<84.55	<45.11		<43.04	<9.85		<0.964	<0.992
Cs-137	20.78(1.35)	<57.22	<34.30		<30.09	<6.62		0.110(0.0072)	0.110(0.0072)
Bi-214	5.82(3.24)	<123.40	<72.36		<59.38	<14.11		0.031(0.017)	0.031(0.017)
Ra-226	5.65(3.14)	28.18(28.18)	<70.02		<57.60	11.32(6.32)		0.21*	0.24*
Ra-228	<18.45	<293.78	<171.04		<144.65	<34.25		<2.87	<3.50
Th-228	<8.05	<117.85	<70.92		<58.90	<15.14		<1.39	<1.43
U-235	<18.59	<303.60	<171.04		<147.72	<35.28		<3.47	<3.57
U-238	<44.02	<653.31	<413.98		<438.48	<82.17		<8.39	<8.62
Am-241	<9.09	<138.35	<85.99		<69.57	<17.20		<1.64	<1.69

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

STATION: BC-3 4/27/79

PHASE 3

Water Volume Filtered: 148.8 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	13.76	50.0			50.0				
Sample Wt., Field (g)	13.76	441.0			188.0				
K-40	396.84(61.64)	206.39(206.39)			38.35(38.35)			1.64*	4.31*
Co-60	<11.74	<140.24			<11.47			<1.02	<1.10
Cs-134	<12.27	<160.5			<13.16			<1.17	<1.25
Cs-137	6.76(2.64)	<113.3			<9.96			<0.83	0.045(0.018)
Bi-214	<17.61	<233.73			<17.30			<1.69	<1.81
Ra-226	5.90(5.12)	<226.67			<16.73			<1.64	0.040(0.034)
Ra-228	<40.59	<551.25			<44.56			<4.00	<4.28
Th-228	<17.61	<223.15			<25.94			<1.67	<1.79
U-235	<42.93	<582.12			<49.44			<4.24	<4.53
U-238	<92.19	<1243.62			<138.18			<9.29	<9.91
Am-241	<19.54	<259.31			<25.57			<1.91	<2.05

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

PHASE 3

STATION: BC-4 4/26/79 Water Volume Filtered: 224.0 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate µCi/liter
Sample Wt., Analysis (g)	16.30	50.0	50.0	50.0	48.5	49.50	50.0		
Sample Wt., Field (g)	16.30	431.0	433.5	435.0	180.4	173.6	186.0		
K-40	414.18(56.24)	386.61(298.68)	<927.69	<974.40	295.86(105.71)	223.94(141.14)	<827.62	4.05*	5.90*
Co-60	<9.89	<37.50	<33.81	<36.98	<9.92	<19.79	<42.13	<0.80	<0.85
Cs-134	<11.02	<42.67	<41.18	<43.94	<12.63	<25.17	<49.58	<0.96	<1.01
Cs-137	<7.29	<28.88	<28.61	<.9.15	<7.94	<14.93	<32.99	<0.64	<0.67
Bi-214	<15.24	<64.65	3.90(3.90)	<64.82	1.26(1.26)	9.37(9.37)	<67.85	0.065*	0.065*
Ra-226	<14.80	<62.93	3.90(3.90)	<63.08	1.26(1.26)	<32.64	<65.99	0.023*	0.023*
Ra-228	<38.14	<160.76	<149.99	<156.17	<42.39	<80.38	<162.35	<3.36	<3.53
Th-228	<15.63	<66.81	<64.16	<68.73	<18.40	<35.41	<66.54	<1.43	<1.50
U-235	<38.96	<167.66	<155.63	<164.87	<43.48	<82.98	<166.46	<3.49	<3.66
U-238	<82.32	<387.04	<374.11	<391.94	<102.11	<196.17	<376.53	<8.16	<8.53
Am-241	<17.28	<80.17	<76.73	<81.35	<20.93	<39.75	<79.97	<1.69	<1.77

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

STATION: BC-4 4/27/79

PHASE 3
Water Volume Filtered: 276.3 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample — Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	14.69	50.0			46.2				
Sample Wt., Field (g)	14.69	410.0			212.3				
K-40	278.88(90.93)	293.97(293.97)			579.58(130.14)			3.16*	4.17*
Co-60	<16.75	<85.69			<12.31			<0.355	<0.415
Cs-134	<17.19	<93.07			<14.65			<0.390	<0.452
Cs-137	<12.38	<66.83			4.03(3.18)			0.015(0.012)	0.015(0.012)
Bi-214	<24.83	<141.45			2.55(2.55)			0.0092(0.0092)	0.0092(0.0092)
Ra-226	<24.24	55.35(44.28)			2.55(2.55)			0.210*	0.210*
Ra-228	<58.91	<348.09			<52.65			<1.45	<1.66
Th-228	<25.56	38.54(37.72)			<22.72			0.139(0.137)	0.139(0.137)
U-235	<64.93	<359.98			<53.29			<1.50	<1.73
U-238	<138.23	<774.90			<125.04			<3.26	<3.76
Am-241	<28.50	<157.85			<25.90			<0.665	<0.768

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

STATION: BC-4 4/28/79

PHASE 3
Water Volume Filtered: 424.0 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	13.63	50.0			50.0				
Sample Wt., Field (g)	13.63	397.0			164.5				
K-40	342.25(40.21)	<1730.92			258.27(143.61)			0.609(0.339)	1.42*
Co-60	<5.25	<65.11			<19.90			<0.200	<0.213
Cs-134	<6.19	<80.99			<23.36			<0.246	<0.261
Cs-137	9.94(1.20)	<57.17			<17.11			<0.175	0.0234(0.00283)
Bi-214	3.07(3.04)	<118.31			<35.86			<0.364	0.00723(0.00717)
Ra-226	<9.0	<114.73			<34.87			<0.353	<0.374
Ra-228	<20.99	<286.63			<88.67			<0.885	<0.935
Th-228	0.67(0.67)	<120.69			<38.82			<0.376	0.00158(0.00158)
U-235	<22.08	<299.34			<86.20			<0.909	<0.961
U-238	<51.66	<682.84			<203.98			<2.09	<2.21
Am-241	<10.67	<149.27			<42.61			<0.453	<0.478

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

STATION: CC-I 4/26/79 PHASE 3 Water Volume Filtered: 193.1 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	13.55	50.0	50.0		46.0	46.0			
Sample Wt., Field (g)	13.55	411.0	464.8		155.7	189.0			
K-40	286.85(37.80)	330.03(330.03)	<971.43		26.47(26.47)	419.58(184.46)		4.02*	5.50*
Co-60	<4.77	<90.01	<39.97		<57.30	<28.92		<1.12	<1.14
Cs-134	<5.57	<96.17	<44.62		<61.03	<32.51		<1.21	<1.24
Cs-137	<3.66	<69.46	<30.21		<40.95	<22.87		<0.847	<0.867
Bi-214	<7.95	<142.62	<65.54		<87.97	9.64(9.64)		0.0499(0.0499)	0.0499(0.0499)
Ra-226	<7.72	73.57(41.51)	<63.68		<85.48	<47.82		0.381(0.215)	0.381(0.215)
Ra-228	<19.92	<339.49	<165.00		<216.42	<121.91		<4.36	<4.47
Th-228	0.93(0.93)	28.77(28.77)	<67.40		<87.04	<53.87		0.149(0.149)	0.154*
U-235	<19.65	<363.74	<164.54		<219.54	<122.28		<4.51	<4.61
U-238	<46.88	<764.46	<386.25		<476.44	<289.17		<9.92	<10.17
Am-241	<9.58	<163.17	<81.34		<150.72	<60.10		<2.36	<2.41

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

PHASE 3

STATION: CC-1 4/27/79 Water Volume Filtered: 572.7 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	16.40	50.0			47.8				
Sample Wt., Field (g)	16.40	404.9			162.0				
K-40	272.90(81.84)	433.24(265.21)			141.91(117.61)			1.00*	1.48*
Co-60	<15.25	<31.58			<15.39			<0.082	<0.109
Cs-134	<18.37	<39.28			<17.98			<0.100	<0.132
Cs-137	<11.53	<25.10			<11.66			<0.064	<0.0843
Bi-214	<24.60	50.21(26.32)			<26.41			0.0877(0.0460)	0.0877(0.0460)
Ra-226	<23.94	48.59(25.51)			<25.60			0.0848(0.0445)	0.0848(0.0445)
Ra-228	<61.01	<137.67			<62.53			<0.350	<0.456
Th-228	<24.60	<57.50			<28.51			<0.150	<0.193
U-235	<61.99	<137.67			<65.29			<0.354	<0.463
U-238	<135.96	<326.35			<155.20			<0.841	<1.08
Am-241	<58.71	<66.81			<31.59			<0.172	<0.274

