NUREG/CR-1030
PNL-3117
Vol. 4

Sediment and Radionuclide Transport in Rivers

Summary Report
Field Sampling Program for Cattaraugus and Buttermilk Creeks, New York

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

Pacific Northwest Laboratory
Operated by
Battelle Memorial Institute

Prepared for
U.S. Nuclear Regulatory Commission

NOTICE

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, or any of their employees, makes any warranty, expressed or implied, or assumes any legal liability of responsibility for any third party's use, or the results of such use, of any information, apparatus, product or process disclosed in this report, or represents that its use by such third party would not infringe privately owned rights.

Availability of Reference Materials Cited in NRC Publications

Most documents cited in NRC publications will be available from one of the following sources:

1. The NRC Public Document Room, 1717 H Street, N.W.
   Washington, DC 20555
2. The NRC/GPO Sales Program, U.S. Nuclear Regulatory Commission,
   Washington, DC 20555
3. The National Technical Information Service, Springfield, VA 22161

Although the listing that follows represents the majority of documents cited in NRC publications, it is not intended to be exhaustive.

Referenced documents available for inspection and copying for a fee from the NRC Public Document Room include NRC correspondence and internal NRC memoranda; NRC Office of Inspection and Enforcement bulletins, circulars, information notices, inspection and investigation notices; Licensee Event Reports; vendor reports and correspondence; Commission papers; and applicant and licensee documents and correspondence.

The following documents in the NUREG series are available for purchase from the NRC/GPO Sales Program: formal NRC staff and contractor reports, NRC-sponsored conference proceedings, and NRC booklets and brochures. Also available are Regulatory Guides, NRC regulations in the *Code of Federal Regulations*, and *Nuclear Regulatory Commission Issuances*.

Documents available from the National Technical Information Service include NUREG series reports and technical reports prepared by other federal agencies and reports prepared by the Atomic Energy Commission, forerunner agency to the Nuclear Regulatory Commission.

Documents available from public and special technical libraries include all open literature items, such as books, journal and periodical articles, and transactions. *Federal Register* notices, federal and state legislation, and congressional reports can usually be obtained from these libraries.

Documents such as theses, dissertations, foreign reports and translations, and non-NRC conference proceedings are available for purchase from the organization sponsoring the publication cited.

Single copies of NRC draft reports are available free upon written request to the Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

Copies of industry codes and standards used in a substantive manner in the NRC regulatory process are maintained at the NRC Library, 7920 Norfolk Avenue, Bethesda, Maryland, and are available there for reference use by the public. Codes and standards are usually copyrighted and may be purchased from the originating organization or, if they are American National Standards, from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

GPO Printed copy price $6.00

NUREG/CR-1030
PNL-3117
Vol. 4
RE, RW

Sediment and Radionuclide Transport in Rivers

Summary Report
Field Sampling Program for Cattaraugus and Buttermilk Creeks, New York

Manuscript Completed: September 1982
Date Published: November 1982

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

Pacific Northwest Laboratory
P. O. Box 999
Richland, WA 99352

Prepared for
Division of Health, Siting and Waste Management
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555
NRC FIN B2275

ABSTRACT

A three-phase field sampling program was conducted on the Buttermilk-Cattaraugus Creek system 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. Phase 1 of the sampling program was conducted during November and December 1977; Phase 2 during September 1978; and Phase 3 during April 1979. Bed sediment, suspended sediment, and water samples were collected over a 45-mile reach of the creek system. Bed sediment samples were also collected at the mouth of Cattaraugus Creek in Lake Erie. A fourth sampling trip was conducted during May 1980 to obtain supplementary channel geometry data and flood plain sediment samples. 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.

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. A 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 composed of three phases of data collection. Phase 1 data collection was conducted during November and December 1977 (Ecker and Onishi 1979), Phase 2 data collection during September 1978 (Walters, Ecker and Onishi 1982), and Phase 3 during April 1979 (Ecker, Walters and Onishi 1982).

Suspended sediment, bed sediment and water samples were collected at ten sampling stations covering approximately 45 miles of stream channel of Cattaraugus and Buttermilk Creeks and a background station on Great Valley Creek (Phase 2 only). A fourth samping trip was conducted during May 1980 to obtain supplementary channel geometry data and flood plain sediment samples. 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 occurring in these two water courses, with levels significantly higher than background levels, during the three phase sampling program were cesium-137 and strontium-90. These radionuclides had significantly higher activity levels above background in the bed sediment, 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.

CONTENTS

FIGURES

TABLES

ACKNOWLEDGMENTS

The authors wish to acknowledge the significant and valuable contributions by others to the planning and execution of both the field data collection and analysis. For their assistance in the field work the authors wish to acknowledge the efforts of S. J. Phillips, R. G. Parkhurst, S. M. Brown, and R. L. Skaggs of Pacific Northwest Laboratory. The authors also wish to acknowledge the assistance of Mr. Steve Mollelo and Mr. Steve Potter of the New York State Geological Survey during the field work and the guidance provided by Dr. Phillip R. Reed of the U.S. Nuclear Regulatory Commission.

The radiological analyses was performed under subcontracts to H. E. Oens of U.S. Testing, Inc. (Phase 1 only) and Drs. William R. Schell, Ahmed Nevissi, and Thomas Sibley of the University of Washington, Laboratory of Radiation Ecology.

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 to provide radiological and hydrological data for calibration and verification of the sediment-contaminant transport model SERATRA developed by Pacific Northwest Laboratory (Onishi 1977).

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 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 these 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 pump down 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.

At the request of the U.S. Nuclear Regulatory Commission (NRC) a three-phase field data collection pogram was planned to provide data for the verification of a sediment-contaminated transport model, SERATRA, developed by Pacific Northwest Laboratory. Another purpose is to provide more detailed information on radionuclide activity levels in the Buttermilk-Cattaraugus Creek system. Creek bed and suspended sediment and water samples were collected for gamma-ray measurement and radiochemical analysis. The sediment samples were separated into sand, silt, and clay size classes for radiological analyses because of the different transport and physicochemical properties of each. Water discharge and water quality samples were collected at each station except the background station on Great Valley Creek. This report summarizes the major elements of the three phase sampling program and discusses the results of the radiological analysis of the principal radionuclides that were consistently detected at most sampling stations. These are tritium, strontium-90, cesium-137, plutonium-238, and plutonium-239,240. The radionuclide, cesium-134, was added for comparison with cesium-137, although it was not detected as frequently as the others. Mathematical modeling results will be presented under separate reports.

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. The Center is situated along an elongated rolling plain with glaciated bedrock hills along the eastern, western and southern boundaries with the 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 (Figure 2), 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 sites. 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 29.4 mi^2. For the period of record from October 1961 to September 1968, the average discharge of Buttermilk Creek was 46.5 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 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 flood plain area. The flood plain varies in width from 300 to 500 ft and is bounded by high bluffs along most of its length.

A reservoir upstream of the Buttermilk Creek inflow point collects run-off from a small watershed and periodically releases overflow into Buttermilk Creek. Discharge from the reservoir is regulated by a siphon spill-way that maintains reservoir levels below a certain elevation. Once the siphon is primed, large quantities of water are discharge in a short period of time, producing extermely fast rising hydrographs in Buttermilk Creek during periods of relatively low flow.

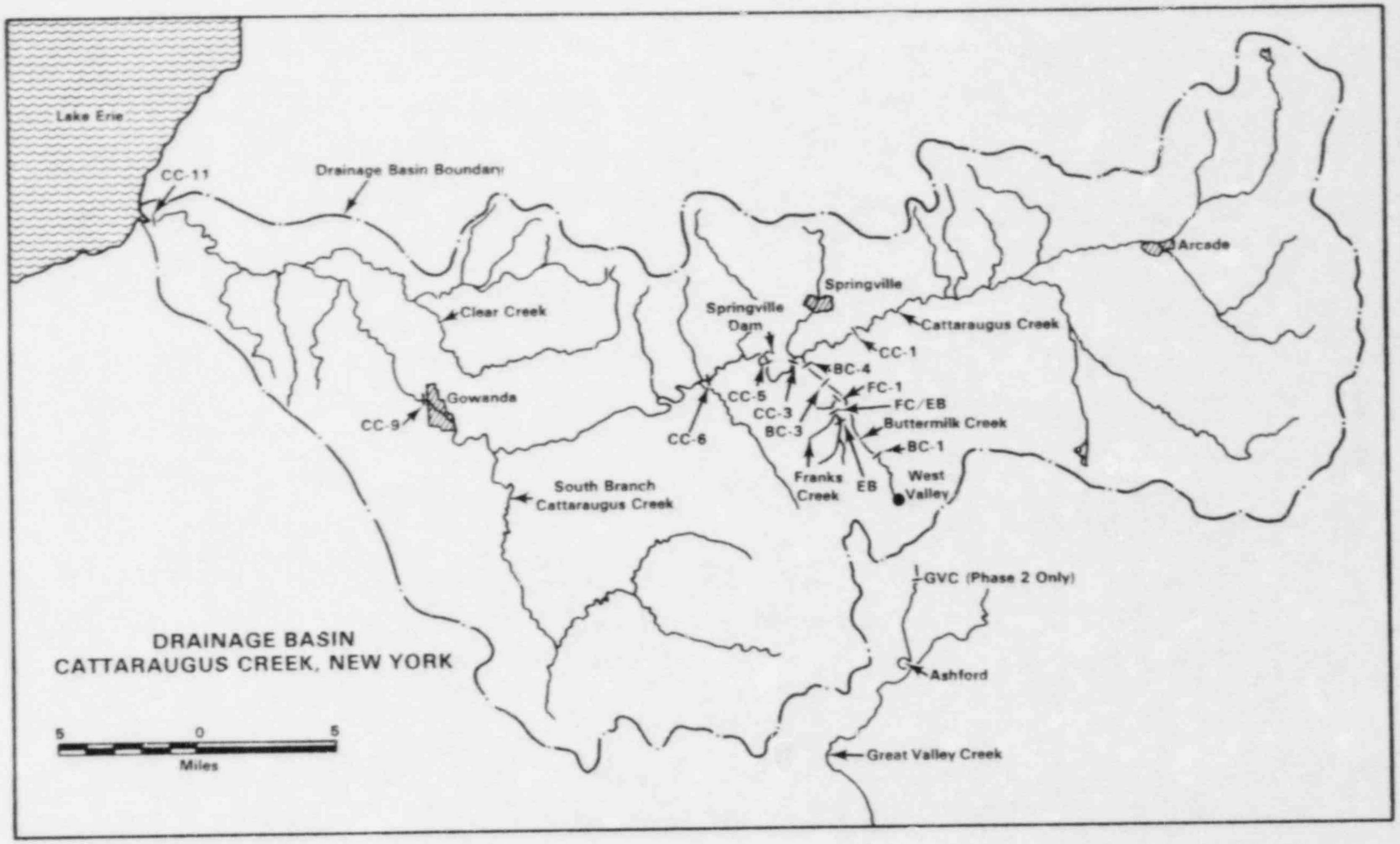

FIGURE 1. Map of the Radiological Sampling Stations on the Cattaraugus Creek System

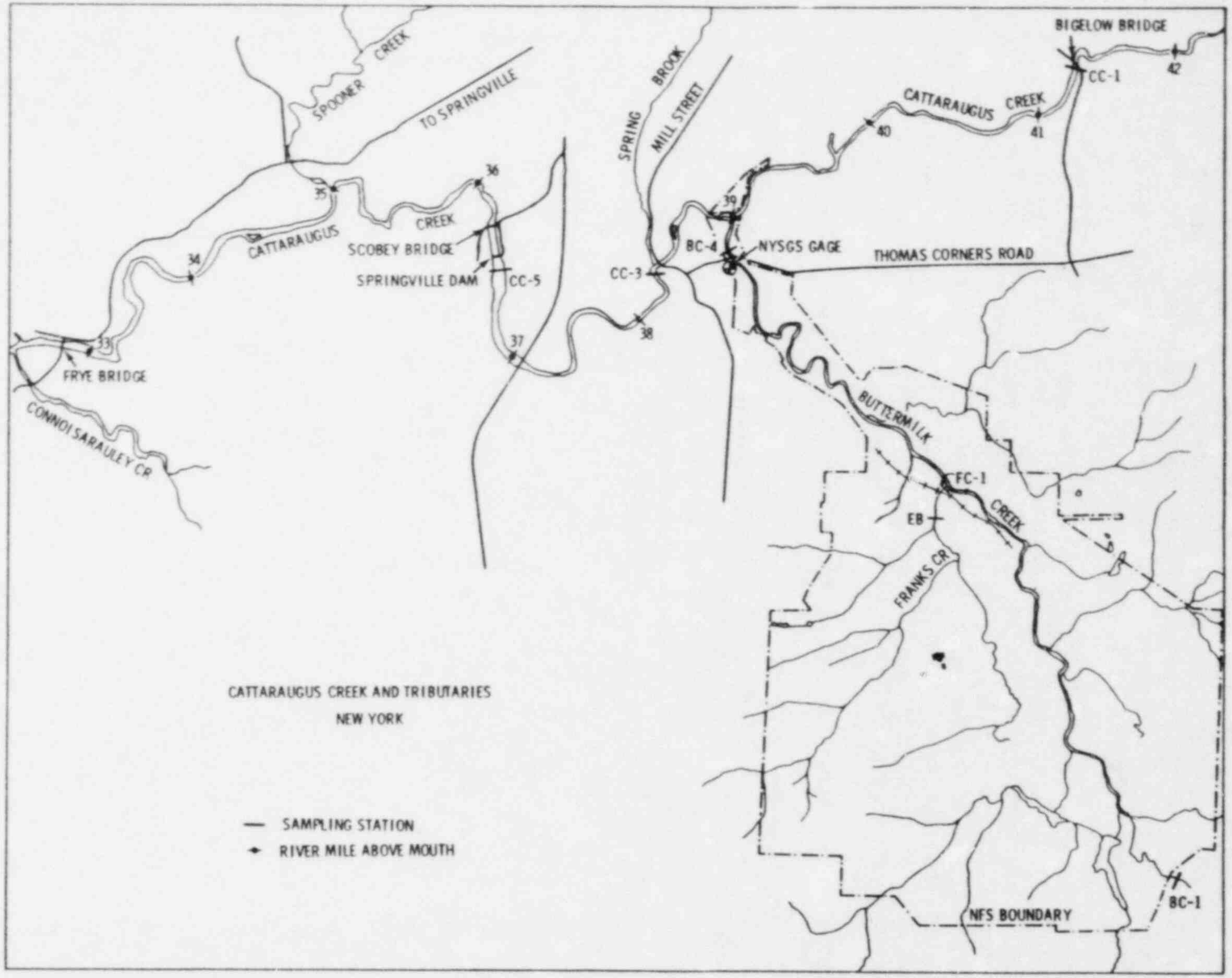

FIGURE 2. Sampling Stations Located in Close Proximity to the West Valley Facilities

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) gage 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 on 7 March 1956, and 6 cfs, respectively, on 21 August 1941.

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-hr 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 (Figure 2). Springville Dam is a 20 ft high dam that creates a small reservoir extending about 0.5 miles upstream through a narrow rock gorge with walls approximately 1000 ft high. 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% of the electric power requirements of the village.

SAMPLING PROGRAM

The data collection procedures for water and suspended sediment were modified following the Phase 1 field work. The modification of the data collection procedures was necessary due to the variations in levels of suspended sediment concentrations and radioactivity which in some cases required the processing of large volumes of water in the field. The following sections briefly discuss the sampling procedures used in Phase 1 and the modified procedures used during Phases 2 and 3.

PHASE 1 PROCEDURES

Large volume samples, suspended sediment samples and bed sediment samples were collected at each station for analyses. The method for collection of the large volume water samples is shown in Figure 3. Approximately 80 gallons (300 liters) of water were collected in five gallon plastic containers using a centrifugal water pump, frozen and returned to the laboratory for separtion of suspended solids from water. Standard filtering methods for separating suspended solids from water could not be used in the field due to the high suspended sediment load (50 to >500 mg/l) in Cattaraugus and Buttermilk Creeks, and because of the extreme difficulty in dividing suspended sediment into size fractions (i.e., sand, silt and clay) for radiological analysis once the suspended sediment is impregnated on filters.

The 80 gallon water samples, when returned to the laboratory, were thawed and the suspended sediment separated from the water by decantation and centrifugation. The water samples were then processed through a large volume water sampler (LVWS). The LVWS is discussed in more detail in the folowing section.

PHASE 2 PROCEDURES

Because of the low radioactivity levels found in the water of Cattaraugus and Buttermilk Creeks, certain modifications were made to the sampling procedures used in Phase 1. The water processed for radiological analysis of suspended sediment and water was increased from 80 gallons to 400 gallons. The separation of suspended sediment from water was included in the field sampling to eliminate the need of transporting large volumes of water. The in-stream sampling of water and suspended sediment was accomplished by utilizing a large volume water sampler developed by Pacific Northwest Laboratories. The sampling apparatus, including the LVWS, is shown in Figure 4. A discussion of the principle of the LVWS and the analysis procedure can be found in the Phase 2 report (Walters, Ecker and Onishi 1982). 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

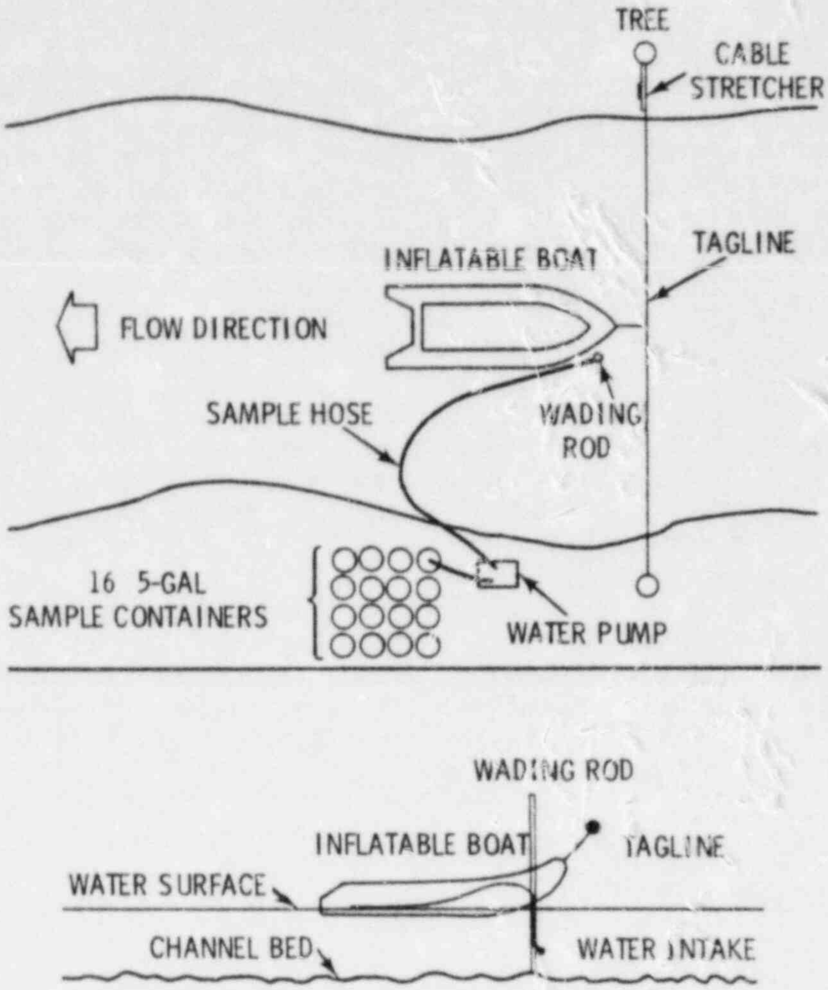

FIGURE 3. Phase 1 Sampling Method

procedure concentrates the quantities of suspended sediment and radionuclides in the field providing a larger sample for laboratory analysis. Because of the possibility of a significant suspended sediment load and the modeling requirement that the sediment be separated into three classes (clay, silt, and sand) the water sampling procedure was divided into two phases: 1) suspended sediment or particulate, and 2) dissolved (including colloidal).