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

PHASE 3

STATION: CC-3 4/27/79 Water Volume Filtered: 628.4 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	2nd	3rd	Resin Beds 1st	2nd	3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	16.12	50.0			50.0				
Sample Wt., Field (g)	16.12	343.0			267.0				
K-40	513.26(56.10)	<2493.61			680.85(175.15)			1.083(0.279)	1.90*
Co-60	<7.21	<121.42			<19.49			<0.224	<0.236
Cs-134	<8.12	<136.86			<23.76			<0.256	<0.269
Cs-137	6.96(1.82)	<92.61			<16.02			<0.173	0.0111(0.00290)
Bi-214	<12.25	<202.71			<35.24			<0.379	<0.398
Ra-226	<11.90	<196.88			<34.18			<0.368	<0.387
Ra-228	<29.34	<449.33			<88.11			<0.855	<0.902
Th-228	2.87(2.87)	<190.71			<37.65			<0.363	0.00457(0.00457)
U-235	<28.69	<500.78			<87.84			<0.937	<0.982
U-238	<69.64	<1094.17			<203.99			<2.07	<2.18
Am-241	<14.22	<220.89			<42.99			<0.420	<0.443

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

STATION: CC-5 4/26/79

PHASE 3
Water Volume Filtered: 385.4 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	15.43	50.0	50.0	50.0	50.0	45.7	46.0		
Sample Wt., Field (g)	15.43	413.0	464.2	470.0	180.05	175.67	188.41		
K-40	416.61(37.65)	254.41(254.41)	<3267.97	1983.4(1015.2)	137.92(29.17)	112.25(112.25)	331.6(182.19)	7.32*	8.40*
Co-60	<4.78	<137.12	<141.58	<178.60	<4.14	<18.80	<26.19	<1.31	<1.33
Cs-134	<5.51	<148.7	<122.1	<181.42	<5.40	<20.55	<30.71	<1.32	<1.33
Cs-137	<3.64	<102.4	<121.2	1734.3(70.5)	<3.78	<13.70	<21.29	4.50(0.183)	4.50(0.183)
Bi-214	0.82(0.82)	<210.63	<251.60	<272.60	<6.84	<30.39	11.49(11.49)	0.030(0.030)	0.0319*
Ra-226	<7.55	<204.44	<244.17	107.63(84.60)	<6.66	<29.51	<45.03	0.279(0.220)	0.279(0.220)
Ra-228	<19.13	<512.12	<547.76	<662.70	<17.28	<73.96	<111.54	<5.00	<5.05
Th-228	<8.36	<206.91	<165.72	410.31(93.06)	<9.90	<32.15	<49.36	1.06(0.241)	1.06(0.241)
U-235	<19.29	<541.03	<635.95	<658.0	<19.63	<74.31	<114.74	<5.30	<5.35
U-238	<45.52	<1160.53	<1374.03	<1447.60	<51.31	<177.43	<265.66	<11.62	<11.73
Am-241	<9.44	<237.48	<292.45	<310.67	<10.44	<36.19	<56.33	<2.45	<2.47

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

PHASE 3

STATION: CC-5 4/27/79 Water Volume Filtered: 457.7 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample Aluminum Oxide Beds 1st	2nd	3rd	Resin Beds 1st	2nd	3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	13.91	50.0	50.0		50.0	50.0			
Sample Wt., Field (g)	13.91	412.0	463.0		151.0	162.2			
K-40	307.13(74.28)	<1619.16	59.73(59.73)		205.38(57.98)	100.24(32.44)		0.798*	1.47*
Co-60	<14.88	<76.63	<93.53		<8.76	<5.03		<0.402	<0.435
Cs-134	<15.72	<83.64	<104.20		<10.87	<6.98		<0.449	<0.484
Cs-137	7.61(2.98)	<57.27	<72.23		<6.80	<4.70		<0.308	0.0166(0.0065)
Bi-214	18.08(5.98)	<126.90	<149.55		<13.74	<9.08		<0.654	0.0395(0.0131)
Ra-226	17.53(5.81)	<123.19	<145.38		<13.29	<8.76		<0.635	0.0383(0.0127)
Ra-228	<55.08	<297.88	<360.68		<32.47	<21.74		<1.56	<1.68
Th-228	<22.67	<120.30	<150.48		<19.33	<12.98		<0.663	<0.712
U-235	<56.75	<312.30	<374.57		<40.32	<25.79		<1.65	<1.77
U-238	<118.10	<667.44	<796.36		<107.51	<71.21		<3.59	<3.85
Am-241	<25.04	<139.26	<275.49		<20.08	<13.30		<0.980	<1.03

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

PHASE 3

STATION: CC-6 4/26/79 Water Volume Filtered: 703.1 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	2nd	3rd	Resin Beds 1st	2nd	3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	14.1	50.0	50.0	50.0		50.0	50.0		
Sample Wt., Field (g)	14.1	398.0	424.0	446.0		167.51	169.79		
K-40	301.46(66.69)	<859.68	<1619.68	33.0(33.0)		<567.86	<497.48(155.53)	0.754*	1.18*
Co-60	<10.94	<33.03	<75.90	<57.09		<21.94	<23.43	<0.301	<0.316
Cs-134	<12.61	<39.40	<84.38	<65.12		<27.14	<26.83	<0.345	<0.363
Cs-137	<8.87	<26.67	<58.51	<46.83		<18.09	<18.24	<0.239	<0.252
Bi-214	<18.61	<58.51	<123.81	<101.69		<39.70	<40.41	<0.518	<0.544
Ra-226	<18.05	<56.91	<120.42	<98.57		<38.53	<39.22	<0.503	<0.529
Ra-228	<45.83	<142.48	<307.82	<256.45		<100.00	<92.20	<1.28	<1.34
Th-228	9.08(4.67)	<60.89	<122.11	<103.92		<41.54	<43.13	<0.529	0.0129(0.0066)
U-235	<45.83	<144.47	<317.58	<252.88		<96.15	<101.03	<1.30	<1.36
U-238	<98.00	<345.86	<678.40	<593.18		<224.46	<234.31	<2.95	<3.09
Am-241	<20.30	<73.23	<141.62	<120.87		<46.57	<48.05	<0.612	<0.641

TABLE D.3. (contd)

PHASE 3

STATION: CC-6   4/27/79   Water Volume Filtered: 526.2 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	14.1	50.0	50.0		50.0	50.0			
Sample Wt., Field (g)	14.1	472.5	421.0		189.8	188.76			
K-40	417.92(50.06)	164.43(164.43)	285.44(285.44)		176.89(45.36)	445.47(125.71)		2.04*	2.83*
Co-60	<7.21	<43.47	<76.62		<7.78	<15.10		<0.272	<0.285
Cs-134	<8.90	<49.61	<82.94		<10.06	<17.55		<0.304	<0.321
Cs-137	<6.01	<31.66	<59.78		<6.45	<11.70		<0.208	<0.220
Bi-214	<11.89	34.02(25.99)	<125.88		<12.34	14.91(9.63)		0.0930*	0.0930*
Ra-226	<11.53	33.08(25.52)	<122.29		<11.96	14.53(9.25)		0.0905*	0.0905*
Ra-228	<30.03	<177.66	<298.91		<30.75	<66.25		<1.09	<1.15
Th-228	<13.24	<77.49	<118.72		<17.08	<27.75		<0.458	<0.483
U-235	<29.19	<181.91	<312.38		<35.30	<65.31		<1.13	<1.19
U-238	<69.23	<432.34	<715.70		<94.52	<149.88		<2.65	<2.78
Am-241	<14.38	<87.89	101.04(31.15)		<18.03	<31.71		0.192(0.0592)	0.192(0.0592)

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

STATION: CC-6 4/28/79 PHASE 3
Water Volume Filtered: 456.6 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	15.49	50.0			50.0				
Sample Wt., Field (g)	15.49	350.0			168.1				
K-40	263.64(63.51)	<1571.50			218.53(53.12)			0.479(0.116)	1.06*
Co-60	<12.44	<75.60			<9.41			<0.186	<0.213
Cs-134	<12.86	<85.05			<10.93			<0.210	<0.238
Cs-137	<8.47	<58.45			<8.91			<0.148	<0.166
Bi-214	<17.97	<123.20			<15.80			<0.304	<0.344
Ra-226	<17.35	42.35(32.90)			<15.30			0.093(0.072)	0.093(0.072)
Ra-228	<44.30	<296.10			<41.86			<0.740	<0.837
Th-228	<17.97	<120.05			<21.52			<0.310	<0.349
U-235	<44.61	<305.90			<42.03			<0.762	<0.860
U-238	<96.50	<654.50			<119.35			<1.70	<1.90
Am-241	<21.07	<137.90			<23.20			<0.353	<0.399

* Indicates standard deviations cannot be determined.

TABLE D.3. (contd)

STATION: CC-9 4/29/79

PHASE 3
Water Volume Filtered: 359.6 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	14.6	50.0			43.2				
Sample Wt., Field (g)	14.6	421.0			252.9				
K-40	257.98(90.08)	<879.89			715.71(215.72)			1.99(0.60)	2.71*
Co-60	<17.67	<36.21			<27.57			<0.177	<0.227
Cs-134	<17.67	<40.42			<32.37			<0.202	<0.252
Cs-137	<13.20	<27.37			<22.76			<0.139	<0.176
Bi-214	<26.13	<59.36			<46.53			<0.295	<0.367
Ra-226	<25.40	<57.68			<45.27			<0.286	<0.357
Ra-228	2.91(2.91)	<149.46			<117.85			<0.743	0.0081(0.0081)
Th-228	<26.57	<61.05			<50.07			<0.309	<0.383
U-235	<66.58	<149.03			<117.09			<0.740	<0.925
U-238	<144.98	<349.85			<270.60			<1.73	<2.13
Am-241	<29.35	<73.68			<57.41			<0.365	<0.446

* Indicates standard deviation cannot be determined.

TABLE D.3. (contd)

STATION: CC-11 4/29/79

PHASE 3
Water Volume Filtered: 302.8 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	2nd	3rd	Resin Beds 1st	2nd	3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	14.98	50.0	50.0	50.0	50.0	50.0	46.69		
Sample Wt., Field (g)	14.98	416.0	423.0	423.0	155.9	173.4	157.0		
K-40	201.03(62.62)	<1876.16	<1903.50	<884.07	371.04(154.50)	<195.94	70.65(70.65)	1.46*	2.12*
Co-60	<11.10	<82.37	<86.29	<36.38	<23.07	<8.84	<20.41	<0.850	<0.887
Cs-134	<11.62	<94.02	<100.67	<40.61	<27.91	<13.53	<25.75	<0.999	<1.04
Cs-137	<8.09	<64.90	<70.22	<27.50	<17.62	<8.67	<16.17	<0.677	<0.704
Bi-214	<16.93	<145.60	<143.40	<59.64	<37.26	<16.99	<37.68	<1.46	<1.51
Ra-226	<16.48	<141.44	<139.17	<57.95	<36.17	<16.47	<36.58	<1.41	<1.47
Ra-228	<41.94	<348.19	<343.90	<150.17	<101.18	<35.89	<93.26	<3.54	<3.68
Th-228	<16.78	<139.36	<137.90	<61.34	<42.72	<42.72	<24.28	<1.47	<1.52
U-235	<42.24	<356.93	<367.16	<149.74	<95.10	<45.95	<92.32	<3.66	<3.80
U-238	<91.38	<761.28	<774.09	<351.51	<224.50	<127.10	<215.09	<8.10	<8.40
Am-241	<19.02	<159.74	<163.70	<74.03	<47.08	<24.97	<43.96	<1.70	<1.76

* Indicates standard deviation cannot be determined.

TABLE D.4. Concentration of Radionuclides in the Channel Bed Sediment of Buttermilk and Cattaraugus Creek Sampling Stations. Results of radiochemical analysis of alpha and beta emitter. Values in parentheses are one standard deviation of the propagated counting error.

PHASE 3 - FIELD PROGRAM

STATION: BC-1 4/26/79

Radionuclide Concentration - Bed Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	82.0	19.61	*	
Sample Weight, Field (gms)	471.43	19.72	0.78	491.93
Sr-90	0.040(0.014)	0.031(0.016)		0.040
Pu-238	0.0014(0.0005)	0.0006(0.0006)		0.00136(0.0005)
Pu-239,240	0.0022(0.0004)	<0.0007		0.0021(0.00038)
Am-241	0.0013(0.0007)	<0.003		0.0012(0.00067)
Cm-244	0.0061(0.0011)	<0.0007		0.0058(0.00105)

* Sample lost or accidentally destroyed.

STATION: EB 4/29/79

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	39.07	37.3	25.0	
Sample Weight, Field (gms)	*	*	*	
Sr-90	1.56(0.12)	0.753(0.074)	0.081(0.038)	
Pu-238	0.011(0.002)	0.0045(0.0003)	<0.0001	
Pu-239,240	0.008(0.002)	0.004(0.001)	0.027(0.015)	
Am-241	0.028(0.006)	0.031(0.009)	0.016(0.014)	
Cm-244	<0.0002	<0.0002	0.023(0.007)	

* Data missing.

TABLE D.4. (contd)

PHASE 3 - FIELD PROGRAM

STATION: FC/EB 4/29/79

Radionuclide Concentration - Bed Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	50.0	50.0	7.5	
Sample Weight, Field (gms)	*	*	*	
Sr-90	0.330(0.049)	0.389(0.041)	2.04(0.51)	
Pu-238	<0.0001	0.0008(0.0001)	0.007(0.002)	
Pu-239,240	0.158(0.026)	0.0026(0.0005)	0.016(0.003)	
Am-241	0.245(0.091)	<0.0019	0.101(0.016)	
Cm-244	0.077(0.042)	0.010(0.006)	0.0084(0.0068)	

* Data missing.

STATION: FC-1

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	50.0	22.4	12.2	
Sample Weight, Field (gms)	566.0	155.0	12.2	733.2
Sr-90	<0.00027	0.579(0.085)	*	0.125(0.018)
Pu-238	0.710(0.105)	0.0034(0.0001)	0.023(0.004)	0.548(0.081)
Pu-239,240	0.785(0.113)	0.0038(0.007)	0.010(0.003)	0.605(0.0872)
Am-241	0.118(0.021)	0.017(0.009)	*	0.0944(0.018)
Cm-244	<0.008	0.012(0.005)	*	0.0025(0.0011)

* Sample lost or accidentally destroyed.

TABLE D.4. (contd)

PHASE 3 - FIELD PROGRAM

STATION: FC-1 4/29/79

Radionuclide Concentration - Bed Sediment
pCi/gm

	Coarse Sand	Medium Sand	Fine Sand	Sand Composite	Silt	Clay	Sample Composite
Sample Weight, Analysis (gms)	88.78	8.5	1.75		10.0	3.2	
Sample Weight, Field (gms)	389.0	120.0	57.0	566.0	155.0	12.2	733.2
Sr-90	1.18(0.038)	3.34(0.137)	1.73(0.216)	1.69(0.0766)	2.20(0.094)	7.44(0.454)	1.91(0.0878)
Pu-238	0.022(0.005)	0.031(0.006)	0.009(0.003)	0.0226(0.005)	0.021(0.008)	0.027(0.006)	0.0224(0.0057)
Pu-239,240	0.029(0.005)	0.026(0.006)	<0.008	0.0255(0.0047)	0.027(0.009)	0.022(0.006)	0.0257(0.0056)
Am-241	0.0209(0.0031)	0.049(0.020)	0.079(0.034)	0.0326(0.0097)	0.021(0.016)	0.114(0.029)	0.0318(0.0114)
Cm-244	0.0089(0.0018)	<0.0017	<0.0081	0.0061(0.0012)	<0.0014	<0.0044	0.0047(0.0009)

TABLE D.4. (contd)

PHASE 3 - FIELD PROGRAM

STATION: BC-4 4/26/79

Radionuclide Concentration - Bed Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	85.5	10.0	0.80	
Sample Weight, Field (gms)	383.20	15.34	0.33	399.37
Sr-90	0.287(0.021)	0.419(0.054)	1.15(0.683)	0.294(0.024)
Pu-238	0.005(0.001)	0.005(0.001)	0.012(0.006)	0.005(0.001)
Pu-239,240	0.007(0.001)	0.003(0.001)	<0.016	0.007(0.001)
Am-241	0.0047(0.0015)	<0.0064	<0.080	0.0045(0.0014)
Cm-244	0.0026(0.001)	<0.0014	<0.018	0.0025(0.001)

STATION: CC-1* 4/28/79

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	76.2	10.0	4.83	
Sample Weight, Field (gms)	441.5	554.8	14.7	1011.0
Sr-90	0.057(0.009)	0.892(0.336)	0.145(0.120)	0.517(0.19)
Pu-238	<0.00004	<0.0014	<0.001	
Pu-239,240	0.0013(0.0003)	0.002(0.002)	0.007(0.002)	0.0017(0.0013)
Am-241	0.0122(0.0017)	0.017(0.014)	0.068(0.030)	0.0154(0.0087)
Cm-244	0.0022(0.0008)	<0.0014	<0.0029	0.001(0.0004)