Water and Suspended Sediment Sampling

The suspended sediment phase used a high-speed continuous flow centrifuge to separate the suspended sediment from the water. A Westfalia Model QTA 7-00-066 Clarifuge was used which has the capability of processing about

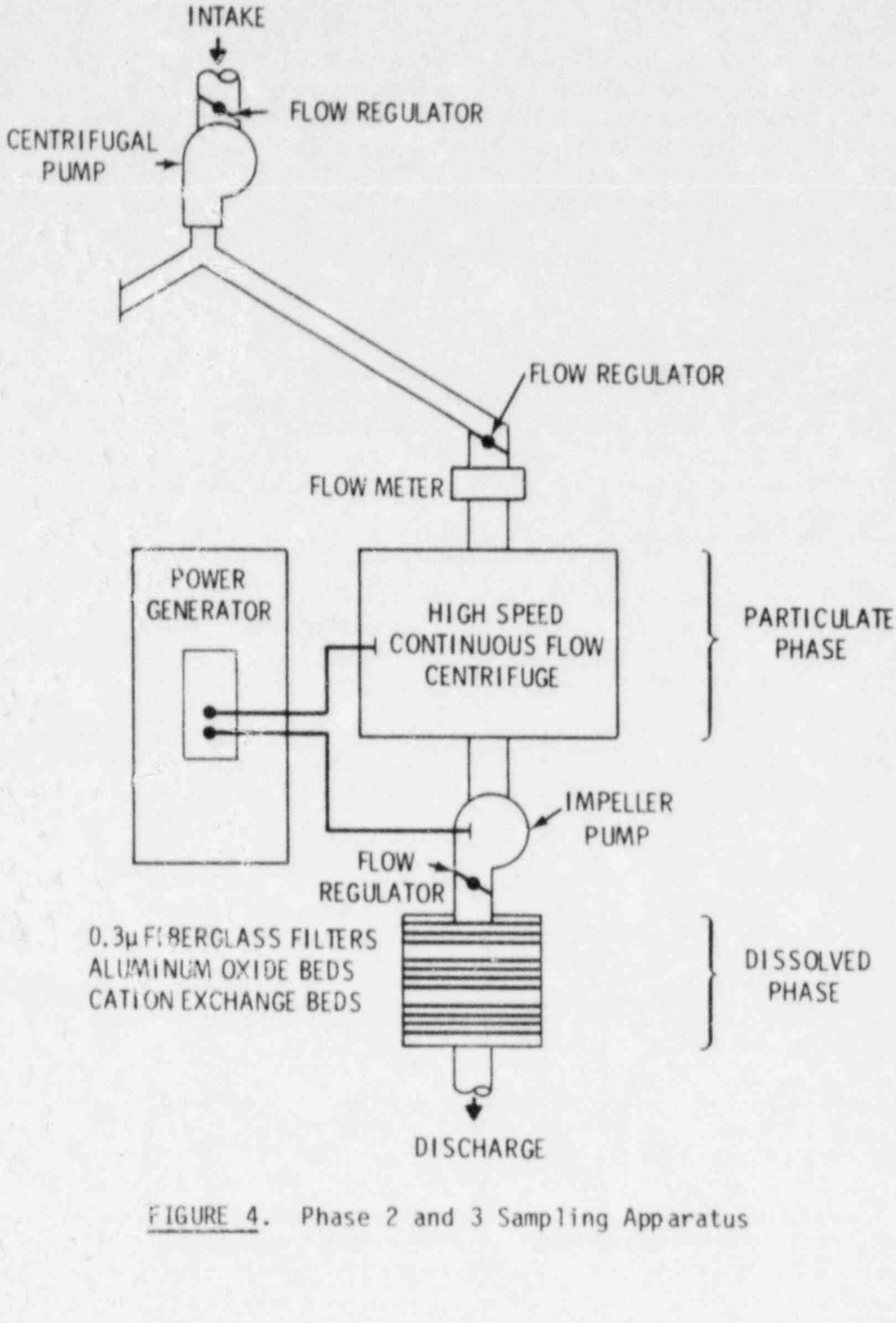

FIGURE 4. Phase 2 and 3 Sampling Apparatus

300 gallons of water per hour at about 900 rpm. The sediment retained in the centrifuge was later partitioned into sand, silt, and clay fractions by further centrifuging in the laboratory.

The dissolved phase used a set of three 0.3 μ fiberglass filters to trap any remaining particulate material not removed by the centrifuge. The filters were placed directly in front of the sorption beds in the LVWS column. The particulate free water then was passed through a series of three allurinum oxide beds and three cation exchange beds to capture the colloidal and dissolved radionuclides. Water samples were taken at the discharge end of the system for tritium analysis.

Bed Sediment Sampling

Samples of bed sediment were collected independently by using a scoop for grab sampling at each sampling station. These samples were separated into sand, silt, and clay in the laboratory before radiological analyses were performed. Bed sediment samples were collected in Lake Erie just outshore from the mouth of Cattaraugus Creek. The samples were collected in tubes which were pushed by hand into the lake bed and capped immediately after withdrawal.

Water Quality Characteristics and Flow Velocity Measurements

The water quality charateristics measured during the sampling proram were water temperature, pH and hardness. Water temperature is required to calculate viscosity for the SERATRA code. The pH and hardness are used in evaluating the adsorption and desorption coefficients.

The water velocity was measured for discharge computations at each sampling station except the background station on Great Valley Creek and the bed materal sampling stations at Erdmans Brook and Lake Erie. Velocity measurements were taken at the 0.2 and 0.8 depths if the total depth was >2.5 ft.

Both the water quality and velocity measurements were made using standard methods and procedures. A more detailed discussion can be found in the Phase 2 report (Walters, Ecker and Onishi 1982) and the Phase 3 report (Ecker, Walters and Onishi 1982).

SAMPLING STATIONS

The use of the LVWS sampling methodology sacrificed mobility since the equipment required mounting on the bed of a truck. This precluded sampling at two of the Phase 1 stations because of inaccessibility. The stations omitted were: 1) BC-2 on Buttermilk Creek located about 1200 ft downstream from the confluence with Franks Creek, and 2) BC-3 at Bond Road Bridge on Buttermilk Creek. However, four bed core samples were collected from Lake Erie near the mouth of Cattaraugus Creek and one additional bed sample from Erdmans Brook

(Franks Creek watershed). The channel cross-sections at most sampling stations were surveyed during each of the three phases. The cross-sections provided channel geometry for water discharge computations and were used to locate sampling points for the data collection program. The cross-section plots for each phase can be found in Appendix A. The individual stations are briefly described in the following paragraphs.

Great Valley Creek (GVC) - Phase 2 Only

This station is located about 5 miles south of BC-1 and about 2 miles north of the town of Ashford, New York. The sampling point is in the upper watershed area of Great Valley Creek which is a tributary of the Allegheny River. The station provides a sampling point in a watershed not a part of the Cattaraugus Creek system but near the NFS facilities and is considered a background station. No cross-section was surveyed.

Erdmans Brook (EB) - Phase 2 and 3

Erdmans Brook, sometimes referred to as Franks Creek, is defined as a small tributary to Franks Creek as shown in the map of Figure 2. Only bed material samples were taken at this location and provide a comparison of radioactivity levels with bed material samples at other locations. No cross-section survey was made of the sampling station.

Franks Creek-Erdmans Brook (FC/EB) - Phase 3 Only

Only bed materials 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 at the sampling station. The sampling station was located about 2000 ft upstream of the confluence of Franks Creek and Buttermilk Creek.

Franks Creek-Station 1 (FC-1) - Phase 1, 2, and 3

The NFS facilities are located within the Franks Creek watershed and the creek is the main uncontrolled outflow point from the facilities area. There is another outflow point just upstream at a siphon spillway of a small reservoir within the facilities area that peridically releases to Buttermilk Creek. The sampling station cross-section (Figures A.1, A.2, and A.3) is located at the Baltimore and Ohio Railroad culvert outlet which is about 100 ft upstream of the confluence with Buttermilk Creek. This creek is the only surface water outflow point for the NFS facilities monitored in this study.

Buttermilk Creek-Station 1 (BC-1) - Phase 1, 2, and 3

This station is upstream of the mouth of Franks Creek and therefore upstream of the outflow from the NFS facilities. 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 Figures A.4, A.5 and A.6. The suspended sediment sample was taken at about mid-depth of the cross-section sampling point.

Buttermilk Creek Station 2 (BC-2) - Phase 1 Only

This station is located on Buttermilk Creek Approximately 1,200 ft downstream from the confluence of Franks Creek and about 2 miles upstream from Cattaraugus Creek (Figure A.7).

Buttermilk Creek-Station 3 (BC-3) - Phase 1 and 3

This cross-section is located on Buttermilk Creek about 100 ft downstream of the abandoned Bond Road Bridge. The abandoned bridge is about 1.3 miles upstream from Cattaraugus Creek. The cross-section is plotted in Figures A.8 and A.9.

Buttermilk Creek-Station 4 (BC-4) - Phase 1, 2, and 3

The station at BC-4 is an intermediate sampling station between the Franks Creek outflow and Cattaraugus Creek. The cross-section (Figures A.10, A.11 and A.12) is located about 100 ft downstream from the Thomas Corners Road bridge and 0.2 miles upstream from Cattaraugus Creek.

Cattaraugus Creek-Station 1 (CC-1) - Phase 1, 2, and 3

This station is located directly beneath Bigelow Bridge (Elk Street Bridge) and is the upstream background station for Cattaraugus Creek. The cross-sectional sampling point was positioned next to the right bank bridge abutment as shown in Figures A.13, A.14 and A.15.

Cattaraugus Creek-Station 3 (CC-3) - Phase 1, 2, and 3

The stream cross-section for this station is located about 100 ft downstream of Felton Bridge (Mill Street Bridge). The sampling points were varied over the cross-section for each phase as shown in Figures A.16, A.17 and A.18. This is the first sampling station downstream of the Buttermilk Creek confluence.

Cattaraugus Creek-Station 5 (CC-5) - Phase 1, 2 and 3

This station is located in Springville Reservoir about 500 ft upstream of the concrete spillway. Samples were taken at various horizontal and vertical distances over the cross-section as shown in Figures A.19, A.20 and A.21.

Cattaraugus Creek-Station 6 (CC-6) - Phase 3 Only

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 in Figure A.22.

Cattaraugus Creek-Station 9 (CC-9) - Phase 1, 2 and 3

This station is located at Gowanda, New York, about 21 miles downstream from Springville Dam. The stream cross-section, shown in Figures A.23, A.24 and A.25 is located about 150 ft 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) - Phase 1, 2, and 3

This station is located underneath the New York Central Railroad Bridge about 4000 ft upstream from the mouth of Cattaraugus Creek at Lake Erie. The stream cross-section is shown in Figures A.26, A.27 and A.28.

Lake Erie Stations 1,2, 3, and 4 - Phase 2 and 3

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.

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 quantities 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 from 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. 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 (D[illegible] 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.

PHASE 1 FLOW CONDITIONS

During the Phase 1 sampling period from November 30 through December 5, 1977 the U.S. Geological survey gage was inoperable and no readings are available. Using precipitation records, topographic maps, and synthetic unit hydrographs determined by Snyders Method (Viessman et al. 1977) the hydrograph for the sampling period was developed (Figure 5). Two significant events occurred during the six-day sampling period. The first event was approximately 3065 cfs during the first and second day of sampling. The second event of approximately 2970 cfs occurred during the fourth and fifth days of sampling. The lower flows were on the order of 700 to 800 cfs.

PHASE 2 FLOW CONDITIONS

Daily average discharges for the period from September 15 through September 28, 1978 were obtained frm the U.S. Geological Survey office at Ithaca, New York. The discharge hydrograph for the time period is plotted in Figure 5. The hydrograph shows that the sampling took place during the recession curve where the runoff from an earlier rainfall event was being withdrawn from basin storage. The flow at Gowanda during the sampling period varied from 520 cfs on September 20 to 171 cfs on September 26, 1978. Flows approaching base flow conditions at Gowanda existed for the last two or three days of the sampling period. The average daily discharge of 731 cfs for Cattaraugus Creek at Gowanda indicates that very low flow conditions existed during most of the sampling period.

PHASE 3 FLOW CONDITIONS

During the Phase 3 sampling program the discharge at the Gowanda gage increased from 540 cfs on April 26 to 910 cfs on April 28 and then decreased to less than 600 cfs on April 29, 1979 (Figure 5). 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. The small peak superimposed on the major hydrograph peak is due to a siphon spillway release from a small reservoir on Buttermilk Creek just upstream of the FC-1 sampling station. Discharge from the reservoir is regulated by the siphon spillway which maintains reservoir levels below a certain elevation. Once the siphon is primed, large quantities of water are discharged in a short period of time, producing extremely fast rising hydrographs in Buttermilk Creek during periods of relatively low flow.

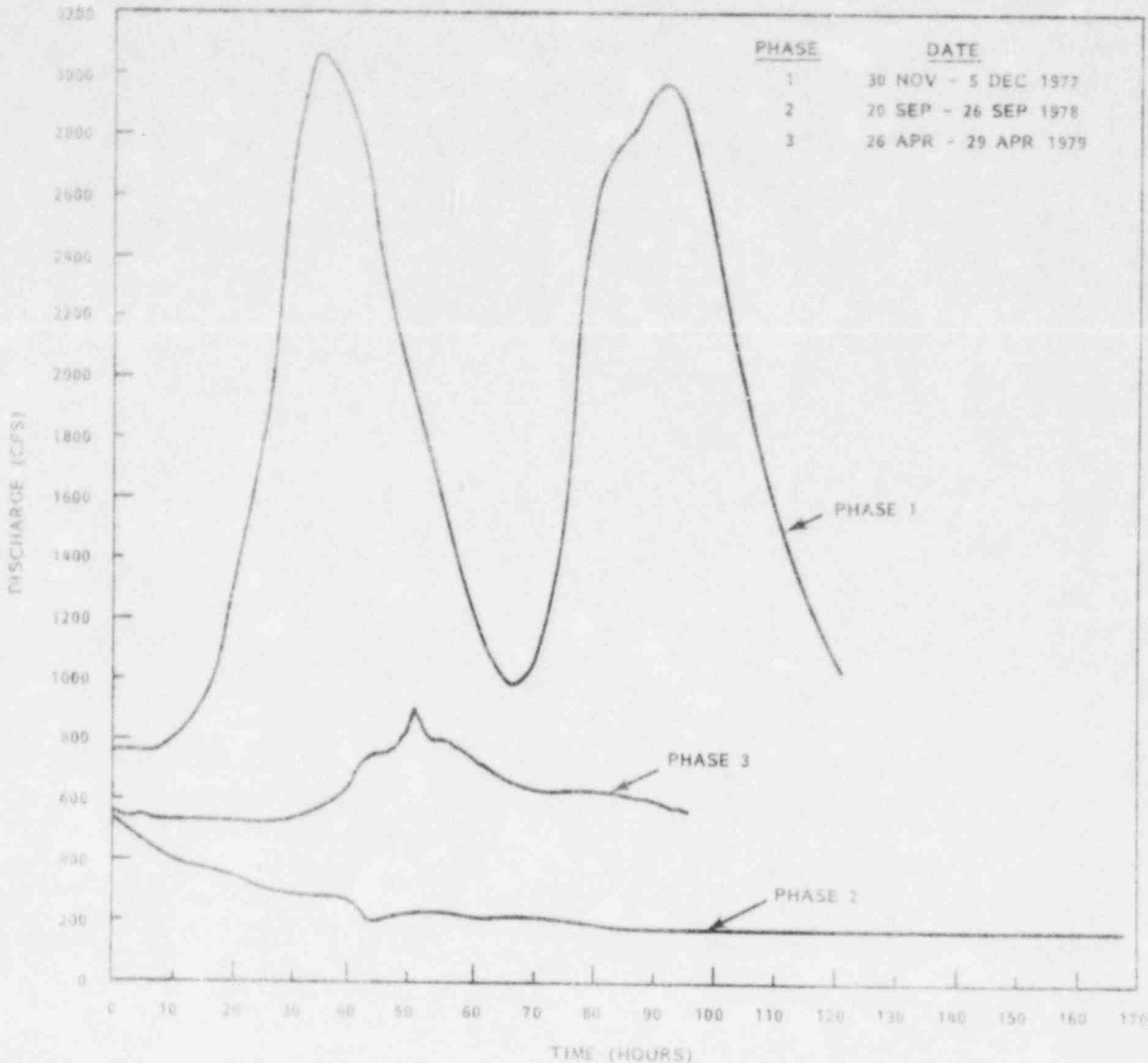

FIGURE 5. Discharge Hydrographs for Phases 1, 2 and 3 at the Gowanda Gage (USGS) Near Station CC-9 on Cattaraugus Creek, New York

SEDIMENT CHARACTERISTICS

The sediment transported by a stream can have a wide range of sizes, shapes, densities, and chemical properties. Particle size is perhaps the dominant factor that determines the transportability of a class of sediment. The sizes range from boulders down to the finest of clay particles. Two distinct categories of stream sediment load can be defined for the range of sizes: 1) bed material load, and 2) wash load.

The bed material load consists of sand sizes and larger particles that have sufficiently high settling velocities and tend to concentrate near the streambed during transport. These particles become part of the streambed during low flow conditions. The wash load consists of silt and clay sized material that tend to be dispersed rather uniformly through the water column. The finer particles of this category can be colloidal in behavior.

This distinction has been introduced for two reasons. First, there is a great difference between the transport velocity of the two categories. The wash load moves through the river system with the same velocity as the water. During floods, the washload particles can easily travel from their point of origin in the watershed to their point of final deposition. In constrast, the bed material transport velocity is several orders of magnitude less than the flow. During floods, the bed material load travels only short distances and traverses these distances in short hops. Bed particles can require years to travel the same distance wash load particles travel during one flood event.

The second reason for the distinction between the two categories is that the wash load is source dependent. It is derived primarily from overland flow during rainfall-runoff events and is determined by erosion characteristics of the watershed. The bed material is already available in the stream channel bed and moves only when sufficient water velocity is reached. Therefore, the rate of transport of bed particles depends on the availability of particles in the bed and the flow rate of the stream.

The percentages of sand, silt, and clay in the channel bed sediment samples for Phases 1, 2 and 3 are listed in Tables 1, 2 and 3, respectively. The concentrations in milligrams per liter (mg/l) of sand, silt and clay in the suspended sediment samples for Phases 1, 2 and 3 are listed in Tables 4, 5 and 6, respectively. The percentage values of bed sediment (Tables 1, 2 and 3) indicate that lower percentages of silt and clay were present during Phase 1 as compared to Phase 2 and 3 values. This could be due to the higher flow velocities of the Phase 1 flow conditions entraining the finer bed material. During the extreme low flow conditions of Phase 2 the percentages of silt and clay found in the bed material were much higher. The higher concentrations of sand in the suspended sediment samples of Phase 1 can also be attributed to the higher flow velocities.

TABLE 1. Percentage of Sand, Silt and Clay in Phase 1 Bed Sediment

Station	Sand %	Silt %	Clay %
BC-1	98.55	1.25	0.20
FC-1	28.04	68.51	3.45
BC-2/1	98.86	1.13	0.01
BC-2/2	99.308	0.689	0.003
BC-3/1	99.46	0.53	0.01
BC-3/2	98.17	1.83	0.0
BC-4/1	98.53	1.47	0.0
BC-4/2	99.08	0.89	0.03
CC-1	99.24	0.759	0.002
CC-3/1	99.47	0.527	0.0028
CC-3/2	98.66	1.33	0.0043
CC-3/3	99.82	0.18	0.0034
CC-5/1	89.19	10.53	0.28
CC-5/2	81.09	18.68	0.23
CC-9	98.89	1.10	0.01
CC-11	87.47	11.34	1.18

TABLE 2. Percentage of Sand, Silt and Clay in Phase 2 Bed Sediment

Station	Sand %	Silt %	Clay %
BC-1	95.20	4.53	0.27
EB	41.90	50.26	7.87
FC-1	67.39	29.65	2.96
BC-4	84.35	14.87	0.78
CC-1	91.53	8.23	0.24
CC-3/1	65.13	34.17	0.70
CC-3/2	95.46	4.44	0.10
CC-3/3	82.92	15.58	1.50
CC-5/1	0.88	89.20	9.91
CC-5/2	0.89	89.17	9.94
CC-5/3	0.30	86.60	13.10
CC-9	92.61	7.33	0.06
CC-11	8.77	83.88	7.35

TABLE 3. Percentage of Sand, Silt and Clay in Phase 3 Bed Sediment

Station	Date	Sand %	Silt %	Clay %
BC-1	4-26-79	95.83	4.01	0.16
EB	*1			
FC/EB	*1			
FC-1	4-29-79	77.20	21.14	1.66
BC-4	4-26-79	95.95	3.84	0.21
CC-1	4-29-79	51.37	45.89	2.74
CC-3	4-27-79	98.99	0.98	0.03
CC-5	4-28-79	99.12	0.86	0.02
CC-6	4-26-79	98.58	1.38	0.04
CC-9	4-29-79	94.37	5.51	0.12
CC-11	4-29-79	60.09	39.30	0.61
LE-1 *2	4-25-79	3.78	94.40	1.82
LE-2	4-25-79	9.05	89.46	1.49
LE-3	4-25-79	*3	*3	*3
LE-4	4-25-79	83.09	16.67	0.24

*1 Station not sampled.
*2 Lake Erie Stations 1 through 4.
*3 Core sample lost.

TABLE 4. Concentration of Suspended Sediment in mg/l for Phase 1

Station	Sand	Silt	Clay	Total
BC-1	2.2	96.8	9.7	108.70
FC-1	0.9	132.6	16.4	149.90
BC-2/1	20.1	85.1	3.75	108.95
BC-2/2	13.7	95.6	42.8	152.18
BC-3/1	0.5	18.1	1.8	20.40
BC-3/2	8.1	31.9	2.7	42.70
CC-1	1.8	36.0	1.85	39.65
CC-3/1				
0.2d	2.15	27.3	1.2	30.65
0.5d	2.6	23.85	1.3	27.75
0.8d	2.8	26.5	1.15	30.45
CC-3/2	0.5	26.85	29.2	56.60
CC-3/3	0.6	25.25	27.9	53.75
CC-5/1	0.2	3.8	2.4	26.40
CC-5/2				
0.2d	0.2	29.3	2.7	32.20
0.5d	0.2	32.1	3.4	35.70
0.8d	0.2	28.2	3.1	31.50
CC-9				
0.2d	0.7	25.3	1.15	27.15
0.8d	0.0	23.0	1.2	24.2

TABLE 5. Concentration of Suspended Sediment in mg/l for Phase 2

Station	Sand	Silt	Clay	Total
GVC-1	0.170	4.582	2.562	7.314
BC-1	0.575	10.870	2.283	13.728
FC-1	0.133	8.744	3.43	12.309
BC-4	0.544	59.562	17.680	77.786
CC-1	0.54	13.997	3.433	17.974
CC-3/1 (top)	0.087	6.924	1.803	8.814
CC-3/1 (bottom)	0.173	10.148	4.466	14.787
CC-3/2	0.342	19.309	5.545	25.196
CC-3/3	0.204	15.270	2.104	17.578
CC-5/1	0.021	34.445	4.142	38.608
CC-5/2 (top)	0.024	15.990	3.041	19.055
CC-5/2 (mid)	0.030	20.708	4.043	24.781
CC-5/2 (bottom)	0.002	44.401	4.827	49.230
CC-5/3	0.026	20.708	2.119	22.853
CC-9	0.691	24.308	8.277	33.276
CC-11 (top)	0.073	12.869	3.041	15.983
CC-11 (bottom)	0.095	20.456	3.213	23.764

TABLE 6. Concentration of Suspended Sediment in mg/l for Phase 3

Station	Date	Sand	Silt	Clay	Total
BC-1	4-26-79	0.05	2.62	0.32	2.99
	4-27-79	2.89	50.12	7.12	60.13
	4-28-79	0.65	13.22	4.7	18.59
FC-1	4-26-79 (am)	0.66	71.95	26.22	98.83
	4-26-79 (pm)	0.91	12.37	3.97	17.25
	4-27-79 (am)	0.49	55.30	22.81	78.60
	4-27-79 (pm)	0.99	48.86	21.23	71.08
	4-28-79 (am)	0.06	6.11	3.28	9.45
BC-3	4-27-79	0.71	14.07	2.82	17.60
BC-4	4-26-79	0.16	16.95	0.00	17.11
	4-27-79	0.65	57.20	14.66	72.51
	4-28-79	0.17	11.96	3.45	15.58
CC-1	4-26-79	0.15	4.11	0.23	4.49
	4-47-79	1.64	89.25	22.70	113.59
CC-3	4-27-79	2.36	36.25	8.29	46.90
CC-5	4-26-79	0.40	21.98	5.45	27.83
	4-27-79	1.16	30.80	5.55	37.51
	4-28-79	1.02	10.62	1.33	12.97
CC-9	4-29-79	0.83	5.59	1.08	7.50
CC-11	4-29-79	3.71	13.37	1.84	18.92

RADIOLOGICAL ANALYSIS

Results of the radiological analysis of bed sediment, suspended sediment, and water samples for tritium, strontium-90, cesium-134, cesium-137, plutonium-238, and plutonium-239,240 are discussed in this section. These radionuclides were identified as having a relatively higher level of activity in the vicinity of the Nuclear Fuel Services (NFS) facilities at West Valley, New York. The background stations near the NFS facilities are BC-1, CC-1, and GVC (Figures 1 and 2). The station at BC-1 is located about one mile upstream of the facilities drainage outlet into Buttermilk Creek at FC-1. The station CC-1 is located on Cattaraugus Creek about two miles upstream of the confluence with Buttermilk Creek. The station GVC (Phase 2 only) is located on Great Valley Creek which is a part of the Allegheny River system and a separate basin from Cattaraugus Creek.

TRITIUM (H-3)

Phase 1

Only three water samples at stations BC-4, CC-3, and CC-11 were analyzed for tritium. None of the samples were from background stations. The tritium levels at these stations were 461 ± 35 pCi/l (BC-4), 305 ± 36 pCi/l (CC-3), and 206 ± 32 pCi/l (CC-11). The station BC-4, which is nearest the NFS site, recorded the highest activity level.

Phase 2 (Figure 6)

The highest level of tritium is found at station FC-1 (3413.93 ± 92.98) with the lowest levels found at the background stations GVC, BC-1 and CC-1. The stations on Cattaraugus Creek downstream from the Buttermilk Creek outflow all show levels slightly above background.

Phase 3 (Figure 7)

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

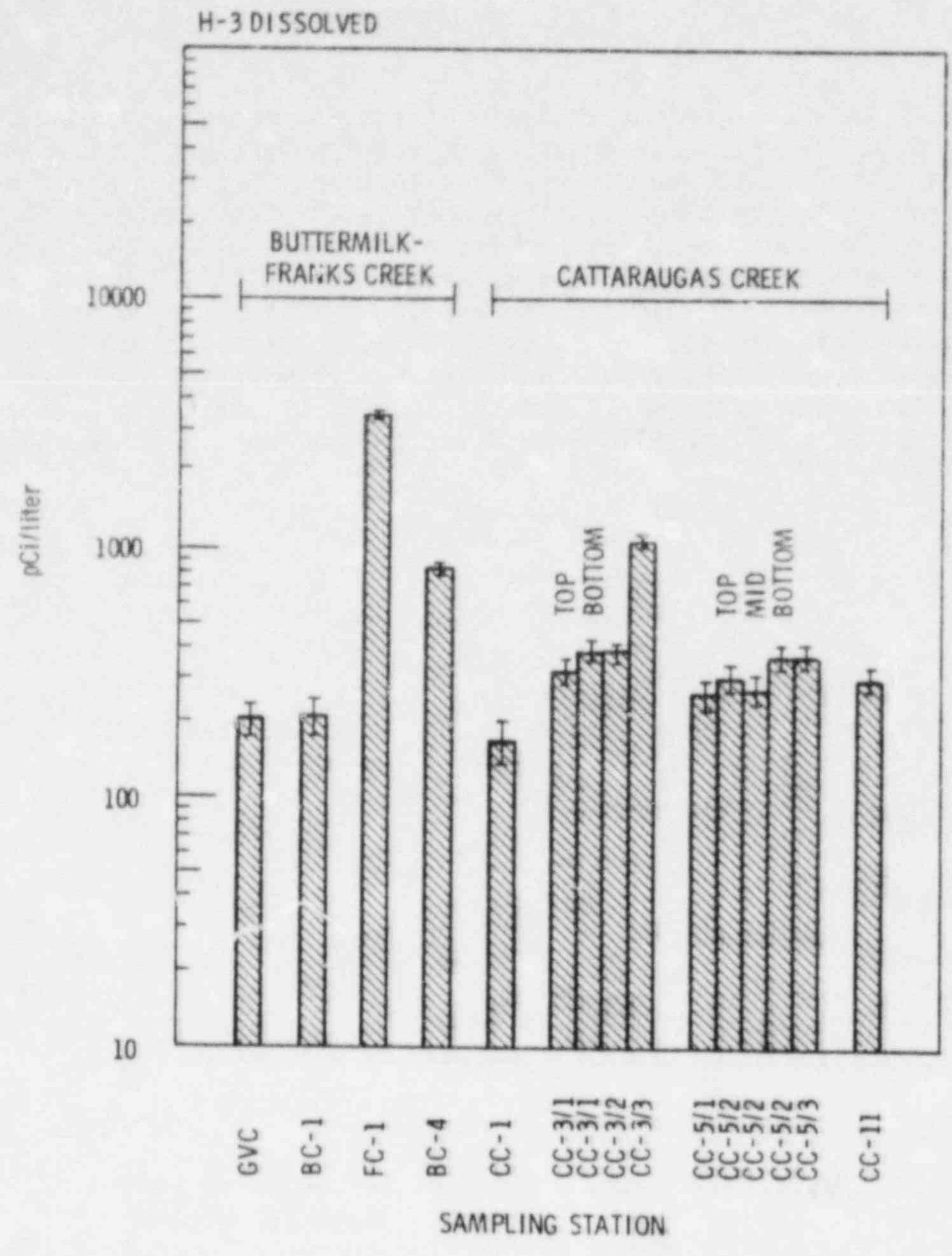

FIGURE 6. Phase 2 Tritium Concentrations

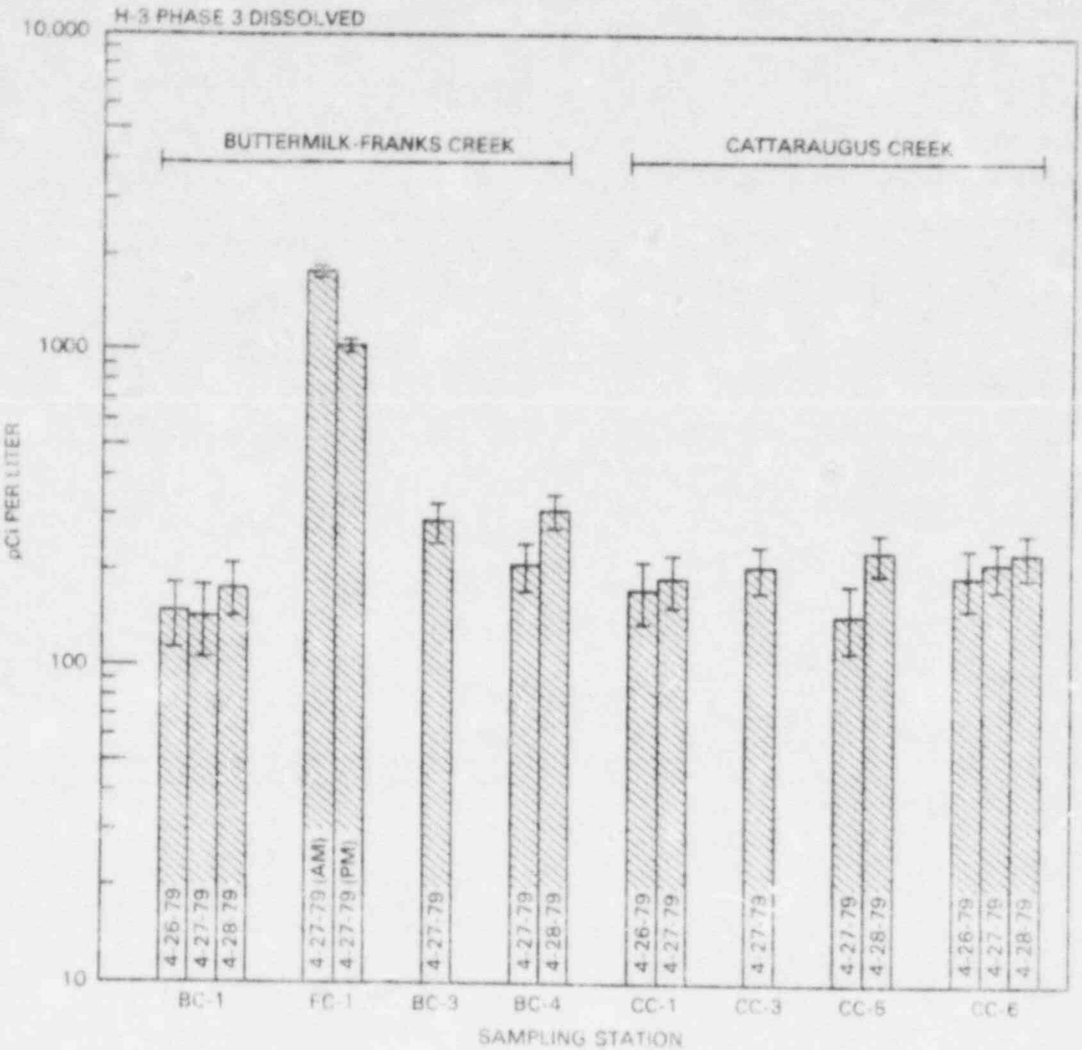

FIGURE 7. Phase 3 Tritium Concentrations

STRONTIUM-90 (Sr-90)

Phase 1

Bed Sediment (Figure 8)

Strontium-90 levels in bed sediment varied from below detection to 0.315 $\pm$ 0.045 pCi/g. The highest value was found at BC-2, station 1 in the bed silt fraction.

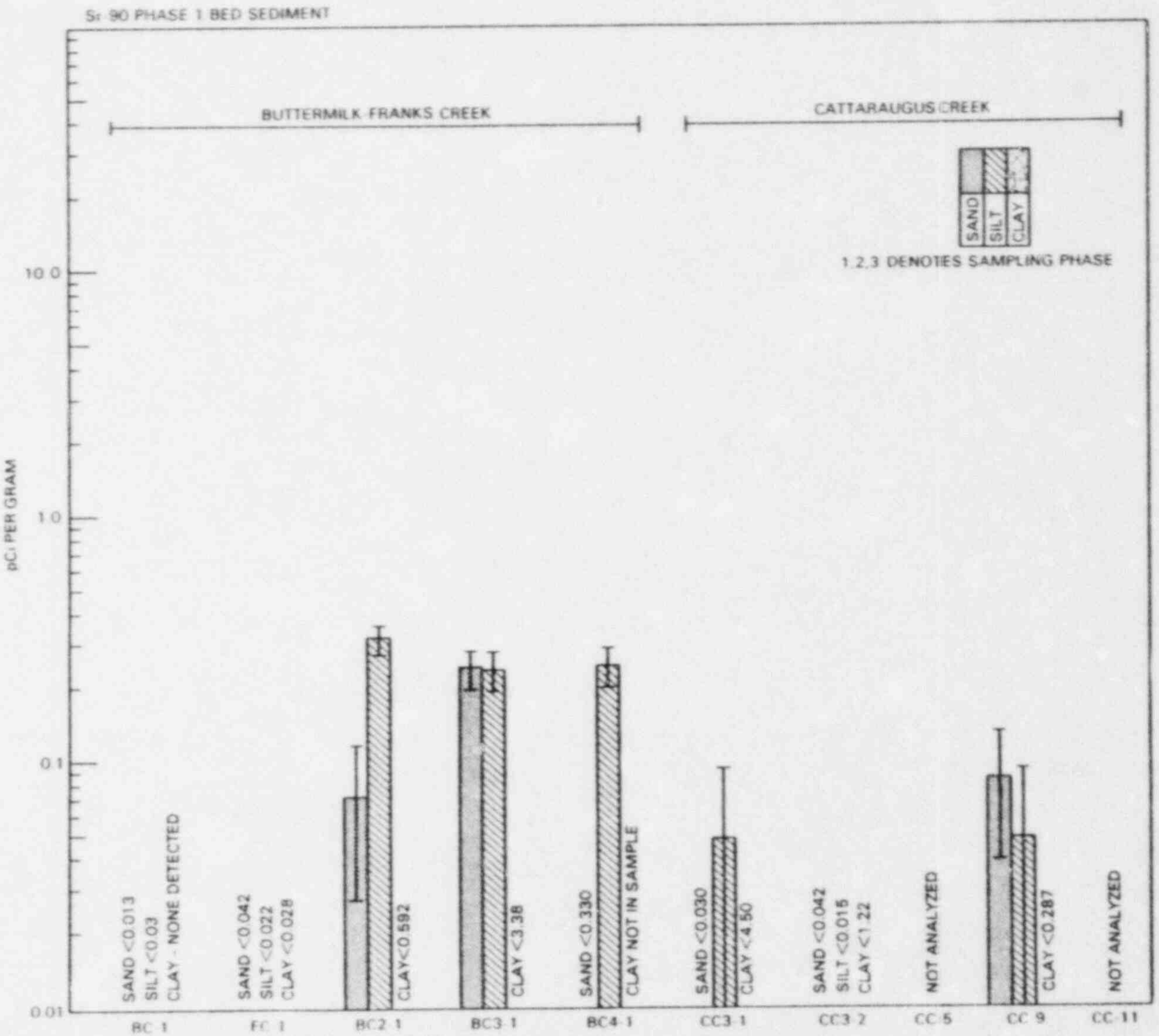

FIGURE 8. Phase 1 Strontium-90 Concentrations in Bed Sediment

Suspended Sediment (Figure 9)

Detectable levels of Sr-90 in suspended sediment were found at most stations. The highest recorded value was found in the suspended sand fraction of CC-5, station 1 in Springville Reservoir with a Sr-90 value of 10.1 ± 4.5 pCi/g.

The highest Sr-90 levels in suspended sediment were found in Springville Reservoir (CC-5) on Cattaraugus Creek. Strontium-90 levels in the suspended sediment of Cattaraugus Creek were as high or higher than in suspended sediment of Buttermilk and Franks Creeks.

Phase 2

Bed Sediment (Figure 10)

The trend for strontium-90 is one of decreasing activity levels downstream from the Erdman's Brook station (EB). The highest activity levels for sand (1.57 ± 0.17 pCi/g), silt (3.42 ± 0.21 pCi/g), and clay (11.07 ± 0.65) were found at station EB. The levels at the background station CC-1 were all below detection. The trend is one of much higher levels at station EB relative to other stations with below detection levels at the background station CC-1, and decreasing activity downstream.

Suspended Sediment (Figure 11)

The maximum concentrations of strontium-90 in suspended sediment were detected at the background stations. The activity levels at GVC and CC-1 were 84.04 ± 4.84 pCi/gm and 778.85 ± 43.24 pCi/gm, respectively. The other stations showed a trend of decreasing activity in the downstream direction from the source station at FC-1.

Dissolved (Figure 12)

Significantly higher levels were found at the Franks Creek source station. The maximum level of Sr-90 (20.39 pCi/l) found at FC-1 was considerably higher than the 0.868 pCi/l found at BC-4. The levels at the downstream stations decrease to near background levels in Cattaraugus Creek.