* Sample collected in tributary of Cattaraugus Creek located about 1500 ft upstream of CC-1

TABLE D.4. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-1 4/29/79

Radionuclide Concentration - Bed Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	2.22	1.0	0.1	
Sample Weight, Field (gms)	2.25	2.01	0.12	4.38
Sr-90	<0.050	<0.111	9.70(6.21)	0.30(0.19)
Pu-238	<0.001	0.034(0.020)	<0.016	0.016(0.009)
Pu-239,240	<0.006	<0.014	<0.074	<0.012
Am-241	0.110(0.056)	<0.064	<0.640	0.056(0.029)
Cm-244	<0.0064	<0.014	<0.142	<0.014

STATION: CC-3 4/27/79

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	83.22	5.0	0.13	
Sample Weight, Field (gms)	524.37	5.2	0.14	529.71
Sr-90	<0.0013	<0.022	<0.854	<0.0013
Pu-238	<0.00004	<0.001	<0.023	<0.00004
Pu-239,240	0.003(0.002)	<0.003	<0.108	0.003(0.002)
Am-241	0.032(0.007)	<0.013	<0.492	0.032(0.007)
Cm-244	0.0169(0.0046)	<0.0028	<0.109	0.0169(0.0046)

TABLE D.4. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-5 4/28/79

Radionuclide Concentration - Bed Sediment
pCi/gm

	Coarse Sand	Medium Sand	Fine Sand	Sand Composite	Silt	Clay	Sample Composite
Sample Weight, Analysis (gms)	80.5	72.9	3.2		5.0	0.11	
Sample Weight, Field (gms)	596.25	101.9	3.36	701.51	6.12	0.12	707.75
Sr-90	0.019(0.006)	0.350(0.022)	<0.035	0.067(0.008)	0.266(0.084)	<1.01	0.0687(0.0086)
Pu-238	0.005(0.002)	0.0009(0.0003)	0.003(0.002)	0.0044(0.002)	0.004(0.002)	<0.027	0.0044(0.002)
Pu-239,240	0.002(0.001)	0.0011(0.0003)	<0.004	0.0019(0.0009)	<0.003	<0.107	0.0019(0.0009)
Am-241	0.0085(0.0033)	0.0074(0.0041)	<0.020	0.0083(0.0034)	0.032(0.010)	<0.582	0.0085(0.0035)
Cm-244	0.003(0.0023)	<0.0002	0.048(0.045)	0.0028(0.0022)	0.0047(0.0035)	<0.129	0.0028(0.0022)

TABLE D.4. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-6 4/26/79

Radionuclide Concentration - Bed Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	82.1	5.0	0.2	
Sample Weight, Field (gms)	510.88	7.16	0.21	518.25
Sr-90	0.107(0.015)	<0.022	<0.555	0.105(0.0148)
Pu-238	<0.00004	0.002(0.001)	<0.015	0.00003(0.00001)
Pu-239,240	0.002(0.001)	<0.003	<0.070	0.002(0.001)
Am-241	0.0069(0.0027)	<0.0128	0.84(0.24)	0.0071(0.0027)
Cm-244	0.0045(0.0021)	0.0048(0.0047)	<0.071	0.0044(0.0021)

STATION: CC-9

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	79.5	50.0	1.0	
Sample Weight, Field (gms)	1168.1	68.2	1.46	1237.76
Sr-90	0.033(0.011)	0.011(0.011)	<0.111	0.032(0.011)
Pu-238	0.024(0.004)	<0.003	<0.003	0.023(0.004)
Pu-239,240	0.008(0.002)	0.045(0.014)	<0.014	0.01(0.003)
Am-241	0.0098(0.0023)	0.0047(0.0022)	<0.064	0.0095(0.0022)
Cm-244	0.0033(0.0014)	0.0021(0.00150	<0.014	0.0032(0.0014)

TABLE D.4. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-11

Radionuclide Concentration - Bed Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	79.3	50.0	1.0	
Sample Weight, Field (gms)	520.24	340.3	5.26	865.8
Sr-90	0.028(0.007)	<0.002	<0.111	0.017(0.0042)
Pu-238	0.002(0.001)	<0.0014	<0.003	0.0012(0.0006)
Pu-238,240	<0.0002	<0.0003	<0.014	<0.00038
Am-241	0.0058(0.0041)	0.0036(0.0031)	<0.064	0.0049(0.0037)
Cm-244	0.0239(0.0049)	0.0025(0.0015)	<0.014	0.0153(0.0035)

TABLE D.5. Radionuclide Concentration in the Suspended Sediment of Buttermilk and Cattaraugus Creek Sampling Stations. Results of radiochemical analysis of alpha and beta emitting radionuclides. Values in parentheses are one standard deviation of the propagated counting error.

PHASE 3 - FIELD PROGRAM

STATION: BC-1* 4/26/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.03	2.56	0.28	
Sample Weight, Field (gms)	0.05	2.62	0.32	2.99
Sr-90	<3.70	0.646(0.583)	2.21(1.71)	0.802(0.69)
Pu-238	<0.10	0.011(0.006)	0.029(0.027)	0.013(0.008)
Pu-239,240	<0.467	0.020(0.008)	<0.048	0.018(0.007)
Am-241	<2.13	0.105(0.061)	1.18(0.23)	0.22(0.08)
Cm-244	<0.473	0.067(0.038)	<0.049	0.06(0.03)

* Data not presented graphically.

STATION: BC-1 4/27/79

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	1.43	25.0	7.0	
Sample Weight, Field (gms)	2.89	50.12	7.12	60.13
Sr-90	<0.078	0.093(0.034)	<0.016	0.08(0.03)
Pu-238	<0.002	<0.0001	<0.0004	<0.00023
Pu-239,240	<0.010	0.0024(0.001)	<0.002	0.0019(0.0008)
Am-241	<0.045	<0.003	<0.010	<0.0059
Cm-244	<0.010	0.0139(0.0049)	0.041(0.02)	0.02(0.01)

TABLE D.5. (contd)

PHASE 3 - FIELD PROGRAM

STATION: BC-1* 4/28/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.61	13.12	4.62	
Sample Weight, Field (gms)	0.65	13.22	4.72	18.59
Sr-90	1.47(0.688)	0.093(0.047)	0.323(0.163)	0.20(0.10)
Pu-238	0.0095(0.0081)	<0.0002	<0.001	0.0003(0.00028)
Pu-239,240	<0.023	<0.001	<0.003	<0.0023
Am-241	0.51(0.41)	1.47(0.24)	12.06(5.52)	4.13(1.59)
Cm-244	0.37(0.30)	1.16(0.20)	<0.003	0.84(0.15)

* Data not presented graphically.

STATION: FC-1/1* 4/26/79 (AM)

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.49	25.0	25.0	
Sample Weight, Field (gms)	0.66	71.95	26.22	98.83
Sr-90	5.03(1.04)	0.452(0.033)	1.18(0.04)	0.68(0.04)
Pu-238	0.073(0.063)	0.002(0.001)	0.003(0.001)	0.003(0.001)
Pu-239,240	<0.029	0.003(0.001)	0.003(0.001)	0.003(0.001)
Am-241	<0.131	<0.0026	0.102(0.011)	0.03(0.003)
Cm-244	<0.029	0.046(0.023)	0.0429(0.0067)	0.05(0.02)

* Data not presented graphically.

TABLE D.5. (contd)

PHASE 3 - FIELD PROGRAM

STATION: FC-1/2* 4/26/79 (PM)

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.91	12.12	1.0	
Sample Weight, Field (gms)	0.91	12.37	3.97	17.25
Sr-90	2.70(0.984)	0.505(0.036)	0.514(0.507)	0.62(0.20)
Pu-238	0.013(0.008)	0.005(0.001)	<0.003	0.004(0.001)
Pu-239,240	<0.015	0.003(0.001)	<0.014	0.002(0.0007)
Am-241	<0.07	0.021(0.006)	0.30(0.18)	0.08(0.05)
Cm-244	0.34(0.14)	0.004(0.0024)	0.105(0.081)	0.04(0.03)

* Data not presented graphically.