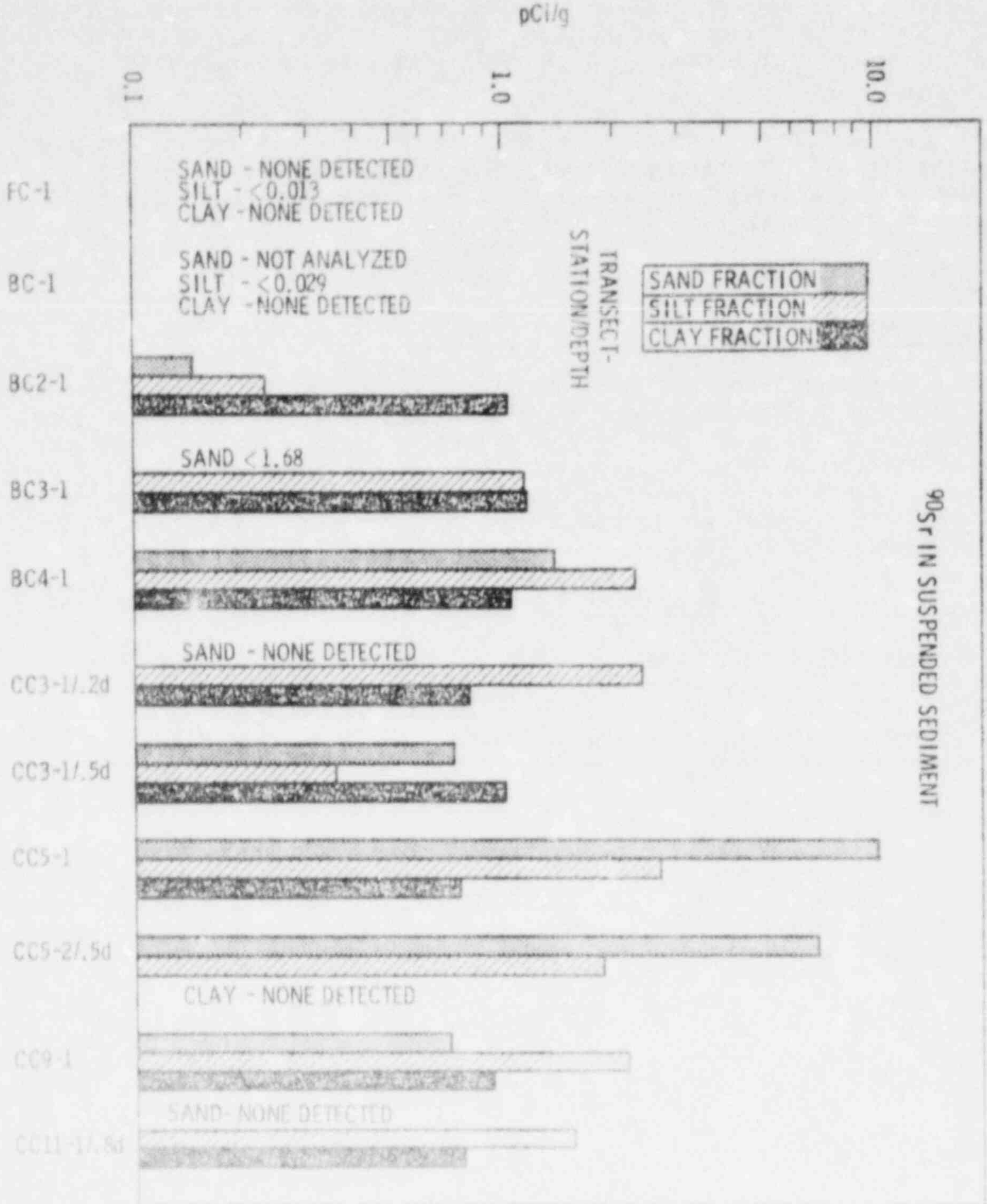

FIGURE 9. Phase 1 Strontium-90 Concentrations in Suspended Sediment

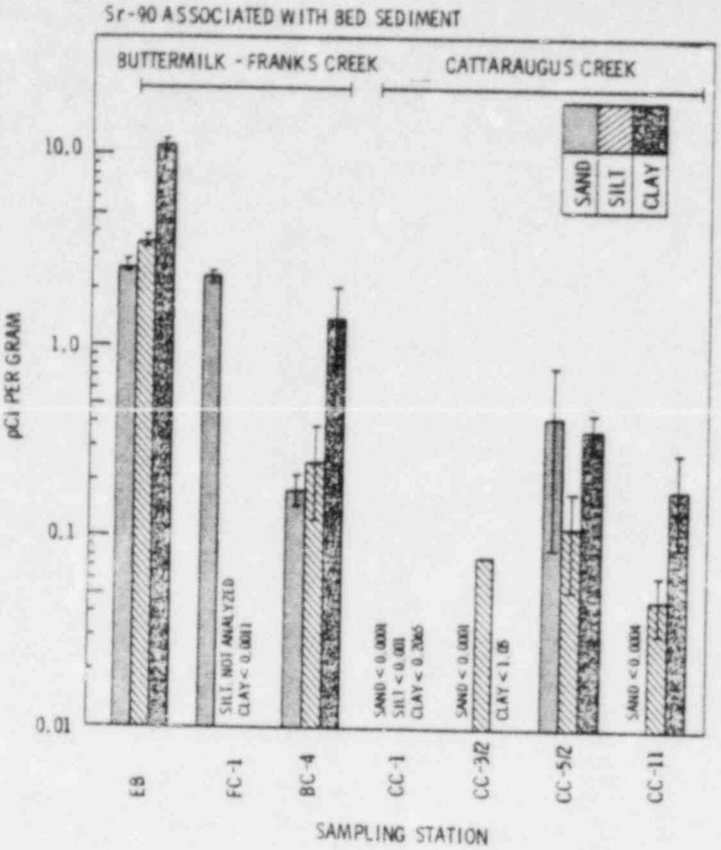

FIGURE 10. Phase 2 Strontium-90 Concentrations in Bed Sediment

Phase 3

Bed Sediment (Figure 13)

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 $\pm$ 0.45 pCi/gm. Background Sr-90 levels in bed sediment were below 1.0 pCi/gm except in one sample from CC-1 where the measured concentrationin the bed clay fraction was 9.70 $\pm$ 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.

Suspended Sediment (Figure 14)

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. The

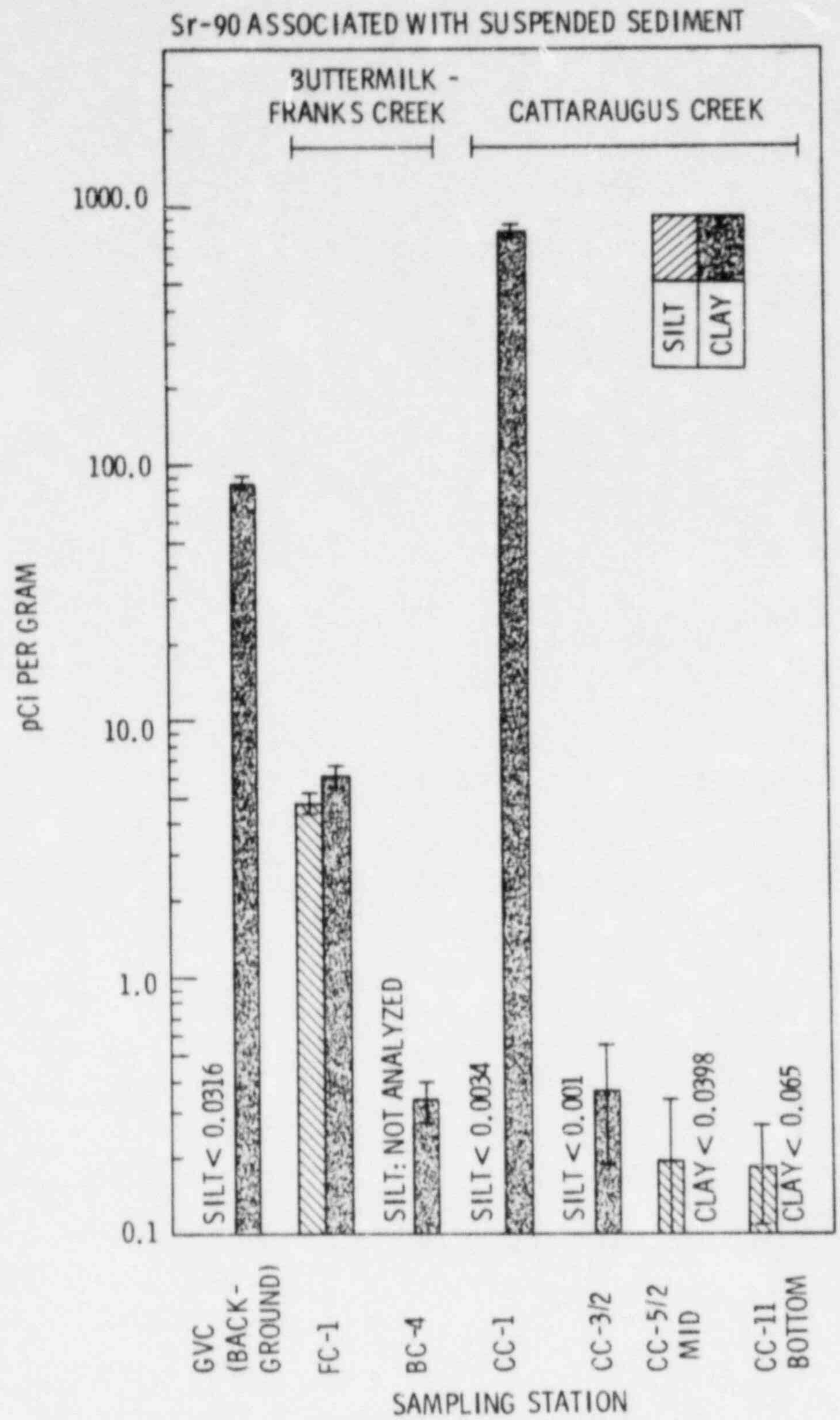

FIGURE 11. Phase 2 Strontium-90 Concentrations in Suspended Sediment

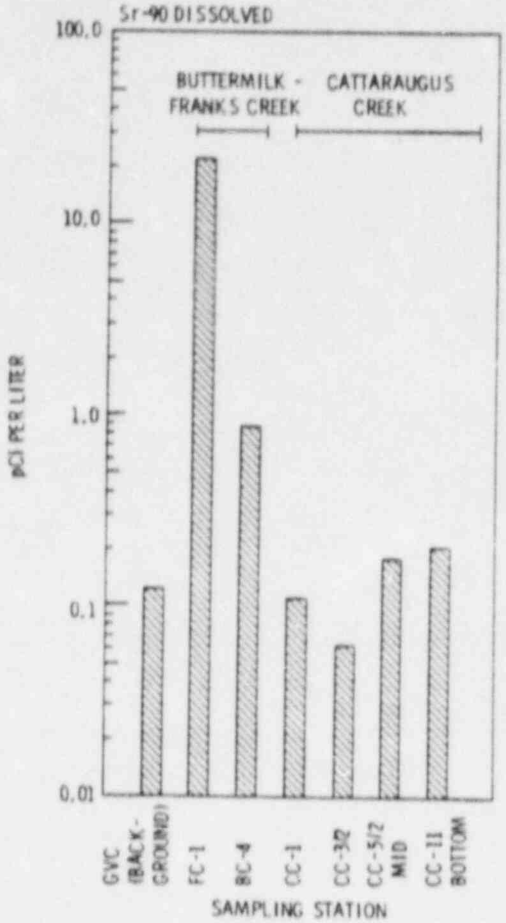

FIGURE 12. Phase 2 Strontium-90 Concentrations in Water

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.

Dissolved (Figure 15)

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. Strontium-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.

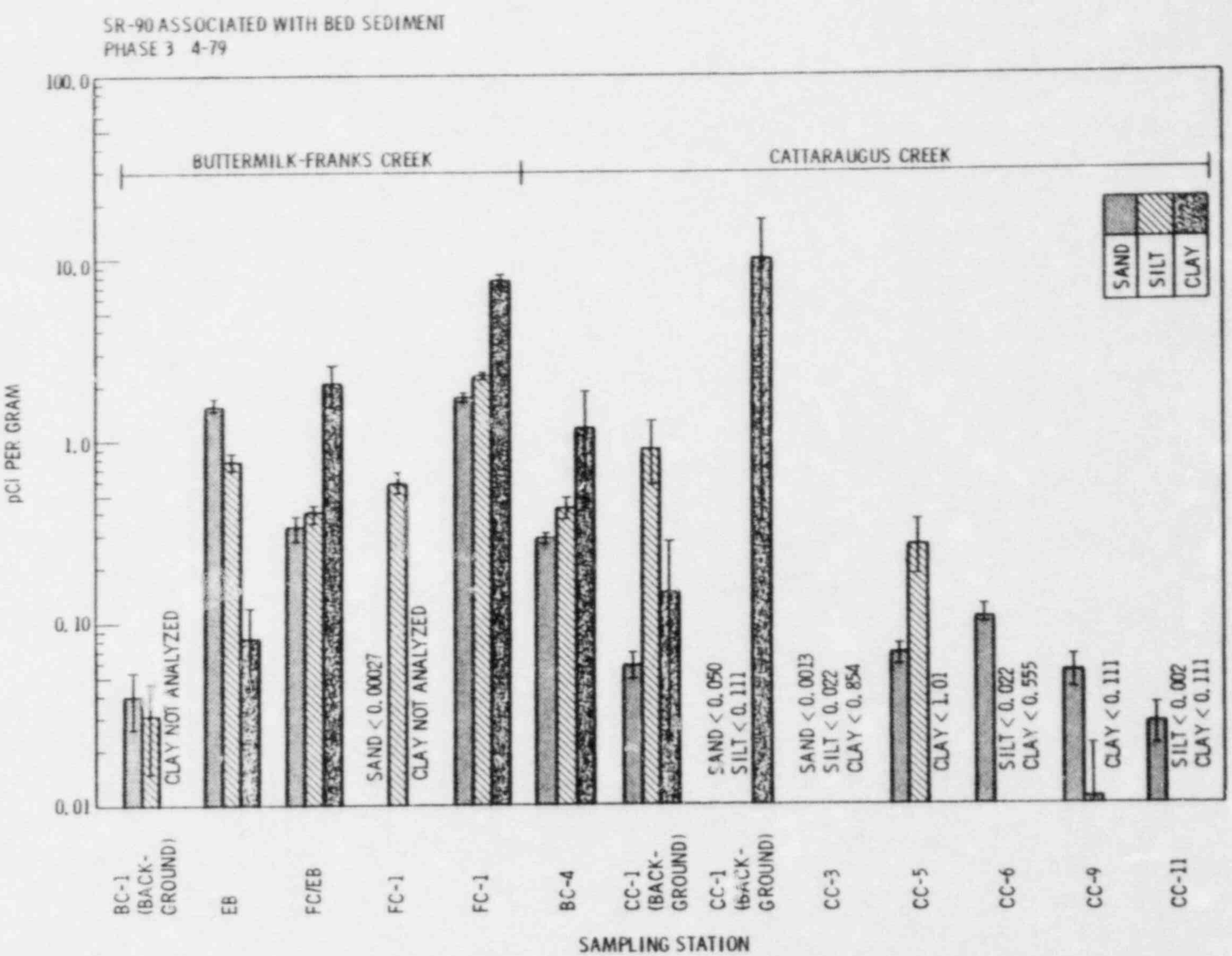

FIGURE 13. Phase 3 Strontium-90 Concentrations in Bed Sediment

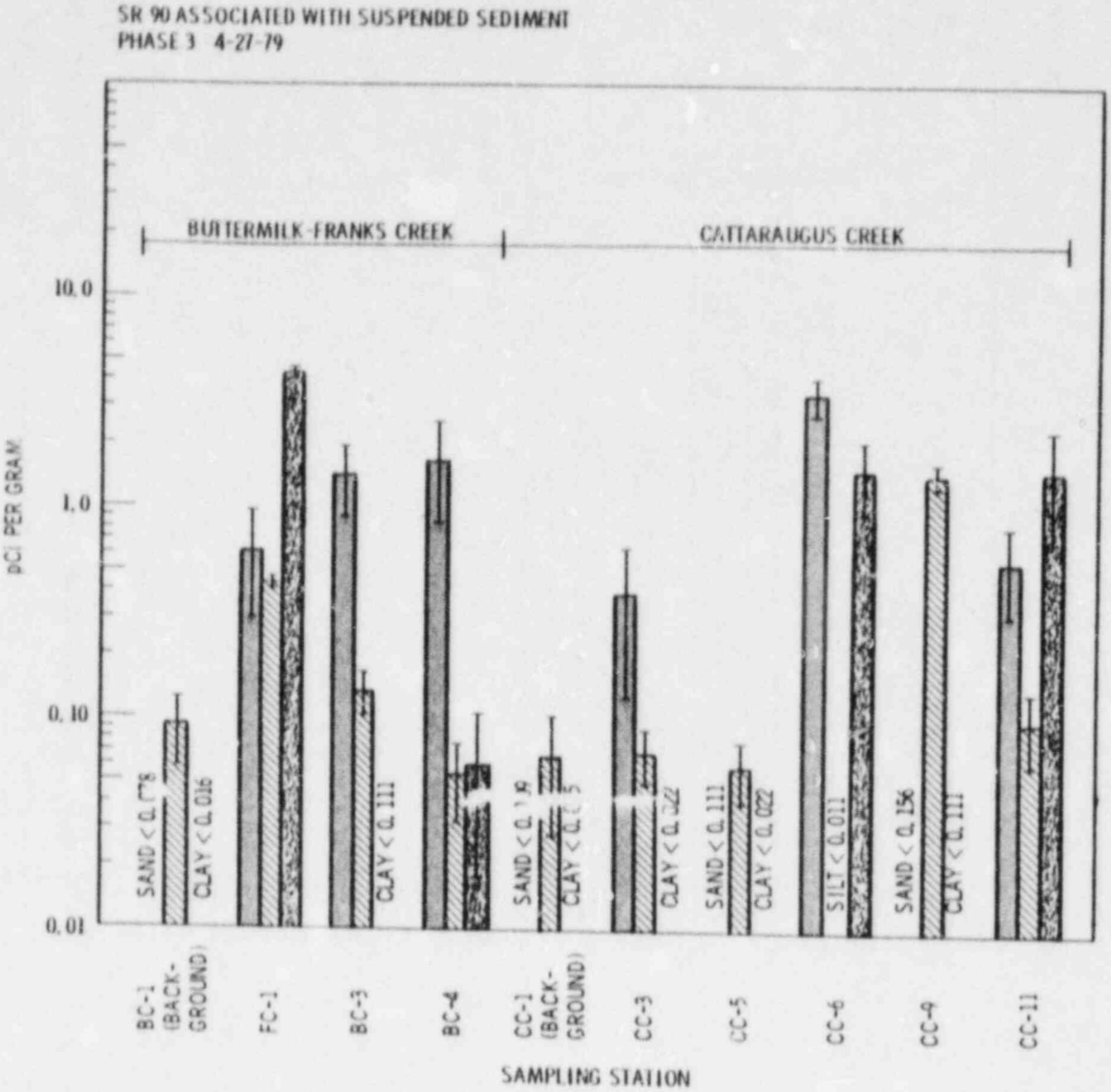

FIGURE 14. Phase 3 Strontium-90 Concentration in Suspended Sediment

CESIUM-134 (Cs-134)

Phase 1

Bed Sediment (Figure 16)

Cesium-134 activity was primarily found at the Franks and Buttermilk Creeks sampling stations. It was below detection of the background stations BC-1 and CC-1. The only Cattaraugus Creek stations recording any activity were CC-5 at Springville Reservoir and CC-11 at the mouth of Cattaraugus Creek which are both backwater areas where sediment deposits accumulate. The maximum activity (2.17 ± 0.64 pCi/gm) level was found with clay at CC-11.

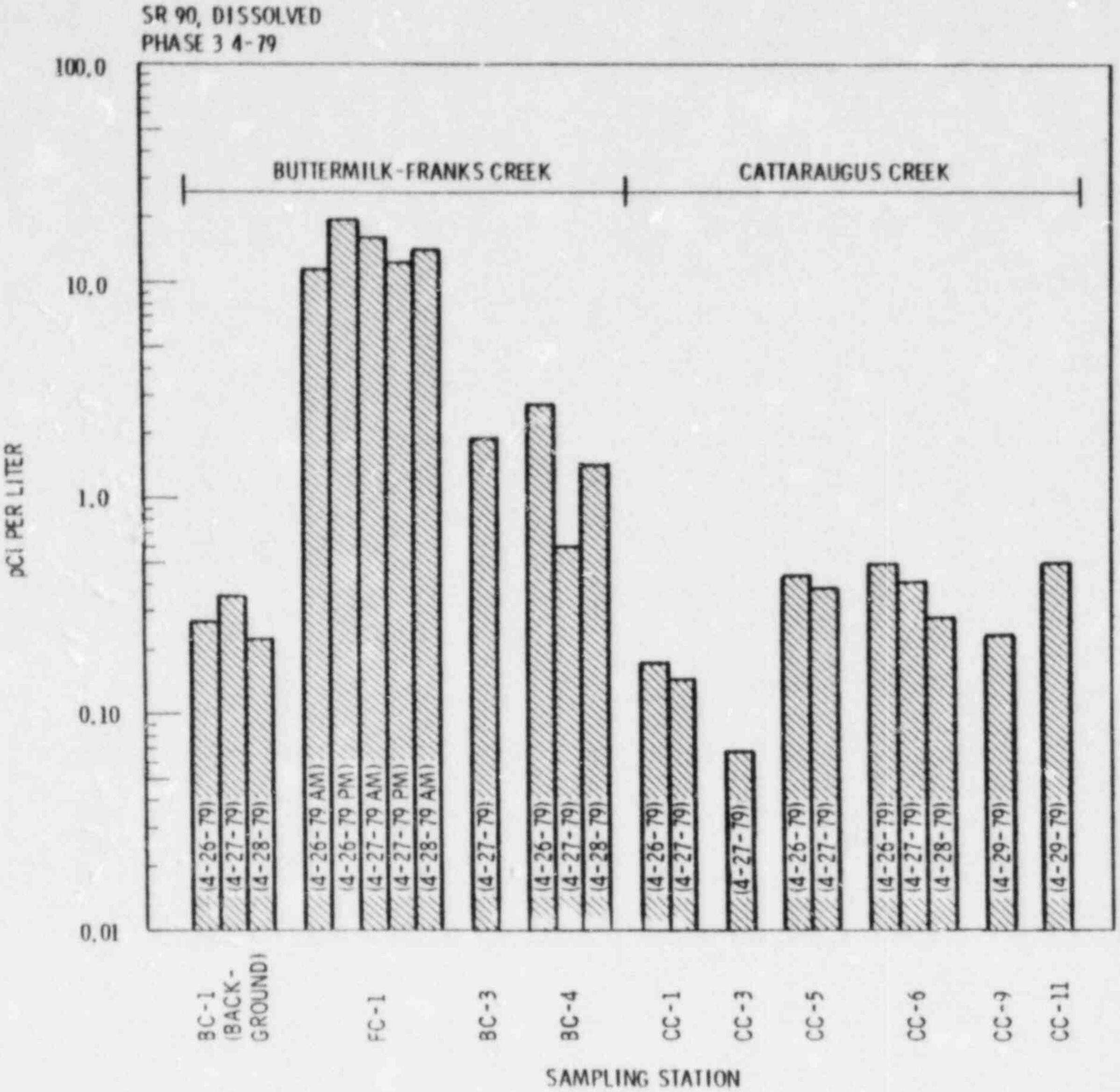

FIGURE 15. Phase 3 Strontium-90 Concentrations in Water

Suspended Sediment

Cesium-134 was detected only at the source station, FC-1. The maximum activity of 0.24 ± 0.19 pCi/gm was associated with sand. The levels for silt and clay were 0.12 ± 0.02 pCi/gm and 0.17 ±0.03 pCi/gm, respectively.

Dissolved (Figure 17)

The maximum concentration of Cs-134 in water was detected at the Cattaraugus Creek background station CC-1 (0.084 ± 0.07 pCi/l). The lowest

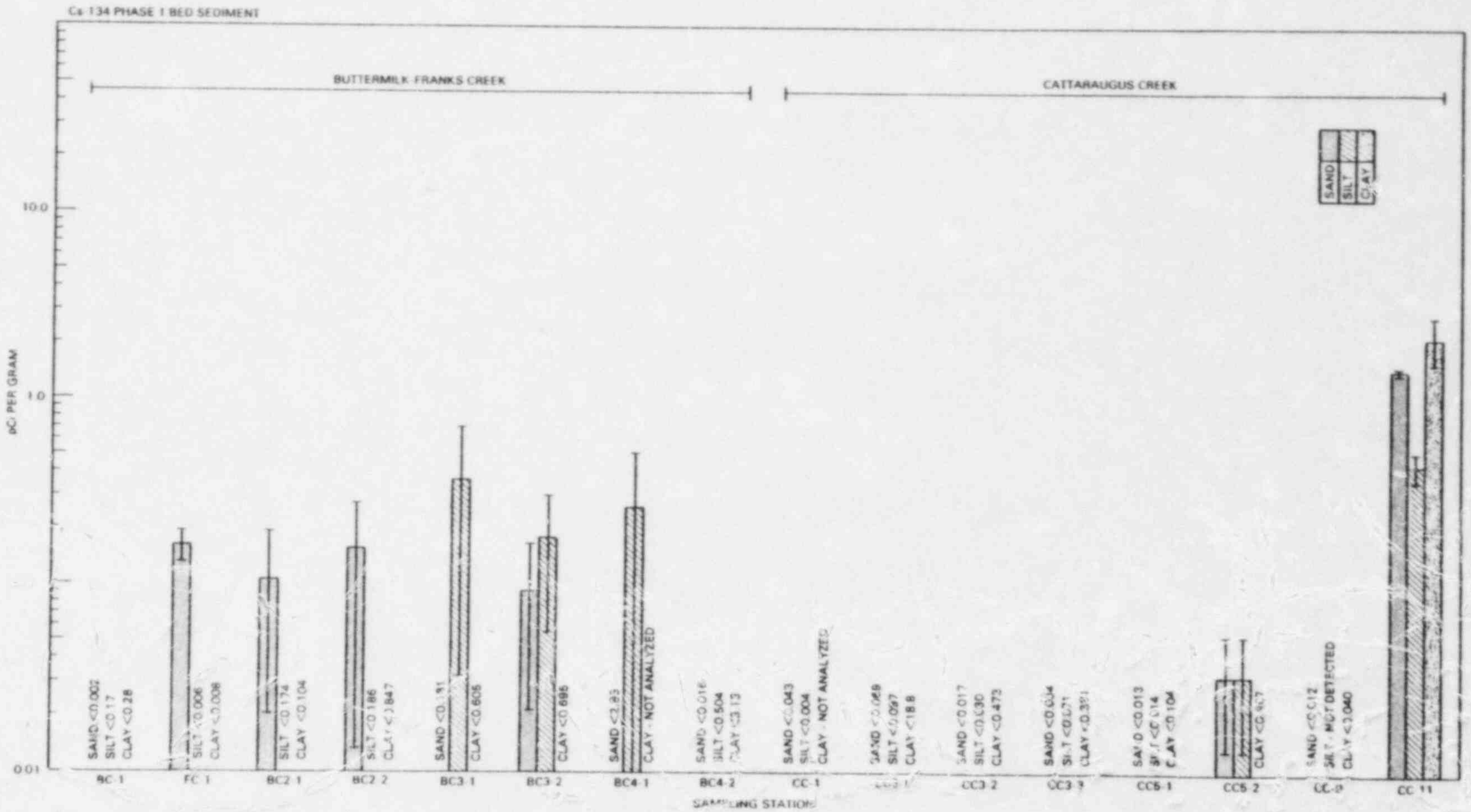

FIGURE 16. Phase 1 Cesium-134 Concentration in Bed Sediment

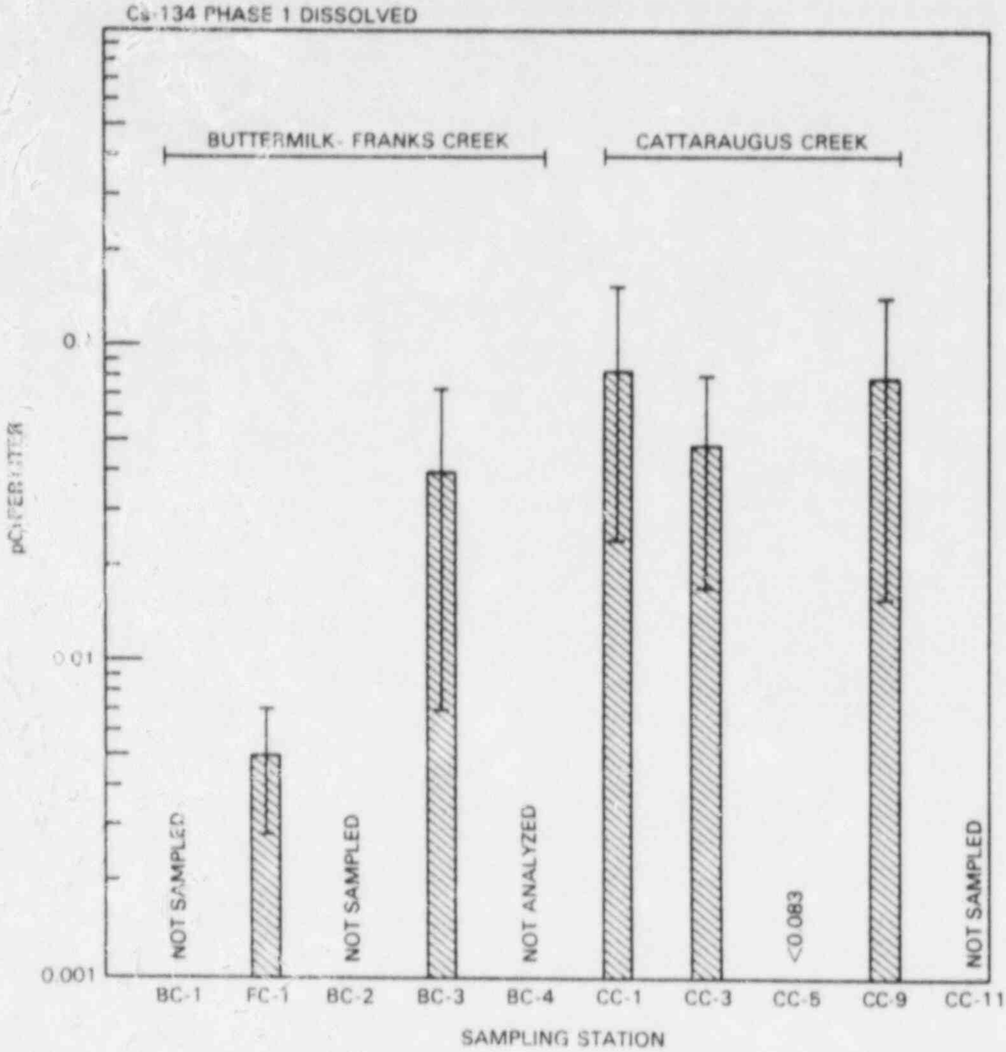

FIGURE 17. Phase Cesium-134 Concentration in Water

activity level of 0.005 $\pm$ 0.002 pCi/l was detected at the source station FC-1. For the stations analyzed the trend in activity levels is to increase in the downstream direction.

Phase 2

Bed Sediment (Figure 18)

The highest activity levels are associated with clay with no definite trend indicated between sand and silt as to which has the lowest activity. Cesium-134 was found predominantly at the stations in close proximity to the NFS facilities. The highest activity levels for sand and silt were found in Erdmans Brook with a gradual decrease in the downstream direction to BC-4 near

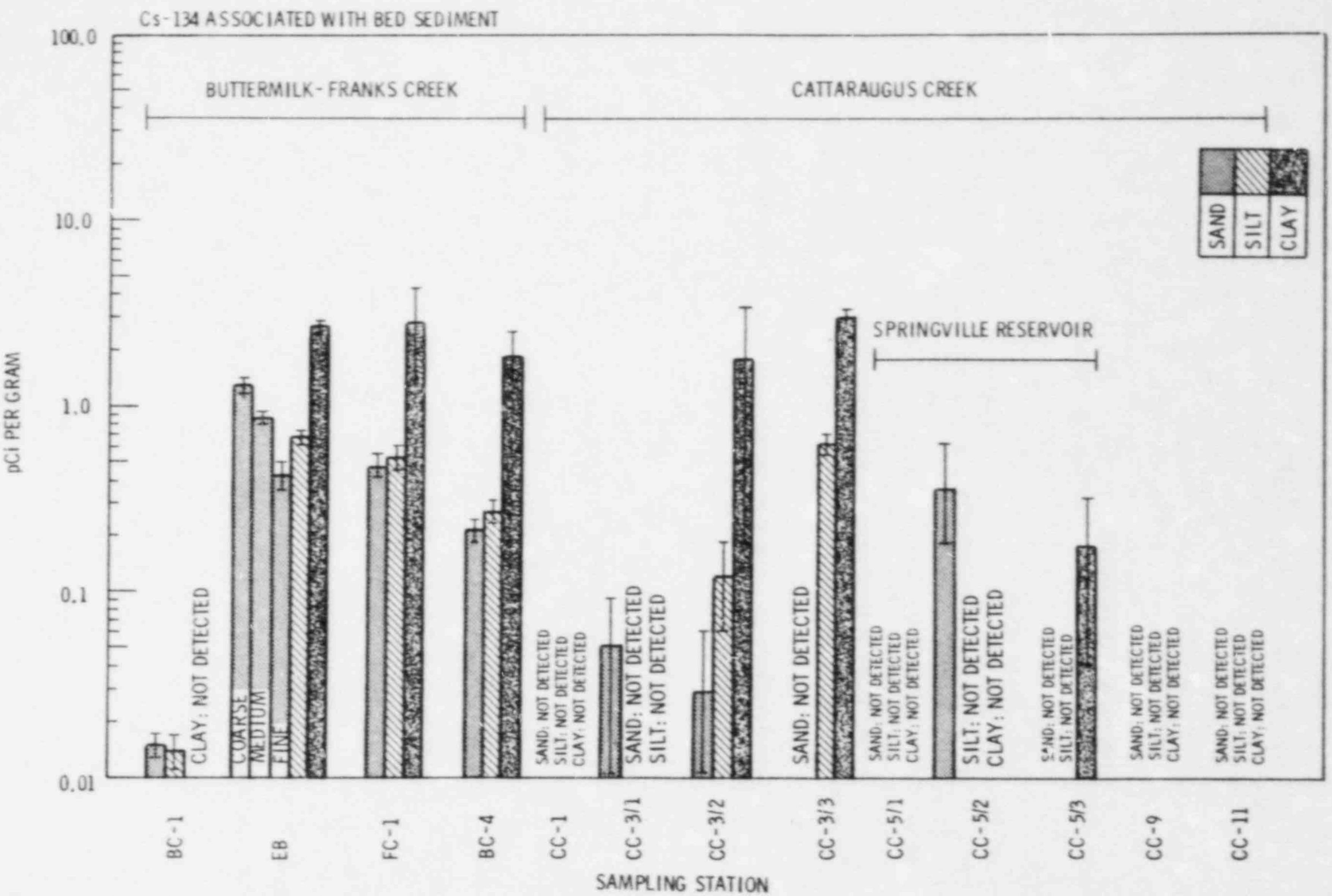

FIGURE 18. Phase 2 Cesium-134 Concentrations in Bed Sediment

the mouth of Buttermilk Creek. The background station BC-1 near the NFS facilities showed relatively very low levels as did the background station at CC-1 on Cattaraugus Creek. Both BC-1 and CC-1 are not affected by water and sediment outflow from Franks Creek. Downstream at the Springville Reservoir stations (CC-5/1, 5/2, and 5/3) Cesium-134 was sparsely found at the three sampling stations and was below detection downstream of the dam. That the radionuclide was not found in appreciable levels in Springville Reservoir and was not detected downstream except at one sampling point in Lake Erie may be attributed to its short half-life of about two years.

Suspended Sediment

Cesium-134 was found only at three sampling stations which were GVC (background), FC-1 (source), and at CC-3 located just upstream of Springville Reservoir. It was not found in the waters of the reservoir or at any other station downstream of CC-3. The maximum value of 0.84 ± 0.71 pCi/gm was associated with the clay at CC-3. The activity levels at GVC and FC-1 were 0.42 ± 0.31 pCi/gm (silt) and 0.34 ± 0.13 pCi/gm (silt), respectively.

Dissolved

Cesium-134 was detected at only one station (CC-3) during the Phase 2 sampling. The level at CC-3 was 0.13 ± 0.04 pCi/l.

Phase 3

Bed Sediment

Cesium-134 was found only in the bed sediments of the source station at FC-1 and the two bed sediment sampling stations on the site at EB and FC/EB near the waste burial grounds. The radionuclide was detected on all three classes of sediment (sand, silt and clay). The maximum value of 1.13 ± 0.15 pCi/gm (clay) was found at FC-1.

Suspended Sediment

Cesium-134 was found only at station FC-1 and was predominantly associated with clay. The maximum activity level of 0.458 ± 0.102 pCi/gm was detected on the clay fraction.

Dissolved

Cesium-134 was not detected in the water samples during Phase 3.

CESIUM-137 (Cs-137)

Phase 1

Bed Sediment (Figure 19)

The Cesium-137 levels at the two upstream background stations are very low, the highest background value being found associated with the bed clay fraction of CC-1 (0.16 ± 0.08 pCi/g). In very few cases were the Cesium-137 levels in bed samples downstream of the NFS facilities found to be at or below these control levels.

The highest Cesium-137 in bed sediments were found in Buttermilk Creek and at the mouth of Cattaraugus Creek (CC-11). The clay fraction generally had the highest Cesium-137 levels, as would be expected, due to the large specific surface area of clay size sediment and the affinity of Cesium-137 for sediment. An exception to this was BC-4, station 1, where the Cesium-137 level associated with bed sand was 125 ± 7.4 pCi/g. Three samples had Cesium-137 levels greater than 100 pCi/g. These samples were located at BC-3, station 1 (bed clay: 125 ± 3.1 pCi/g), BC-4, station 1 (bed sand: 125 ± 7.4 pCi/g), and CC-11 (bed clay: 113 ± 2.2 pCi/g).

The Cesium-137 levels in the bed sample from Franks Creek (FC-1) was surprisingly low. The bed sand and clay fractions were 1.0 ± 0.11 pCi/g and 1.11 ± 0.11 pCi/g, respectively. The bed silt fraction had a Cesium-137 value of 0.37 ± 0.09 pCi/g.

Suspended Sediment (Figure 20)

At BC-1, the upstream background station on Buttermilk Creek, Cesium-137 levels associated with suspended sand, silt and clay were, respectively, 0.63 pCi/g, 0.11 pCi/g, and 0.36 pCi/g. At CC-1, the background station on Cattaraugus Creek, Cesium-137 levels associated with the suspended sand and suspended clay fractions were less than the counting error.

The highest Cesium-137 levels in suspended sediments were generally found in Buttermilk Creek and the one Franks Creek sample, and were associated with the suspended sand and clay fractions. At BC-2, station 2 and BC-3, station 2, the Cesium-137 levels associated with suspended sand were 14.50 ± 0.82 pCi/g and 13.6 ± 1.1 pCi/g, respectively. These two stations are the first two stations downstream of Franks Creek which drains the NFS facility. Cesium-137 associated with suspended sand at FC-1 (10.5 ± 2.1 pCi/g) was slightly lower than BC-2, station 2 and BC-3, station 2; however, the suspended silt and clay fractions with Cesium-137 values of 5.17 ± 0.26 Ci/g and 11.3 ± 0.6 pCi/g, respectively, at FC-1 were the highest levels associated with the suspended silt and clay fractions found during the Phase 1 sampling program.