STATION: FC-1/3* 4/27/79 (AM)

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.40	25.5	22.5	
Sample Weight, Field (gms)	0.49	55.30	22.81	78.60
Sr-90	**	0.296(0.029)	1.28(0.051)	0.58(0.04)
Pu-238	0.016(0.009)	0.004(0.001)	0.004(0.001)	0.004(0.001)
Pu-239,240	<0.035	0.003(0.001)	0.003(0.001)	0.0029(0.00099)
Am-241	**	<0.0025	0.106(0.032)	0.03(0.01)
Cm-244	**	0.0038(0.0025)	<0.00063	0.0026(0.0018)

* Data not presented graphically.
** Sample lost or accidently destroyed.

TABLE D.5. (contd)

PHASE 3 - FIELD PROGRAM

STATION: FC-1/4 4/27/79 (PM)

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	1.0	25.0	4.2	
Sample Weight, Field (gms)	0.99	48.86	21.23	71.08
Sr-90	0.633(0.338)	0.445(0.031)	4.38(0.279)	1.63(0.11)
Pu-238	0.011(0.005)	<0.0001	0.035(0.005)	0.01(0.0016)
Pu-239,240	<0.014	0.005(0.002)	0.029(0.004)	0.01(0.0026)
Am-241	<0.064	0.029(0.017)	0.062(0.023)	0.04(0.02)
Cm-244	0.087(0.057)	<0.00057	0.02(0.009)	0.01(0.0033)

STATION: FC-1/5* 4/28/79 (AM)

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.08	5.69	3.3	
Sample Weight, Field (gms)	0.06	6.11	3.28	9.45
Sr-90	<1.39	0.328(0.063)	0.874(0.125)	0.52(0.084)
Pu-238	<0.037	0.004(0.002)	0.008(0.004)	0.005(0.003)
Pu-239,240	<0.175	<0.002	<0.004	0.0037
Am-241	2.32(1.31)	<0.011	0.072(0.017)	0.04(0.014)
Cm-244	<0.178	0.015(0.010)	0.0258(0.0075)	0.02(0.009)

* Data not presented graphically.

TABLE D.5. (contd)

PHASE 3 - FIELD PROGRAM

STATION: BC-3 4/27/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.70	10.09	1.0	
Sample Weight, Field (gms)	0.71	14.07	2.82	17.60
Sr-90	1.44(0.52)	0.136(0.032)	<0.111	0.17(0.05)
Pu-238	0.032(0.024)	0.003(0.001)	<0.003	0.0037(0.0018)
Pu-239,240	<0.020	0.002(0.001)	<0.014	0.002(0.0008)
Am-241	<0.091	0.017(0.012)	<0.064	0.01(0.01)
Cm-244	<0.020	<0.0014	0.086(0.056)	0.01(0.01)

STATION: BC-4* 4/26/79

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.18	16.81	**	
Sample Weight, Field (gms)	0.16	16.95		17.11
Sr-90	<0.617	0.081(0.033)		0.08(0.03)
Pu-238	<0.017	0.0008(0.005)		0.0008(0.0005)
Pu-239,240	<0.082	<0.0008		<0.0016
Am-241	<0.356	0.015(0.009)		0.01(0.01)
Cm-244	0.30(0.25)	<0.0008		0.003(0.003)

* Data not presented graphically.
** No measurable amount of clay present.

TABLE D.5. (contd)

PHASE 3 - FIELD PROGRAM

STATION: BC-4 4/27/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.63	25.0	10.0	
Sample Weight, Field (gms)	0.65	57.2	14.66	72.51
Sr-90	1.70(0.849)	0.055(0.022)	0.062(0.044)	0.07(0.03)
Pu-238	<0.005	0.0009(0.0004)	0.001(0.001)	0.0009(0.0005)
Pu-239,240	<0.022	0.0013(0.0004)	0.002(0.001)	0.0014(0.0005)
Am-241	0.42(0.16)	0.012(0.003)	0.093(0.012)	0.03(0.01)
Cm-244	<0.023	0.0051(0.0016)	0.022(0.005)	0.01(0.002)

STATION: BC-4* 4/28/79

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.10	10.0	1.0	
Sample Weight, Field (gms)	0.17	11.96	3.45	15.58
Sr-90	<1.11	0.133(0.044)	<0.111	0.10(0.03)
Pu-238	<0.030	<0.0003	<0.003	<0.0012
Pu-239,240	<0.140	<0.001	<0.014	<0.0053
Am-241	<0.640	0.018(0.018)	<0.064	0.01(0.01)
Cm-244	2.06(1.18)	<0.0014	**	0.02(0.01)

* Data not presented graphically.
** Sample lost or accidentally destroyed.

TABLE D.5. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-1* 4/26/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.15	1.0	**	
Sample Weight, Field (gms)	0.15	4.11	0.23	4.49
Sr-90	<0.740	<0.111		<0.124
Pu-238	<0.020	<0.003		<0.0034
Pu-239,240	<0.093	<0.014		<0.016
Am-241	<0.427	0.18(0.14)		0.166(0.128)
Cm-244	0.25(0.11)	0.093(0.069)		0.086(0.067)

* Data not presented graphically.
** Sample lost or accidentally destroyed.

STATION: CC-1 4/27/79

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	1.02	25.0	22.51	
Sample Weight, Field (gms)	1.64	89.25	22.70	113.59
Sr-90	<0.109	0.067(0.038)	<0.005	0.05(0.03)
Pu-238	0.043(0.029)	0.001(0.001)	0.011(0.005)	0.003(0.002)
Pu-239,240	<0.014	0.001(0.001)	0.048(0.008)	0.01(0.002)
Am-241	<0.063	0.052(0.008)	<0.0028	0.04(0.01)
Cm-244	<0.014	0.0185(0.0052)	0.0018(0.0011)	0.01(0.004)

TABLE D.5. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-3 4/27/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	1.52	25.0	5.0	
Sample Weight, Field (gms)	2.36	36.25	8.29	46.90
Sr-90	0.392(0.264)	0.070(0.021)	<0.022	0.07(0.03)
Pu-238	<0.002	<0.0001	<0.0006	<0.0003
Pu-239,240	<0.009	0.003(0.001)	<0.003	0.002(0.0008)
Am-241	<0.042	0.0087(0.0032)	0.034(0.016)	0.013(0.005)
Cm-244	<0.0093	0.0163(0.0032)	<0.0028	0.013(0.002)

STATION: CC-5* 4/26/79

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.40	21.78	5.0	
Sample Weight, Field (gms)	0.40	21.98	5.45	27.83
Sr-90	1.41(1.09)	**	0.264(0.144)	0.07(0.04)
Pu-238	<0.007	<0.0001	<0.001	<0.00035
Pu-239,240	<0.035	0.0007(0.0004)	<0.003	0.0006(0.0003)
Am-241	0.51(0.24)	0.071(0.014)	<0.013	0.06(0.01)
Cm-244	<0.036	0.011(0.010)	<0.0028	0.01(0.01)

* Data not presented graphically.
** Sample lost or accidentally destroyed.

TABLE D.5. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-5 4/27/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	1.0	25.0	5.0	
Sample Weight, Field (gms)	1.16	30.8	5.55	37.51
Sr-90	<0.111	0.060(0.019)	<0.022	0.05(0.02)
Pu-238	<0.003	0.0003(0.0002)	<0.001	0.0002(0.0002)
Pu-239,240	<0.014	0.0023(0.0004)	<0.003	0.002(0.0003)
Am-241	<0.064	0.285(0.031)	<0.013	0.23(0.03)
Cm-244	<0.014	0.028(0.011)	<0.0028	0.02(0.01)

STATION: CC-5* 4/28/79

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.81	10.0	1.0	
Sample Weight, Field (gms)	1.02	10.62	1.33	12.97
Sr-90	3.82(2.38)	<0.011	<0.111	0.31(0.19)
Pu-238	<0.004	<0.0003	<0.003	<0.00087
Pu-239,240	<0.017	<0.001	<0.014	<0.0036
Am-241	<0.079	0.038(0.019)	<0.064	0.03(0.02)
Cm-244	<0.018	<0.0014	0.073(0.048)	0.01(0.005)

* Data not presently graphically.

TABLE D.5. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-6* 4/26/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.35	44.4	1.0	
Sample Weight, Field (gms)	0.51	44.95	13.28	58.74
Sr-90	1.54(1.54)	<0.003	<0.011	0.01(0.01)
Pu-238	<0.009	0.0008(0.0003)	0.0006(0.0005)	0.0007(0.0003)
Pu-239,240	<0.040	<0.0003	<0.001	0.00082
Am-241	<0.183	0.0101(0.003)	0.0158(0.0085)	0.01(0.004)
Cm-244	<0.041	0.0016(0.0012)	<0.0014	0.001(0.0009)

* Data not presented graphically.