The Cesium-137 levels in suspended sediment of Cataraugus Creek were generally lower than those in Buttermilk and Franks Creeks, and in many cases the levels were comparable to the levels in suspended sediment of the two

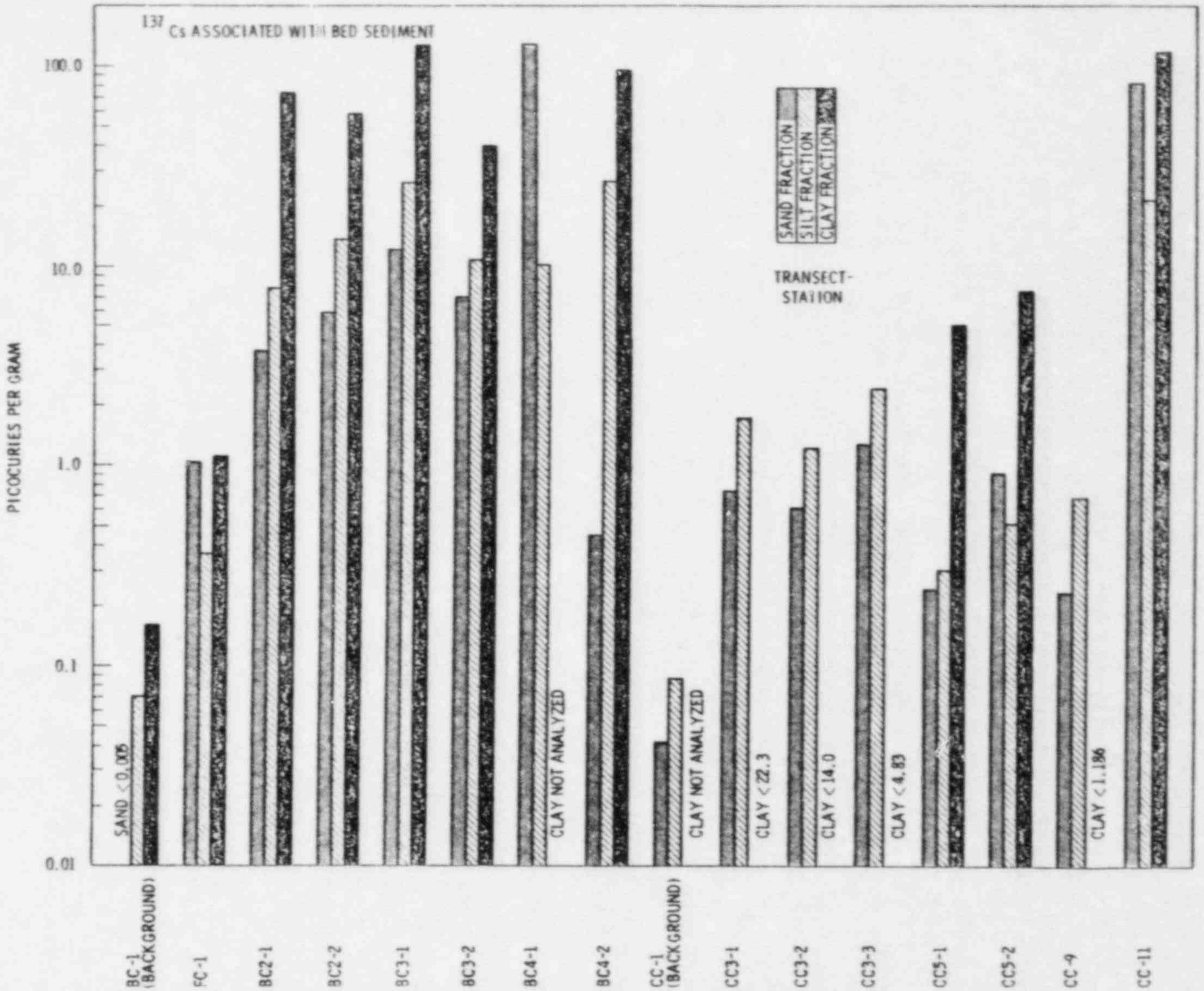

FIGURE 19. Phase 1 Cesium-137 Concentrations in Bed Sediment

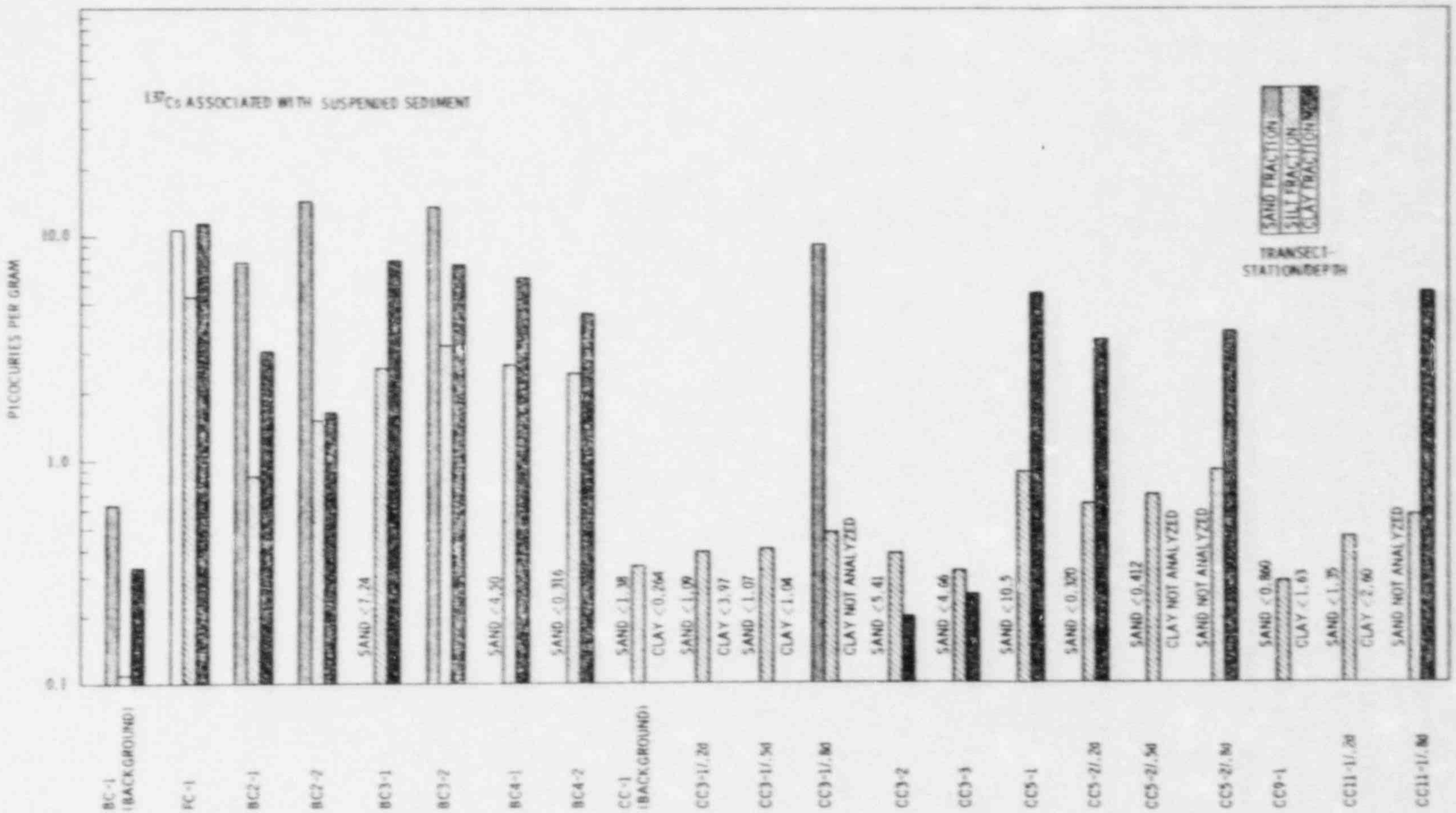

FIGURE 20. Phase 1 Cesium-137 Concentrations in Suspended Sediment

upstream background stations. In a few cases, such as at CC-3, Felton Bridge, CC-5 Springville Reservoir and CC-11, mouth of Cattaraugus Creek, elevated levels of Cesium-137 were found associated with one or more size fractions of suspended sediment. Near the bed of CC-3, station 1 the suspended sand fraction had a Cesium-137 value of 9.02 $\pm$ 2.2 pCi/g. All the suspended clay fractions of samples taken in Springville Reservoir, except for CC5-2/.5d, had ^{137}Cs levels slightly greater than 5 pCi/g.

Dissolved (Figure 21)

Cesium-137 was detected in the water samples at only three stations (FC-1, CC-1 and CC-5). The maximum level of 0.194 $\pm$ 0.02 pCi/l was detected at the source station, FC-1.

Phase 2

Bed Sediment (Figure 22)

The results for Cesium-137 indicate that the NFS facilities are a source of this radionuclide. Activity levels at BC-1 (background) were either very low or below detection. The station at or near the NFS site had the highest overall activity levels for sand, silt and clay. Although station FC-1 and CC-3/3 both recorded levels of 134.0 $\pm$ 9.89 pCi/g for clay which were the highest for any sediment, the general trend is a decrease in levels in the downstream direction. The trend for sand is one of high activity levels at Station EB near the NFS site (72.1 $\pm$ 0.5 pCi/g), which was detected on the coarse fractions, to near uniform levels from 2.04 $\pm$ 0.16 to 1.14 $\pm$ 0.07 pCi/g at CC-3 and CC-5. Below Springville Dam the activity levels drop to less than that of the reservoir levels to 0.34 $\pm$ 0.06 pCi/g at CC-9 and 0.73 $\pm$0.05 pCi/g at CC-11.

Suspended Sediment (Figure 23)

Only the clay and silt samples were analyzed since all the sand samples were less than one gram. Cesium-137 indicated significant levels of activity above background. These higher levels were found only at Station FC-1 in the surface drainage water from the NFS facilities. The activity level for clay and silt were 32.5 $\pm$ 1.5 pCi/g and 11.7 $\pm$ 0.6 pCi/g, respectively. These levels are considerably lower than those for bed sediment at this station. The corresponding activity levels for bed clay and silt at station FC-1 were 134.0 $\pm$ 0.90 pCi/g and 28.6 $\pm$ 0.60 pCi/g, respectively. Although FC-1 is the only station analyzed for the NFS facilities drainage system, it does show considerably higher levels as compared to the other stations and corresponds to the trend of the bed sediment.

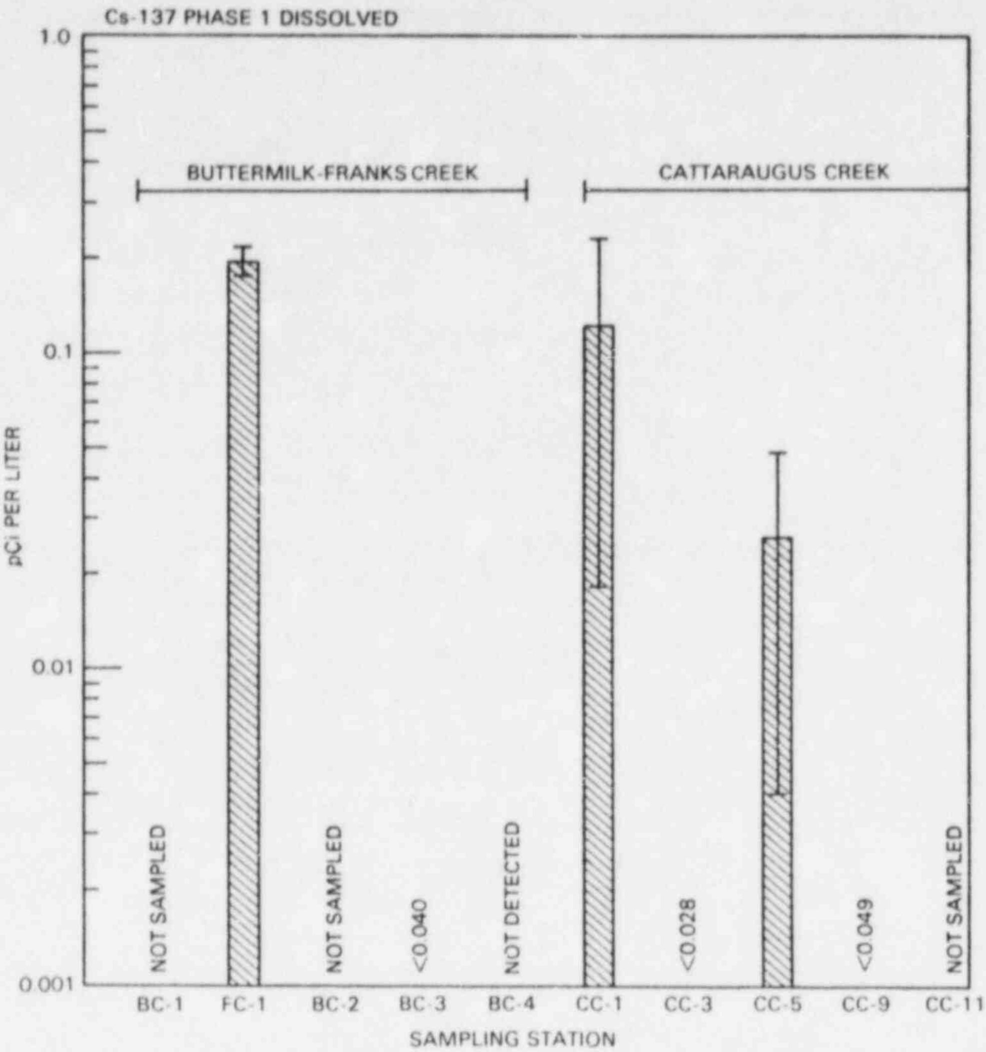

FIGURE 21. Phase 1 Cesium-137 Concentrations in Water

Dissolved (Figure 24)

Only Cesium-137 indicated a significantly higher activity level at the Franks Creek sampling station for gamma counting analysis. The activity levels decrease in the downstream direction and Cesium-137 was not detected at all three background stations (GVS, BC-1, and CC-1). The maximum activity level was detected at FC-1 (0.55 pCi/l) with the next highest level of BC-4 (0.028 pCi/l) about two miles downstream.

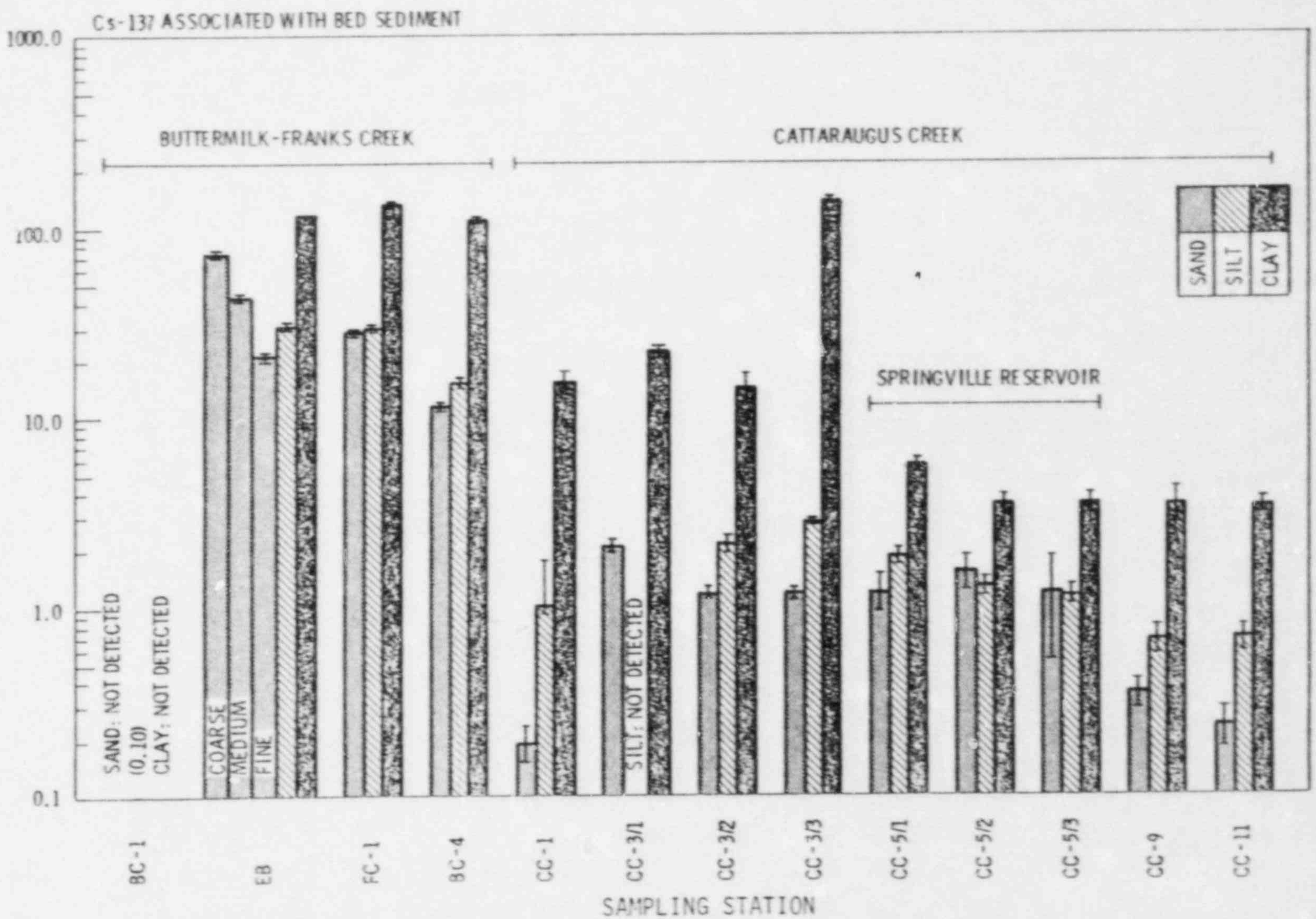

FIGURE 22. Phase 2 Cesium-137 Concentrated in Bed Sediment

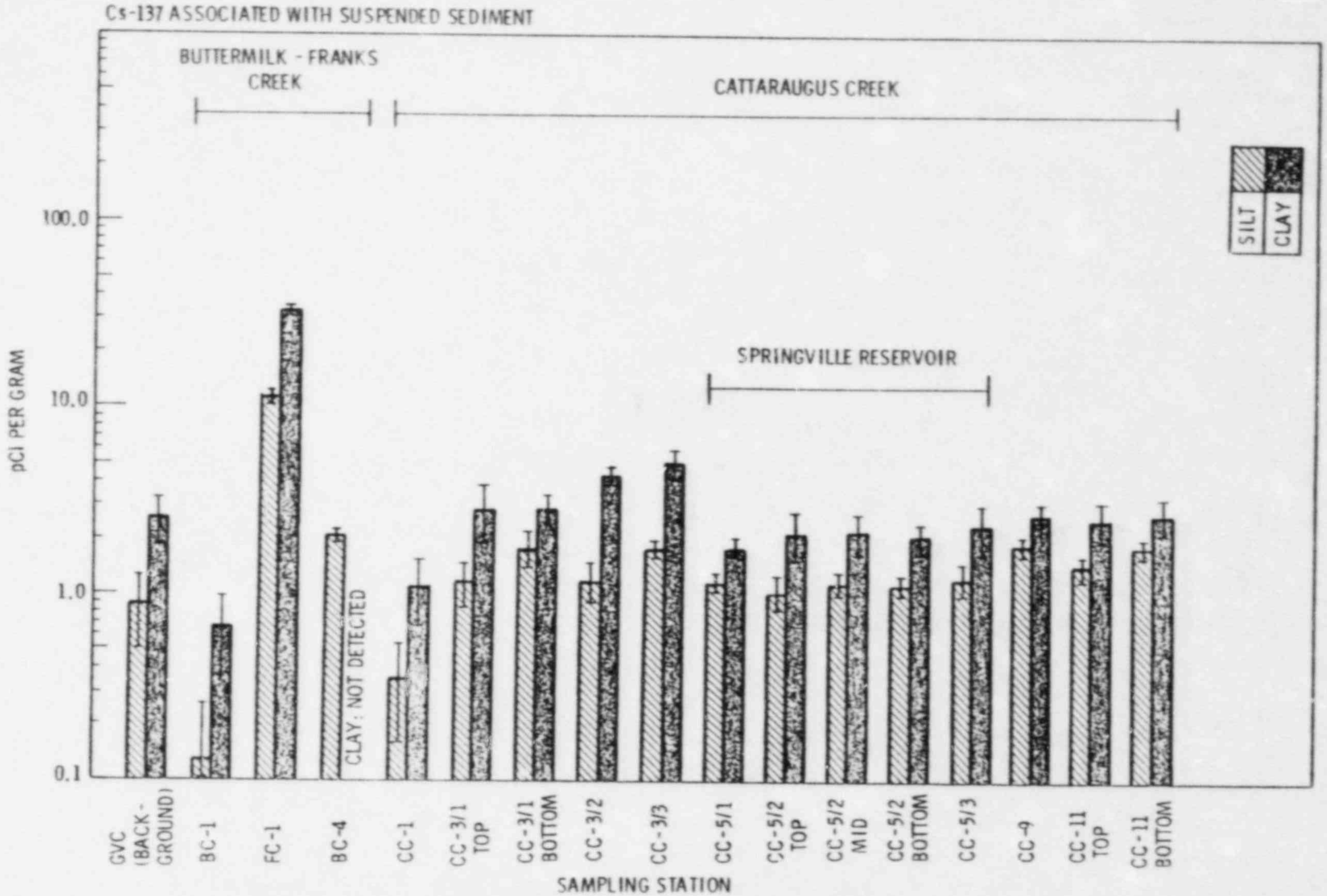

FIGURE 23. Phase 2 Cesium-137 Concentrations in Suspended Sediment

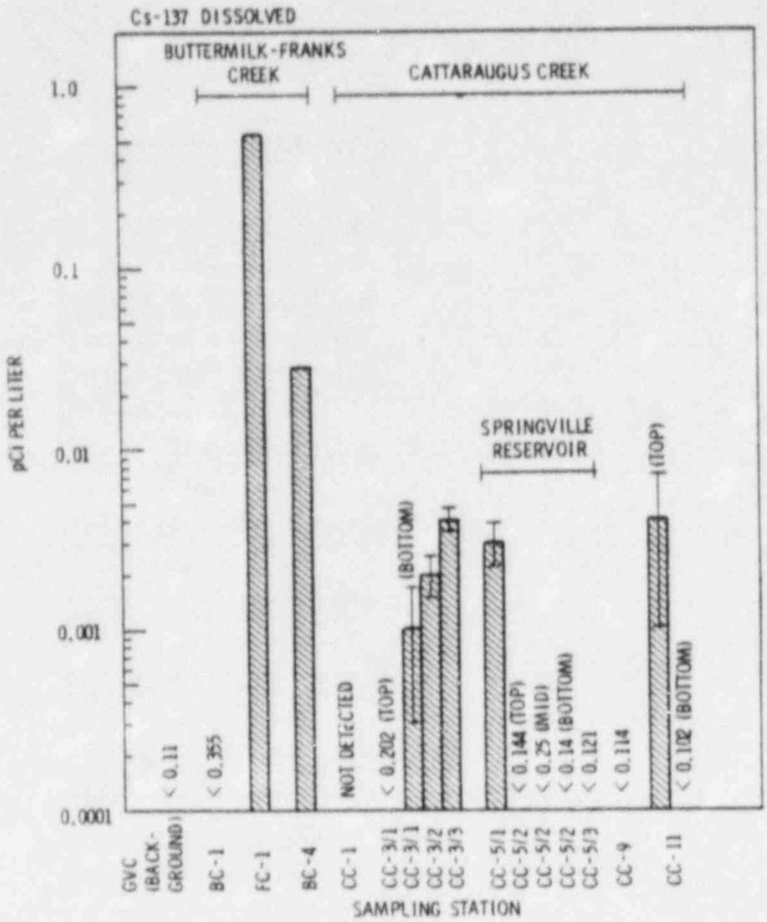

FIGURE 24. Phase 2 Cesium-137 Concentrations in Water

Phase 3

Bed Sediment (Figure 25)

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.

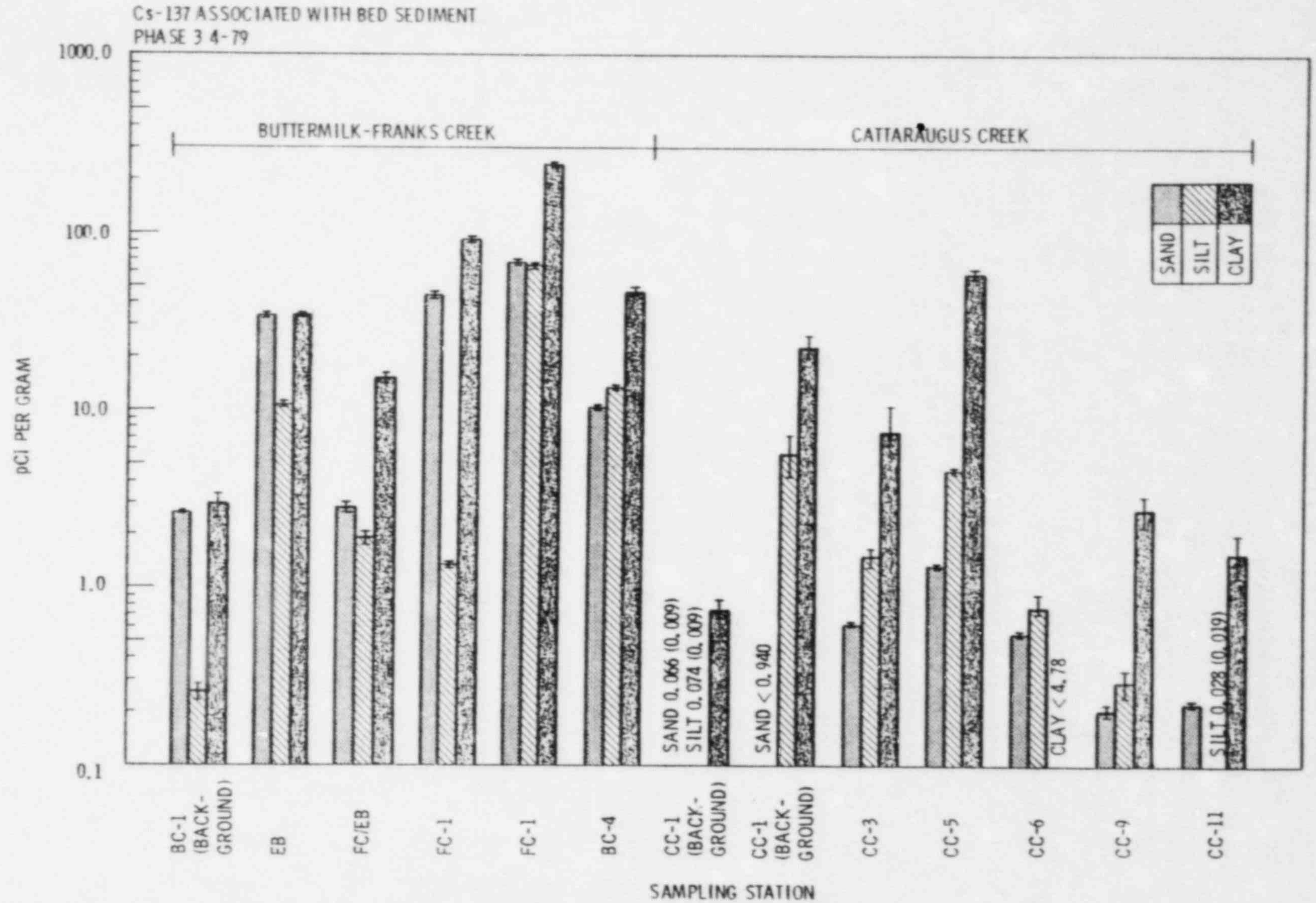

FIGURE 25. Phase 3 Cesium-137 Concentrations in Bed Sediment

Suspended Sediment (Figure 26)

Cesium-137 concentrations in the suspended sediment of Cattaraugus, Buttermilk and Franks Creeks 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 Cattaraugus 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.

Dissolved (Figure 27)

Cesium-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 reek (FC-1) where concentrations varied from 0.11 $\pm$ 0.0072 pCi/l to 0.64 $\pm$ 0.64 pCi/l. One water sample in Springville Reservoir on April 26 had a relatively high Cs-137 concentration of 4.50 pCi/l.

PLUTONIUM-238 (Pu-238)

Phase 1

Bed Sediment

Very few bed sediment samples had detectable levels of Pu-238. The highest Pu-238 value was found in the bed silt fraction of Bc-1 (0.0613 $\pm$ 0.0161 pCi/g). The bed sand fraction of FC-1, bed clay fraction of BC-1 and mixed bed sample of BC-4 had similar Pu-238 levels.

Suspended Sediment

The only suspended sediment samples that had detectable levels of Pu-238 were found in Franks Creek and Buttermilk Creek. The highest Pu-238 value was found associated with the suspended silt fraction of BC3-1 (0.236 $\pm$ 0.16 pCi/g). At FC-1 the suspended silt and clay fractions had Pu-238 levels of 0.0074 $\pm$ 0.0008 pCi/g and 0.0344 $\pm$ 0.0028 pCi/g, respectively. Detectable levels of Pu-238 were also found in the suspended sand fraction of BC-2, station 1 and the suspended silt fraction of BC-1.

Dissolved

Only two water samples were analyzed for Pu-238 (FC-1 and BC-4). The level of Pu-238 at these stations were 0.0134 $\pm$ 0.0026 pCi/l at FC-1 and 0.0154 $\pm$ 0.003 pCi/l at BC-4 (Thomas Corners Bridge).

Phase 2

Bed Sediment (Figure 28)

Plutonium-238 was detected at all stations. The highest values are associated with clay where the maximum activity level of 0.057 $\pm$ 0.006 pCi/g was

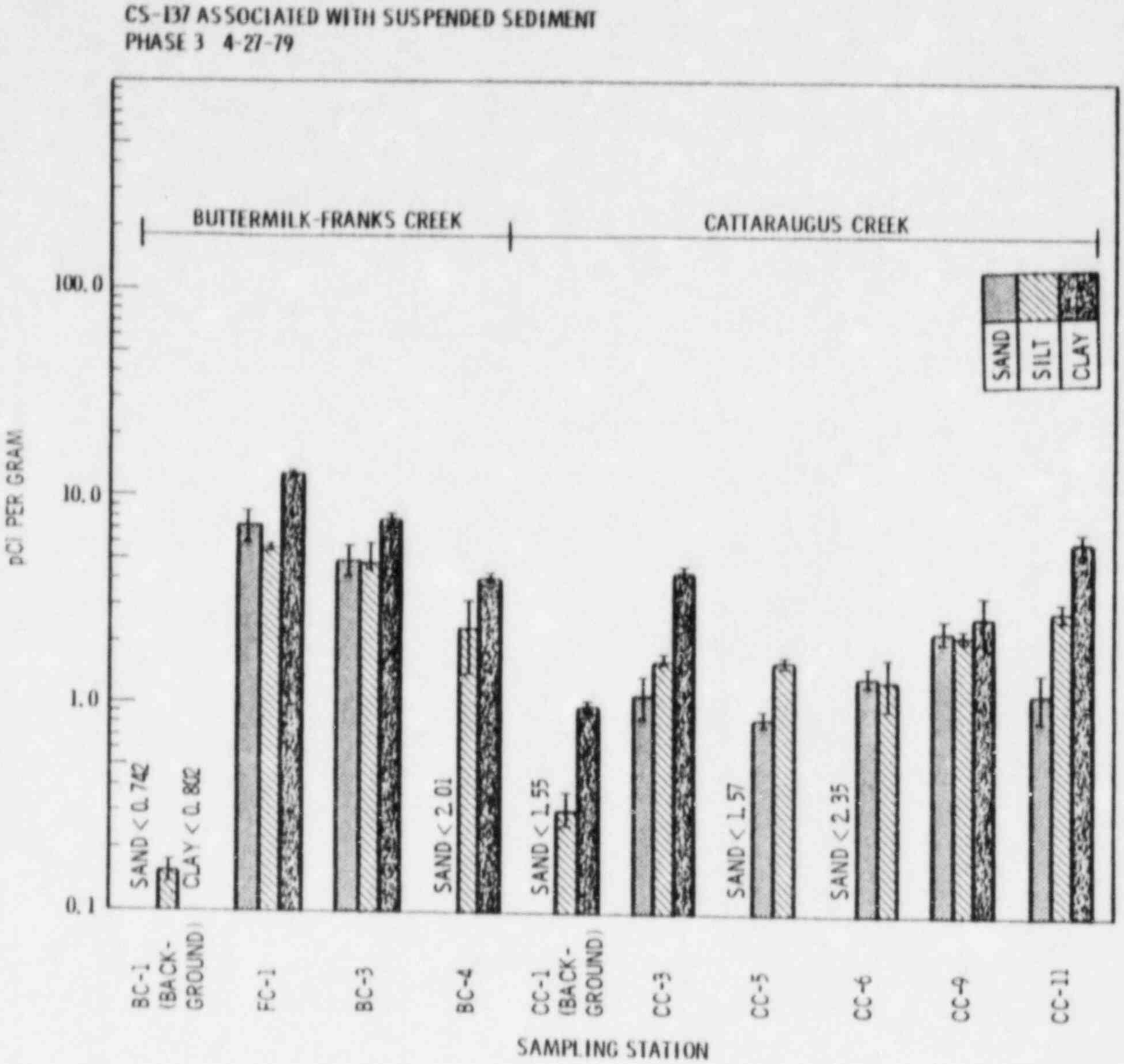

FIGURE 26. Phase 3 Cesium-137 Concentrations in Suspended Sediment

detected at EB. The activity levels for the Buttermilk-Franks Creek system were significantly higher than the Cattaraugus Creek station. The activity levels decrease in the downstream direction.

Suspended Sediment (Figure 29)

The trend for Pu-238 concentrations is one of a slight decrease in activity level in the downstream direction. Plutonium-238 was below detection at the background station GVC. The maximum value of 0.0096 ± 0.0029 pCi/gm was detected at the source station FC-1.

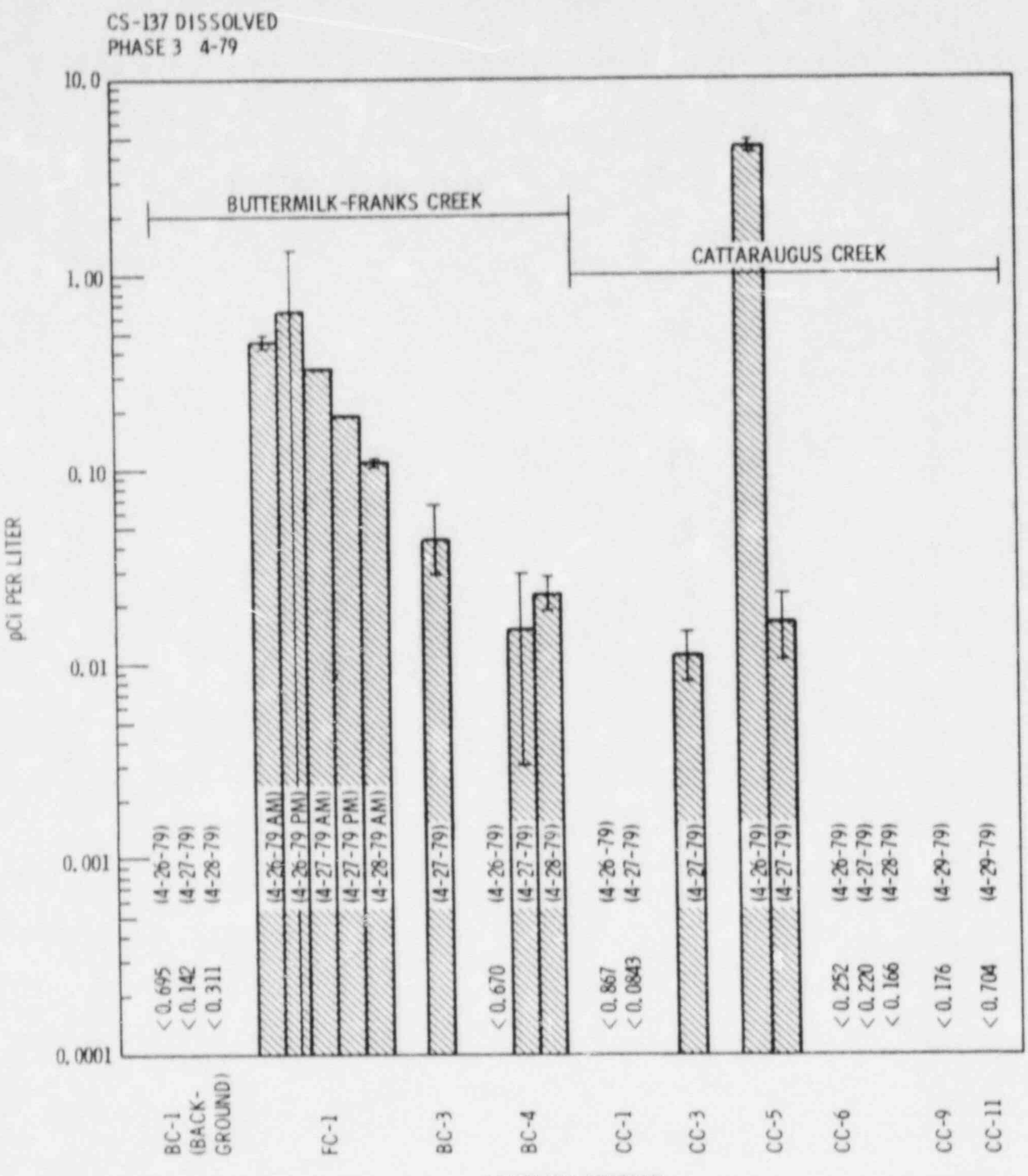

FIGURE 27. Phase 3 Cesium-137 Concentrations in Water

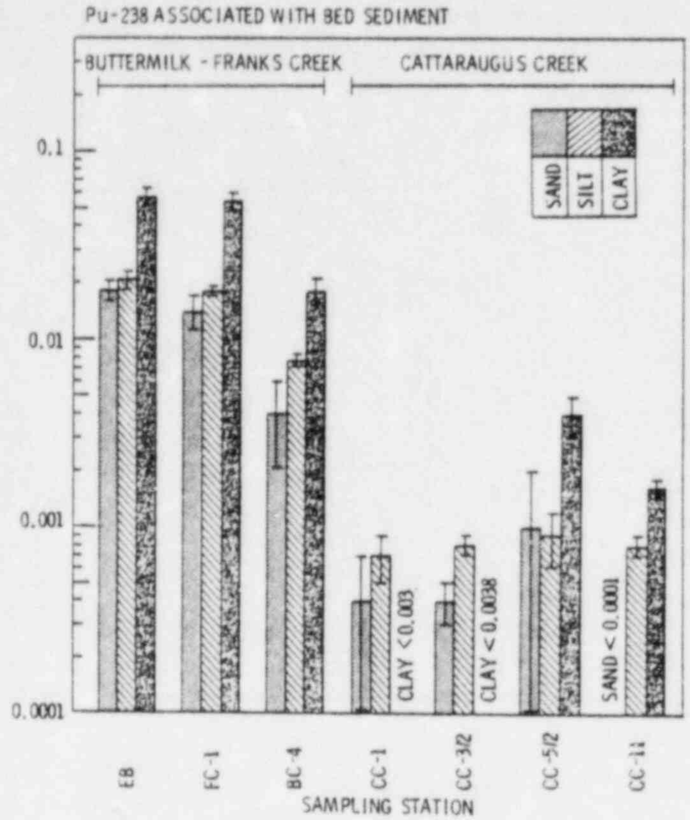

FIGURE 28. Phase 2 Plutonium-238 Concentrations in Bed Sediment

Dissolved (Figure 30)

Plutonium-238 was detected at stations FC-1, BC-4, and CC-1 and was below detection at the stations downstream of the Buttermilk Creek confluence. The maximum value of 0.0017 ± 0.058 was detected at the source station FC-1.