STATION: CC-6 4/27/79

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.90	10.0	1.0	
Sample Weight, Field (gms)	1.18	16.36	2.08	19.62
Sr-90	3.49(0.661)	<0.011	1.53(0.552)	0.38(0.10)
Pu-238	0.017(0.010)	<0.0003	<0.003	0.001(0.0006)
Pu-239,240	<0.004	<0.001	<0.014	0.0026
Am-241	<0.071	0.029(0.0068)	<0.064	0.02(0.01)
Cm-244	0.098(0.071)	0.0088(0.0034)	<0.014	0.01(0.01)

TABLE D.5. (contd)

PHASE 3 - FIELD PROGRAM

STATION: CC-6* 4/28/79

Radionuclide Concentration - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.96	10.0	1.0	
Sample Weight, Field (gms)	1.03	11.89	2.52	15.44
Sr-90	<0.116	<0.011	<0.111	<0.0344
Pu-238	0.316(0.137)	<0.0003	<0.003	0.02(0.01)
Pu-239,240	0.016(0.01)	<0.001	<0.014	0.001(0.0007)
Am-241	0.23(0.11)	<0.0064	0.21(0.12)	0.05(0.03)
Cm-244	0.140(0.077)	0.0104(0.0081)	0.303(0.093)	0.07(0.03)

* Data not presented graphically.

STATION: CC-9 4/29/79

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	0.71	0.5	1.0	
Sample Weight, Field (gms)	0.83	5.59	1.08	7.5
Sr-90	<0.156	1.45(0.174)	<0.111	1.09(0.13)
Pu-238	<0.004	<0.001	0.085(0.047)	0.01(0.01)
Pu-239,240	<0.020	<0.003	0.049(0.028)	0.01(0.004)
Am-241	<0.090	0.076(0.049)	<0.064	0.06(0.04)
Cm-244	<0.020	0.038(0.029)	<0.014	0.03(0.02)

TABLE D.5. (contd).

PHASE 3 - FIELD PROGRAM

STATION: C-11 4/29/79

Radionuclide Concentrati n - Suspended Sediment
pCi/gm

	Sand	Silt	Clay	Composite
Sample Weight, Analysis (gms)	1.36	10.0	1.0	
Sample Weight, Field (gms)	3.71	13.37	1.84	18.92
Sr-90	0.568(0.249)	0.098(0.037)	1.51(0.806)	0.33(0.15)
Pu-238	0.019(0.017)	<0.0003	<0.003	0.004(0.003)
Pu-239,240	<0.01	<0.001	<0.014	0.0040
Am-241	0.086(0.045)	<0.0064	<0.064	0.017(0.009)
Cm-244	0.057(0.032)	0.0077(0.0056)	0.22(0.13)	0.04(0.02)

TABLE D.6. Concentration of Radionuclides in the Water of Buttermilk and Cattaraugus Creek Sampling Stations. Results of radiochemical analysis of alpha and beta emitting radionuclides. Values in parentheses are one standard deviation of the propatated counting error.

STATION: BC-1 4/26/79

PHASE 3
Water Volume Filtered: 325.5 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	12.87	417.0	399.7	418.6	49.0	101.0	41.5		
Sample Wt., Field (g)	12.87	526.0	434.0	442.0	173.6	148.8	183.0		
Sr-90	<0.111	**	18.36(0.81)	21.54(1.63)	36.24(2.60)	4.32(2.28)	10.01(2.06)	0.278*	0.278*
Pu-238	0.062(0.042)	0.043(0.037)	<0.003	<0.003	<0.011	<0.010	<0.013	0.00013 (0.00011)	0.00032*
Pu-239,240	<0.014	<0.018	0.031(0.030)	<0.015	<0.049	<0.048	<0.062	0.000095 (0.000095)	0.000095 (0.000092)
Am-241	0.082(0.056)	0.286(0.047)	0.130(0.101)	0.246(0.088)	1.77(1.39)	<0.218	1.53(0.43)	0.0122*	0.0124*
Cm-244	<0.0011	<0.018	0.118(0.056)	<0.015	<0.05	<0.048	<0.063	0.00036 (0.00017)	0.00036 (0.00017)

* Indicates standard deviation cannot be determined.
** Analysis unreliable due to contamination.

TABLE D.6. (contd)

PHASE 3

STATION: BC-1 4/27/79 Water Volume Filtered: 325.9 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	14.59	398.3			49.42				
Sample Wt., Field (g)	14.59	409.0			161.4				
Sr-90	<0.111	4.31(0.837)			7.43(1.43)			0.0360*	0.0360*
Pu-238	<0.003	<0.003			<0.010			<0.000040	<0.000049
Pu-239,240	<0.014	<0.014			<0.046			<0.000184	<0.000227
Am-241	0.16(0.12)	0.105(0.044)			0.23(0.20)			0.00103*	0.00152*
Cm-244	<0.014	<0.014			<0.046			<0.000184	<0.000237

* Indicates standard deviation cannot be determined.

TABLE D.6. (contd)

STATION: BC-1   4/28/79   PHASE 3
Water Volume Filtered: 465.6 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	13.64	775.0			45.7				
Sample Wt., Field (g)	13.64	808.0			177.8				
Sr-90	<0.111	39.77(1.44)			63.20(3.08)			0.221*	0.221*
Pu-238	<0.003	<0.003			<0.011			<0.00003	<0.00004
Pu-239,240	<0.001	<0.015			<0.050			<0.00014	<0.00014
Am-241	<0.064	<0.067			<0.228			<0.00063	<0.00077
Cm-244	<0.014	0.93(0.21)			<0.051			0.0020(0.0005)	0.0020*

* Indicates standard deviation cannot be determined.

TABLE D.6. (contd)

PHASE 3

STATION: FC-1/1 4/26/79 (AM) Water Volume Filtered: 181.7 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	16.53	477.9	420.8	427.0	50.0	47.6	49.9		
Sample Wt., Field (g)	16.53	482.0	425.55	442.0	162.2	184.1	182.5		
Sr-90	21.7(0.915)	1422.6(37.8)	**	499.6(13.2)	**	70.04(3.04)	144.8(5.19)	11.76*	11.88*
Pu-238	<0.003	<0.003	<0.003	<0.003	<0.010	<0.012	<0.012	<0.000237	<0.000253
Pu-239,240	0.026(0.012)	0.119(0.049)	<0.014	<0.014	<0.045	<0.054	<0.054	0.000655 (0.000270)	0.000798*
Am-241	<0.004	<0.065	<0.065	0.11(0.03)	0.67(0.46)	<0.25	<0.25	0.00429*	0.00429*
Cm-244	<0.0009	<0.014	<0.014	0.019(0.013)	0.72(0.45)	<0.055	<0.055	0.00407*	0.00407*

* Indicates standard deviation cannot be determined.
** Sample lost or accidently destroyed.

TABLE D.6. (contd)

PHASE 3

STATION: FC-1/2 4/26/79 (PM) Water Volume Filtered: 45.4 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	12.86	388.6	419.6		49.6	45.7			
Sample Wt., Field (g)	12.86	398.0	436.0		157.2	174.80			
Sr-90	6.48(1.09)	641.9(17.1)	237.0(6.40)		<0.111	<0.111		19.36*	19.50*
Pu-238	<0.003	<0.003	<0.083(0.025)		<0.010	<0.011		0.00183 (0.00055)	0.00183 (0.00055)
Pu-239,240	<0.014	<0.014	<0.015		<0.044	<0.054		<0.00280	<0.00311
Am-241	<0.064	<0.066	0.134(0.039)		0.44(0.27)	<0.245		0.0126*	0.0126*
Cm-244	0.20(0.12)	<0.014	<0.015		<0.045	<0.054		<0.00282	0.0044 (0.0026)

* Indicates standard deviation cannot be determined.

TABLE D.6. (contd)

PHASE 3

STATION: FC-1/3 4/27/79 (AM) Water Volume Filtered: 212.0 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample — Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	16.0	423.8	393.0		50.0	50.0			
Sample Wt., Field (g)	16.0	432.0	405.6		185.0	156.0			
Sr-90	10.57(0.605)	1022.9(27.2)	1210.5(32.2)		791.8(22.3)	38[illegible].1(11.0)		16.07	16.12*
Pu-238	<0.003	<0.003	<0.003		0.026(0.023)	<0.009		0.00012 (0.00011)	0.00012 (0.00011)
Pu-239,240	0.043(0.037)	<0.014	<0.014		<0.052	<0.044		<0.000585	0.00020 (0.00017)
Am-241	0.18(0.11)	0.20(0.15)	<0.066		0.82(0.78)	<0.200		0.00481*	0.00566*
Cm-244	0.061(0.039)	0.19(0.12)	<0.014		<0.053	1.05(0.60)		0.00585*	0.00614*

* Indicates standard deviation cannot be determined.

TABLE D.6. (contd)

PHASE 3

STATION: FC-1/4 4/27/79 (PM) Water Volume Filtered: 120.4 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	14.78	336.6	442.0		48.36	50.0			
Sample Wt., Field (g)	14.78	345.0	465.0		165.4	152.4			
Sr-90	6.17(1.05)	847.2(22.5)	506.0(13.5)		107.6(3.85)	20.25(2.58)		12.30*	12.35*
Pu-238	<0.003	<0.003	<0.003		<0.010	<0.009		<0.000208	<0.000233
Pu-239,240	0.022(0.020)	<0.014	<0.015		<0.048	<0.043		<0.000997	0.00018 (0.000166)
Am-241	0.143(0.091)	0.097(0.039)	0.37(0.11)		<0.218	1.22(0.97)		0.0140*	0.0152*
Cm-244	<0.014	<0.014	<0.015		<0.048	<0.043		<0.000997	<0.00111

* Indicates standard deviation cannot be determined.

TABLE D.6. (contd)

PHASE 3

STATION: FC-1/5 4/28/79 (AM) Water Volume Filtered: 189.3 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample Aluminum Oxide Beds 1st	2nd	3rd	Resin Beds 1st	2nd	3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	13.67	408.0	452.4		49.6	49.5			
Sample Wt., Field (g)	13.67	427.0	469.9		161.8	147.0			
Sr-90	2.9(0.5)	898.3(24.0)	1058.2(34.5)		444.9(15.0)	266.6(8.18)		14.09*	14.11*
Pu-238	<0.008	0.152(0.031)	<0.003		<0.010	<0.009		0.000803 (0.000164)	0.000803 (0.000164)
Pu-239,240	<0.005	0.016(0.010)	<0.015		<0.046	<0.042		0.000085 (0.000053)	0.000085 (0.000053)
Am-241	<0.064	<0.067	<0.066		<0.208	<0.190		<0.00281	<0.00314
Cm-244	<0.014	<0.015	<0.015		<0.046	<0.042		<0.000623	<0.000697

* Indicates standard deviation cannot be determined.

TABLE D.6. (contd)

STATION: BC-3 4/27/79 PHASE 3 Water Volume Filtered: 148.8 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	2nd	3rd	Resin Beds 1st	2nd	3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	13.76	422.0			50.0				
Sample Wt., Field (g)	13.76	441.0			188.0				
Sr-90	3.49(1.16)	214.5(5.92)			69.3(3.53)			19.1*	1.93*
Pu-238	<0.003	0.043(0.028)			<0.011			0.00029 (0.00019)	0.00029 (0.00019)
Pu-239,240	<0.014	<0.015			<0.053			<0.000457	<0.000551
Am-241	<0.064	0.195(0.065)			<0.241			<0.00131 (0.000437)	0.00131 (0.000437)
Cm-244	0.135(0.077)	<0.015			<0.053			<0.000457	0.00091 (0.00052)

* Indicates standard deviation cannot be determined.

TABLE D.6. (contd)

STATION: BC-4 4/26/79

PHASE 3
Water Volume Filtered: 224.0 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	16.3	421.5	411.5	419.5	48.5	49.5	50.0		
Sample Wt., Field (g)	16.3	431.0	433.5	435.0	180.4	173.6	186.0		
Sr-90	1.19(1.09)	2.82(0.809)	<0.117	**	81.51(4.30)	56.40(2.76)	475.4(13.9)	2.75*	2.76*
Pu-238	<0.003	<0.004	0.344(0.086)	0.173(0.055)	<0.011	<0.011	<0.011	0.00231*	0.00231*
Pu-239,240	<0.014	<0.013	<0.015	<0.015	<0.051	<0.049	<0.052	<0.000871	<0.000933
Am-241	<0.064	1.06(0.08)	0.29(0.15)	0.095(0.056)	<0.238	0.42(0.29)	0.27(0.21)	0.00953*	0.00953*
Cm-244	<0.014	0.020(0.015)	<0.015	<0.015	<0.053	<0.050	0.19(0.14)	0.00094*	0.00094*

* Indicates standard deviation cannot be determined.
** Sample lost or accidently destroyed.

TABLE D.6. (contd)

STATION: BC-4 4/27/79

PHASE 3
Water Volume Filtered: 276.3 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	14.69	392.3			46.2				
Sample Wt., Field (g)	14.69	410.0			212.3				
Sr-90	<0.111	76.71(2.83)			88.06(6.96)			0.596*	0.596*
Pu-238	0.050(0.040)	<0.004			<0.014			<0.000065	0.00018 (0.00014)
Pu-239,240	<0.014	<0.017			<0.064			<0.000293	<0.000344
Am-241	0.29(0.09)	0.88(0.18)			<0.294			0.00318 (0.000651)	0.00423*
Cm-244	<0.014	<0.015			<0.065			<0.000290	<0.000340

* Indicates standard deviation cannot be determined.

TABLE D.6. (contd)

PHASE 3

STATION: BC-4 4/28/79 Water Volume Filtered: 424.0 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	13.63	384.0			50.0				
Sample Wt., Field (g)	13.63	397.0			164.5				
Sr-90	1.46(0.52)	164.4(4.49)			322.1(11.7)			1.147*	1.151*
Pu-238	<0.008	0.020(0.020)			<0.010			0.000047 (0.000047)	0.000047 (0.000047)
Pu-239,240	0.0079(0.0056)	<0.014			<0.046			<0.00014	0.000019 (0.000013)
Am-241	0.170(0.168)	<0.066			0.48(0.33)			0.00113 (0.00078)	0.00153*
Cm-244	<0.014	0.34(0.24)			<0.047			0.00080 (0.00057)	0.00080 (0.00057)

* Indicates standard deviation cannot be determined.

TABLE D.6. (contd)

STATION: CC-1 4/26/79 PHASE 3 Water Volume Filtered: 193.1 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	13.55	389.4	442.8		46.0	46.0			
Sample Wt., Field (g)	13.55	411.0	464.8		155.7	189.0			
Sr-90	<0.111	12.58(0.884)	11.42(0.601)		9.09(1.56)	<0.111		0.171*	0.171*
Pu-238	<0.003	0.045(0.027)	<0.003		<0.011	<0.012		0.00023 (0.00014)	0.00023 (0.00014)
Pu-239,240	<0.014	<0.015	<0.015		<0.047	<0.058		<0.00070	<0.00077
Am-241	0.215(0.092)	<0.068	0.140(0.102)		<0.217	<0.263		0.000725 (0.000528)	0.00184*
Cm-244	<0.014	<0.015	0.059(0.044)		0.22(0.14)	<0.058		0.00144*	0.00144*

* Indicates standard deviation cannot be determined.

TABLE D.6. (contd)

STATION: CC-1 4/27/79

PHASE 3
Water Volume Filtered: 572.7 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	16.4	390.1			47.8				
Sample Wt., Field (g)	16.4	404.9			162.0				
Sr-90	**	33.29(2.39)			49.01(2.29)			0.144*	0.144*
Pu-238	<0.003	<0.003			<0.01			<0.000023	<0.00003
Pu-239,240	<0.0008	0.062(0.052)			<0.047			0.00011 (0.00009)	0.00011 (0.00009)
Am-241	0.21(0.11)	<0.066			0.46(0.25)			0.000803 (0.000437)	0.00117*
Cm-244	<0.014	(0.17(0.13)			<0.048			0.00030 (0.00023)	0.00030 (0.00023)

* Indicates standard deviation cannot be determined.
** Sample lost or accidently destroyed.

TABLE D.6. (contd)

STATION: CC-3 4/27/79

PHASE 3
Water Volume Filtered: 628.4 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	16.12	327.5			50.0				
Sample Wt., Field (g)	16.12	343.0			267.0				
Sr-90	<0.111	42.48(1.37)			**			0.0676 (0.00218)	0.0676 (0.00218)
Pu-238	<0.003	<0.003			<0.016			<0.00003	<0.00004
Pu-239,240	<0.014	<0.015			<0.075			<0.00014	<0.00017
Am-241	<0.064	0.644(0.051)			<0.342			0.00102 (0.00008)	0.00102 (0.00008)
Cm-244	<0.014	<0.015			<0.076			<0.00014	<0.00017

* Indicates standard deviation cannot be determined.
** Sample lost or accidently destroyed.

TABLE D.6. (contd)

STATION: CC-5 4/26/79

PHASE 3
Water Volume Filtered: 385.4 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	15.43	389.2	439.2	454.4	50.0	45.67	46.0		
Sample Wt., Field (g)	15.43	413.0	464.2	470.0	180.05	175.67	188.41		
Sr-90	3.47(1.15)	**	***	21.73(1.07)	67.59(2.66)	37.28(1.81)	35.29(4.06)	0.420*	0.429*
Pu-238	0.008(0.008)	0.111(0.067)	<0.003	<0.003	<0.011	<0.012	<0.012	0.000288 (0.000174)	0.00031*
Pu-239,240	<0.014	<0.015	<0.015	<0.014	<0.050	<0.054	<0.057	<0.00053	<0.00057
Am-241	0.356(0.099)	**	0.181(0.068)	0.084(0.037)	1.48(1.13)	<0.246	<0.262	0.00453	0.00545*
Cm-244	<0.014	**	<0.015	<0.014	<0.051	<0.055	<0.058	<0.00050	<0.00054

* Indicates standard deviation cannot be determined.
** Sample lost or accidently destroyed.
*** Analysis unreliable due to contamination.

TABLE D.6. (contd)

PHASE 3

STATION: CC-5 4/27/79 Water Volume Filtered: 457.7 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	2nd	3rd	Resin Beds 1st	2nd	3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	13.91	393.0	441.5		50.0	50.0			
Sample Wt., Field (g)	13.91	412.0	463.0		151.0	162.2			
Sr-90	<0.111	49.80(1.76)	18.21(0.734)		69.71(3.13)	37.32(1.86)		0.382*	0.382*
Pu-238	<0.003	<0.003	<0.003		<0.009	<0.010		<0.000055	<0.000061
Pu-239,240	<0.014	<0.015	<0.015		<0.042	<0.046		<0.00026	<0.00029
Am-241	<0.064	0.38(0.19)	0.111(0.048)		0.17(0.13)	<0.212		0.00144*	0.00144*
Cm-244	<0.014	<0.015	<0.015		<0.043	<0.047		<0.00026	<0.00029

* Indicates standard deviation cannot be determined.

TABLE D.6. (contd)

STATION: CC-6 4/26/79 PHASE 3 Water Volume Filtered: 703.1 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	14.1	385.0	408.0	423.4		50.0	50.0		
Sample Wt., Field (g)	14.1	398.0	424.0	446.0		167.51	169.79		
Sr-90	9.73(0.671)	38.50(1.29)	36.27(1.20)	33.03(1.11)		131.8(4.61)	99.33(3.69)	0.482*	0.496*
Pu-238	<0.003	<0.003	0.165(0.041)	0.056(0.047)		<0.010	<0.010	0.00031*	0.00031*
Pu-239,240	<0.014	<0.014	<0.015	<0.015		<0.047	<0.048	<0.00020	<0.00022
Am-241	<0.005	<0.066	<0.067	<0.067		0.36(0.29)	0.29(0.26)	0.00092*	0.00092*
Cm-244	0.0049(0.0040)	<0.014	<0.015	<0.015		0.23(0.16)	<0.048	0.00033 (0.00023)	0.00033*

* Indicates standard deviation cannot be determined.

TABLE D.6. (contd)

STATION: CC-6 4/27/79 PHASE 3
Water Volume Filtered: 526.2 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	2nd	3rd	Resin Beds 1st	2nd	3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	14.1	450.2	401.5		50.0	50.0			
Sample Wt., Field (g)	14.1	472.5	421.0		189.8	188.76			
Sr-90	1.89(0.560)	31.77(1.57)	33.90(1.11)		91.23(3.91)	57.01(3.12)		0.407*	0.410*
Pu-238	<0.003	0.406(0.169)	<0.003		<0.011	<0.011		0.00077 (0.00032)	0.00077 (0.00032)
Pu-239,240	<0.014	0.029(0.019)	<0.015		<0.053	<0.053		0.00006 (0.00004)	0.00006 (0.00004)
Am-241	<0.064	<0.067	<0.067		<0.243	1.5(1.0)		0.0029 (0.0019)	0.0029 (0.0019)
Cm-244	<0.014	<0.015	<0.015		<0.054	<0.054		<0.00026	<0.00029

* Indicates standard deviation cannot be determined.

TABLE D.6. (contd)

PHASE 3

STATION: CC-6 4/28/79 Water Volume Filtered: 456.6 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample — Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	15.49	339.6			50.0				
Sample Wt., Field (g)	15.49	350.0			168.1				
Sr-90	6.96(0.576)	41.55(1.72)			77.94(3.53)			0.261*	0.277*
Pu-238	<0.003	<0.003			<0.010			<0.00003	<0.00004
Pu-239,240	<0.014	<0.014			<0.047			<0.0001	<0.0002
Am-241	<0.064	0.58(0.15)			<0.215			0.0013 (0.0003)	0.0013 (0.0003)
Cm-244	<0.014	0.299(0.087)			<0.048			0.00065 (0.00019)	0.00065 (0.00019)

* Indicates standard deviation cannot be determined.

TABLE D.6. (contd)

STATION: CC-9 4/29/79 PHASE 3 Water Volume Filtered: 359.6 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	14.6	405.0			43.21				
Sample Wt., Field (g)	14.6	421.0			252.9				
Sr-90	<0.111	15.76(0.693)			65.73(5.16)			0.227*	0.227*
Pu-238	0.076(0.047)	0.475(0.078)			<0.018			0.0013 (0.00022)	0.0015*
Pu-239,240	<0.014	<0.015			<0.082			<0.00027	<0.00031
Am-241	0.35(0.31)	<0.067			<0.374			<0.0012	0.00097 (0.00086)
Cm-244	<0.014	<0.015			<0.083			<0.00027	<0.00031

* Indicates standard deviation cannot be determined.

TABLE D.6. (contd)

PHASE 3

STATION: CC-11 4/29/79 Water Volume Filtered: 302.8 liters

Isotope	Particulate Filters pCi/total sample	Dissolved pCi/total sample: Aluminum Oxide Beds 1st	Aluminum Oxide Beds 2nd	Aluminum Oxide Beds 3rd	Resin Beds 1st	Resin Beds 2nd	Resin Beds 3rd	Total Dissolved pCi/liter	Total Dissolved and Particulate pCi/liter
Sample Wt., Analysis (g)	14.98	407.0	400.0	404.0	50.0	50.0	46.7		
Sample Wt., Field (g)	14.98	416.0	423.0	423.0	155.9	173.4	157.0		
Sr-90	1.15(0.358)	**	35.57(1.36)	**	63.44(5.71)	35.43(2.68)	13.45(2.69)	0.488*	0.492*
Pu-238	0.071(0.035)	<0.003	0.055(0.037)	<0.003	<0.009	<0.010	<0.010	0.00018 (0.00012)	0.00042*
Pu-239,240	<0.014	<0.014	<0.015	<0.015	<0.044	<0.049	<0.047	<0.00061	<0.00065
Am-241	0.083(0.058)	0.134(0.060)	<0.068	<0.067	<0.200	0.36(0.21)	<0.215	0.00163*	0.00191*
Cm-244	<0.014	0.030(0.022)	<0.015	0.044(0.031)	<0.044	<0.049	<0.048	0.00024*	0.00024*

* Indicates standard deviation cannot be determined.
** Analysis unreliable due to contamination.

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16. ABSTRACT *(200 words or less)*

A field sampling program was conducted on Cattaraugus and Buttermilk Creeks, New York during April 1979 to investigate the transport of radionuclides in surface waters as part of a continuing program to provide data for application and verification of Pacific Northwest Laboratory's (PNL) sediment and radionuclide transport model, SERATRA. Bed sediment, suspended sediment and water samples were collected during unsteady flow conditions over a 45 mile reach of stream channel. Radiological analysis of these samples included gamma ray spectrometry analysis, and radiochemical separation and analysis of Sr-90, Pu-238, Pu-239, 240, Am-241 and Cm-244. Tritium analysis was also performed on water samples. Based on the evaluation of radionuclide levels in Cattaraugus and Buttermilk Creeks, the Nuclear Fuel Services facility at West Valley, New York, may be the source of Cs-137, Sr-90, Cs-134, Co-60, Pu-238, P-239-240, Am-241, Cm-244 and tritium found in the bed sediment, suspended sediment and water of Buttermilk and Cattaraugus Creeks. This field sampling effort was the last of a three phase program to collect hydrologic and radiologic data at different flow conditions.

17. KEY WORDS AND DOCUMENT ANALYSIS

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River	Strontium-90
Sediments	Plutonium
Lake Erie	Tritium
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