Phase 3

Bed Sediment (Figure 31)

The highest background level of Pu-238 was found at the background station CC-1 on Cattaraugus Creek. The maximum level at this station was 0.034 ± 0.020 pCi/gm for silt. The Pu-238 concentration of 0.71 ± 0.105 pCi/gm for the bed sediment sand sample was the only activity level above background.

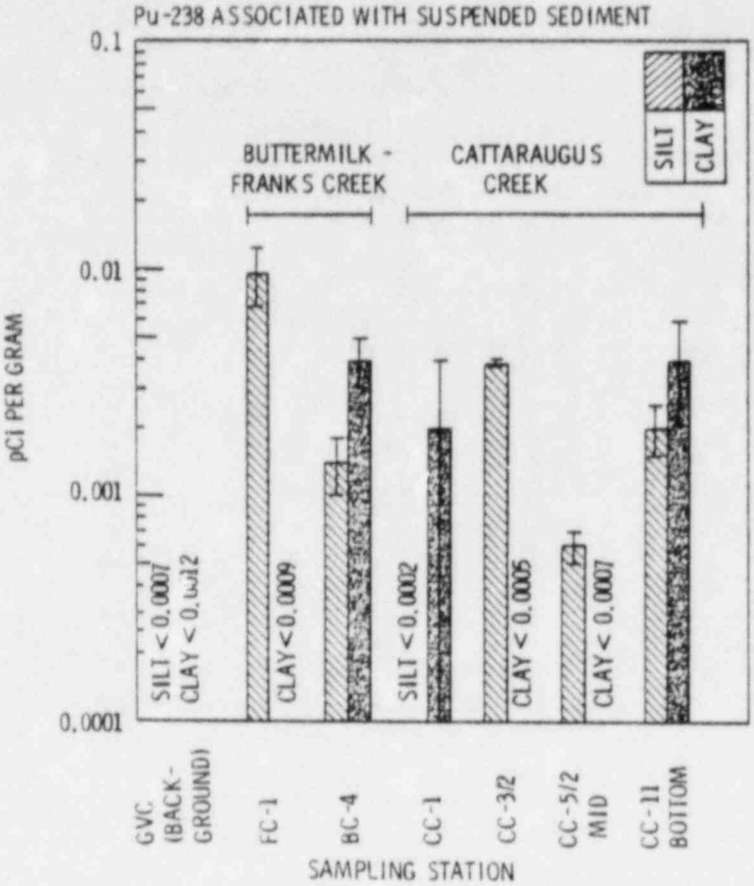

FIGURE 29. Phase 2 Plutonium-238 Concentrations in Suspended Sediment

Suspended Sediment (Figure 32)

The highest background level of Pu-238 was found at the background station CC-1. The maximum background value of 0.043 $\pm$ 0.029 pCi/gm was detected on sand at this station.

The station where activity levels of suspended sediment exceeded background were FC-1/1 (sand: 0.073 $\pm$ 0.063 pCi/g) on April 26, CC-6 (sand: 0.316 $\pm$ 0.137 pCi/g) on April 28, and CC-9 (clay: 0.085 $\pm$ 0.047 pCi/g) on April 29.

Dissolved (Figure 33)

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

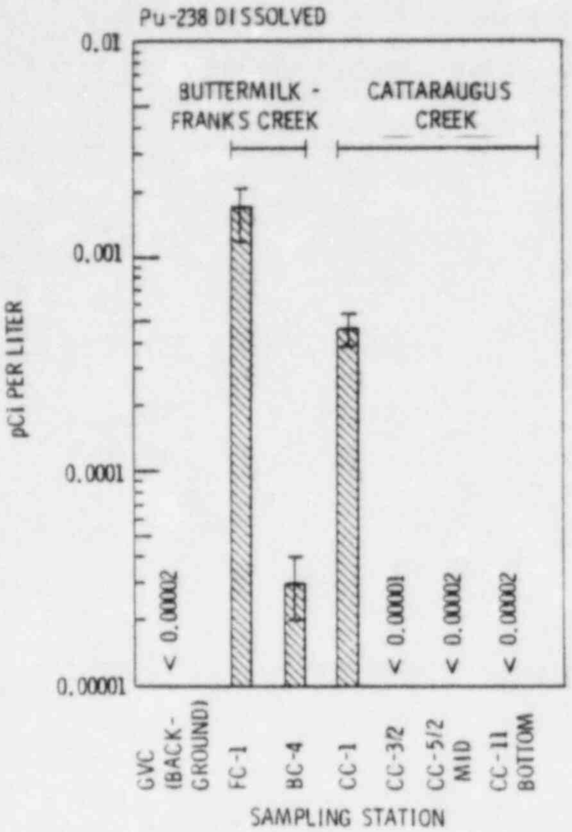

FIGURE 30. Phase 2 Plutonium-238 Concentrations in Water

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 background stations.

PLUTONIUM-239,240

Phase 1

Bed Sediment

The only bed sediment samples with detectable levels of Pu-238,240 were found at FC-1, BC-4, BC-1 and CC-3. The highest Pu-239,240 value of 0.0239 ± 0.0093 pCi/g was found in the bed silt fraction of BC-1, the upstream background station on Buttermilk Creek.

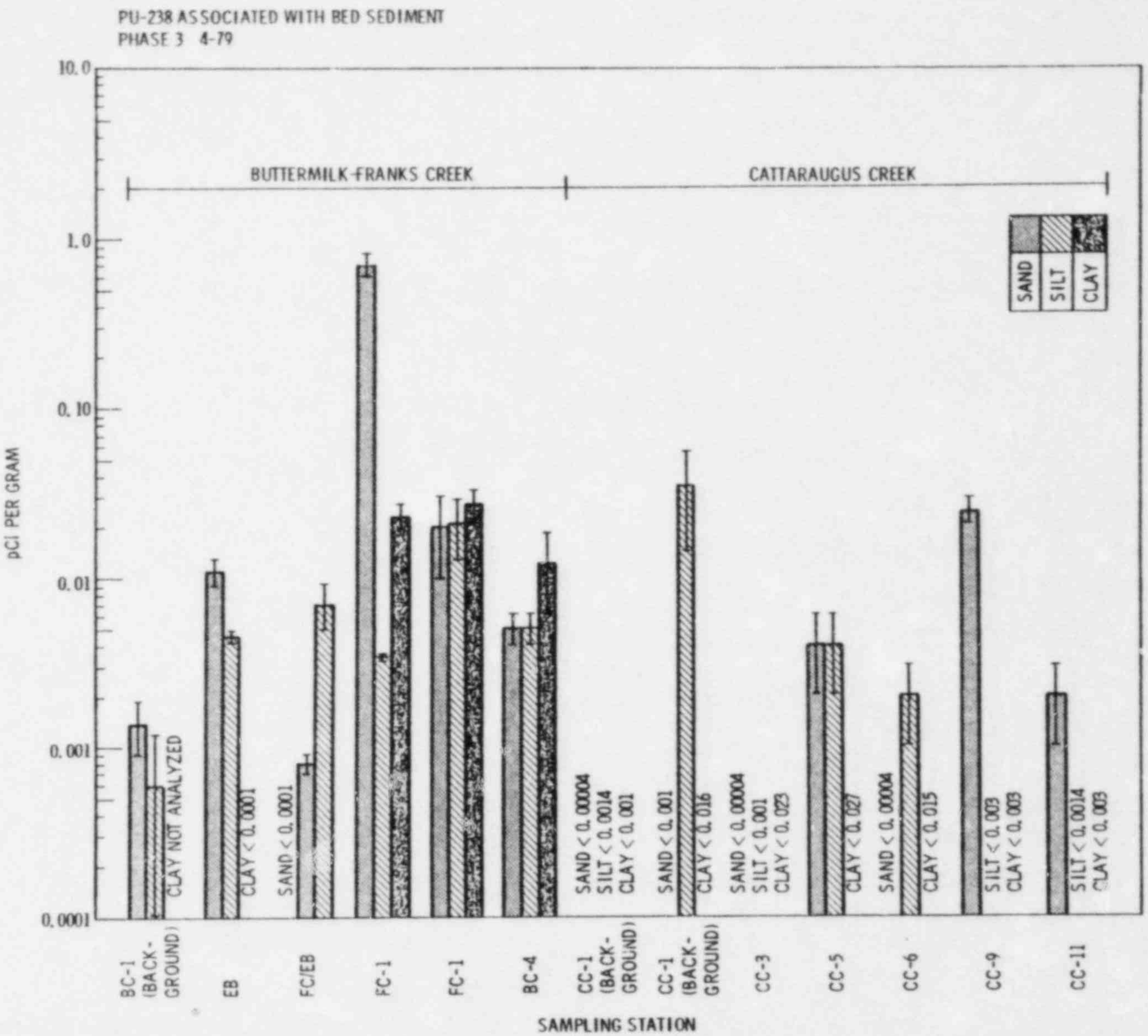

FIGURE 31. Phase 3 Plutonium-238 Concentrations in Bed Sediment

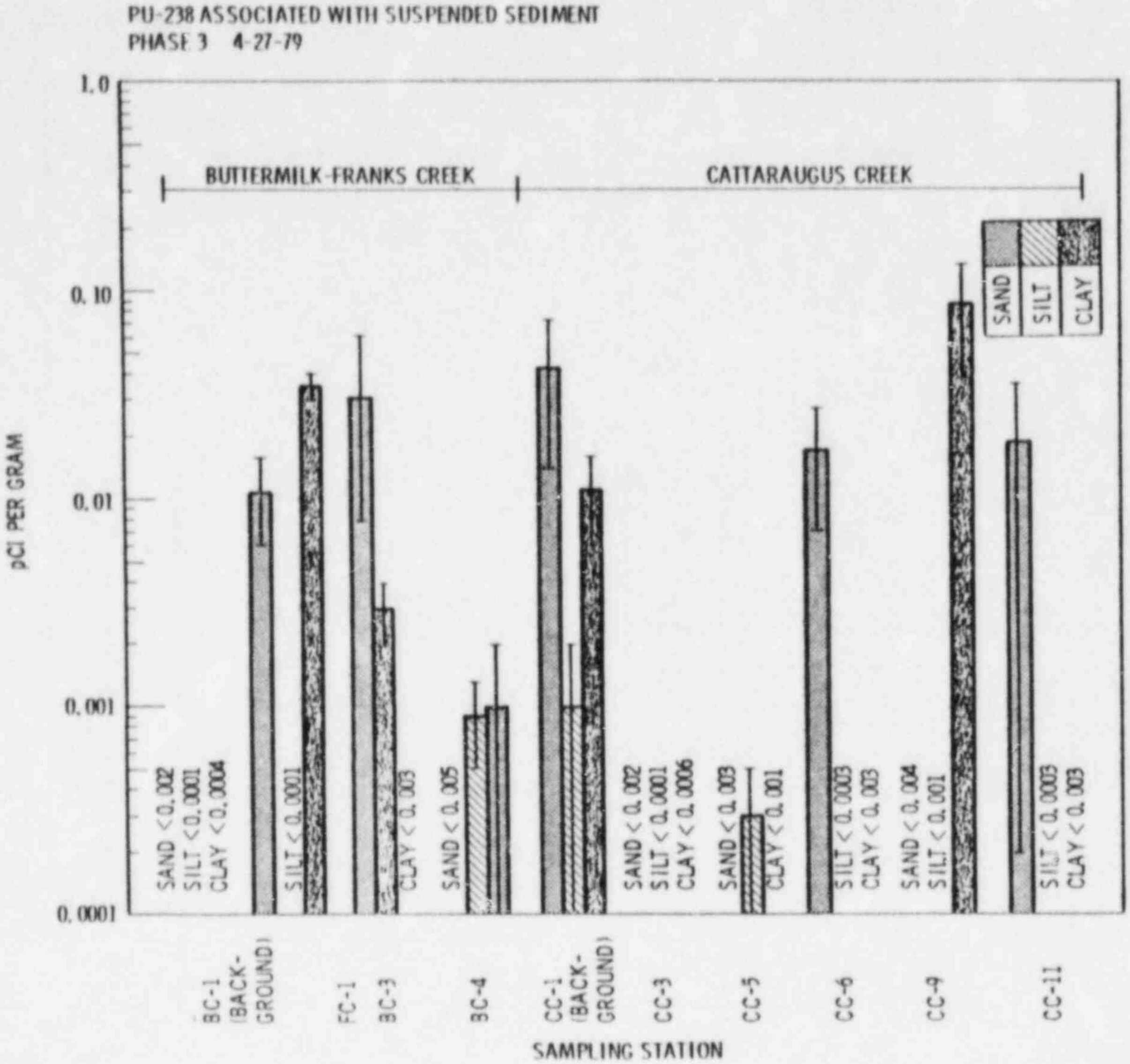

FIGURE 32. Phase 3 Plutonium-238 Concentrations in Suspended Sediment

Suspended Sediment

Detectable levels of Pu-239,240 in suspended sediment were found only at FC-1, BC-1 and near the surface of CC-3, station 1. The highest Pu-239,240 value of 0.0988 $\pm$ 0.049 pCi/g was found in the suspended sand fraction of CC-3, station 1. The suspended silt and clay fractions of FC-1 had Pu-239,240 levels of 0.0013 $\pm$ 0.0004 pCi/g and 0.0139 0.0017 pCi/g, respectively.

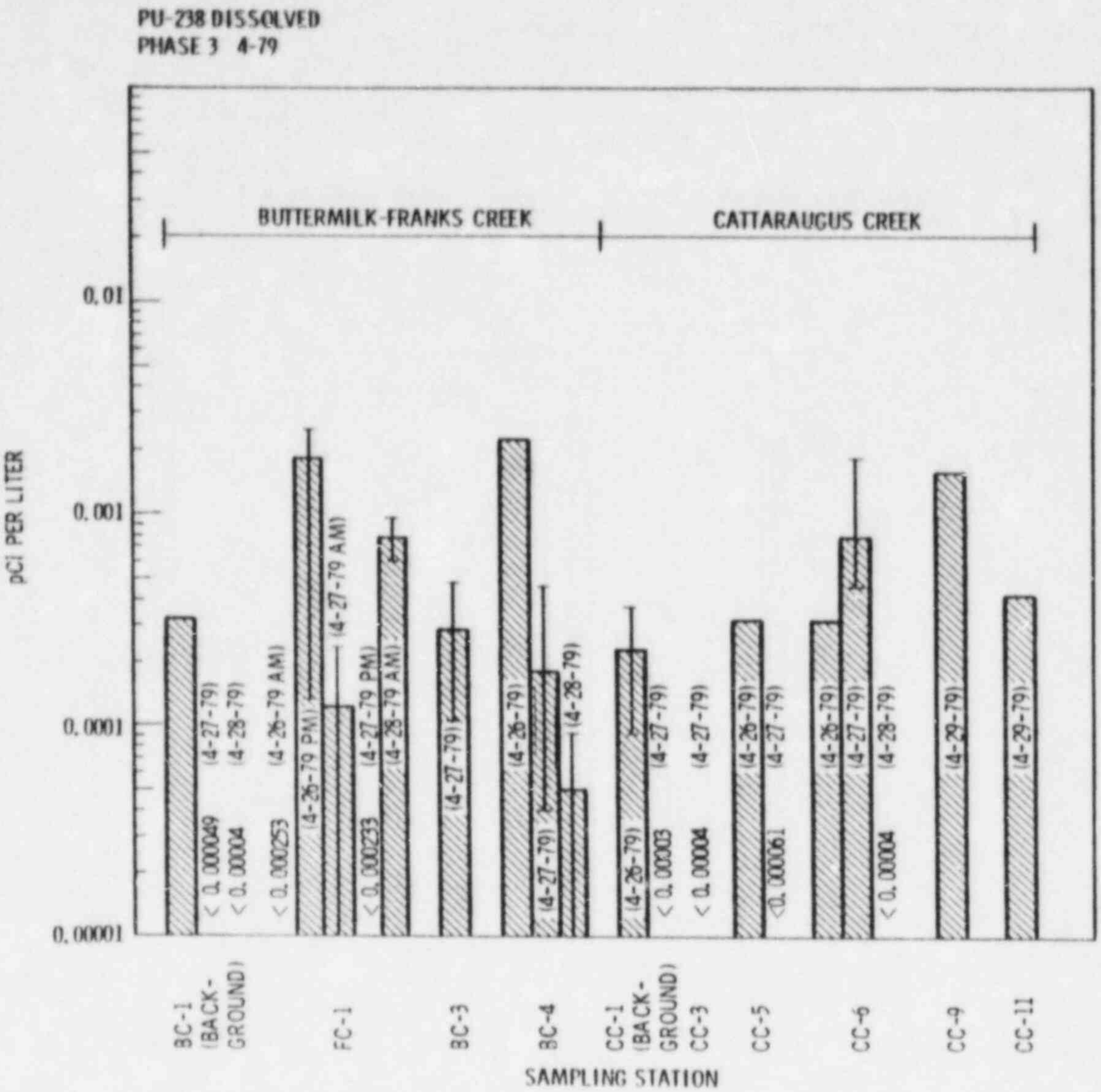

FIGURE 33. Phase 3 Plutonium-238 Concentrations in Water

Dissolved

Only two water samples were analyzed for Pu-239,240 (FC-1 and BC-4). The levels of Pu-239,240 at FC-1 and BC-4 were 0.002 ± 0.001 Ci/l and 0.0038 ± 0.0015 pCi/l, respectively.

Phase 2

Bed Sediment (Figure 34)

The trends for Pu-239,240 are very similar to those for Pu-238. It was detected at all stations and the highest values are associated with clay at Station FC-1 (0.05 $\pm$ 0.006). The highest activity levels are found for stations of the Buttermilk-Franks Creek system.

Suspended Sediment (Figure 35)

The higher activity levels of Pu-239,240 were consistently found in the upstream stations FC-1 and BC-4 and the background station GVC. The maximum value of 0.027 $\pm$ 0.007 pCi/gm at FC-1 was associated with clay. Activity levels were detected on silt only downstream of the Buttermilk Creek confluence.

Dissolved (Figure 36)

The maximum value of Pu-239,240 detected in water samples was 0.00058 pCi/l at the background station CC-1. The activity level at the source station, FC-1, was 0.0056 $\pm$ 0.00009 pCi/l.

Phase 3

Bed Sediment (Figure 37)

The overall trend near the NFS facility for Pu-239,240 was one of the higher activity levels at the source station, FC-1, and relatively high levels at the nearby sampling stations. The maximum value of 0.785 $\pm$ 0.113 pCi/gm was associated with sand at station FC-1. Plutonium-239,240 was detected on all three classes of sediment (sand, silt and clay) at the stations in the immediate vicinity of the NFS facilities (EB, FC/EB, and FC-1). At all stations on Cattaraugus Creek below the Buttermilk Creek confluence Pu-239,240 was found primarily with sand. The overall trend is a decrease in activity level in the downstream direction.

Suspended Sediment (Figure 38)

Although the detectable activity levels do not necessarily decrease in the downstream direction, fewer samples are yielding detectable levels. The higher value of activity levels are associated with the clay samples at FC-1, CC-1 (background), and CC-9. The maximum value of 0.048 $\pm$ 0.008 pCi/l was found at CC-1.

Dissolved (Figure 39)

Plutonium-239,240 was detected in four out of five samples at FC-1. The maximum activity level of 0.0008 pCi/l was detected at FC-1. Most of the

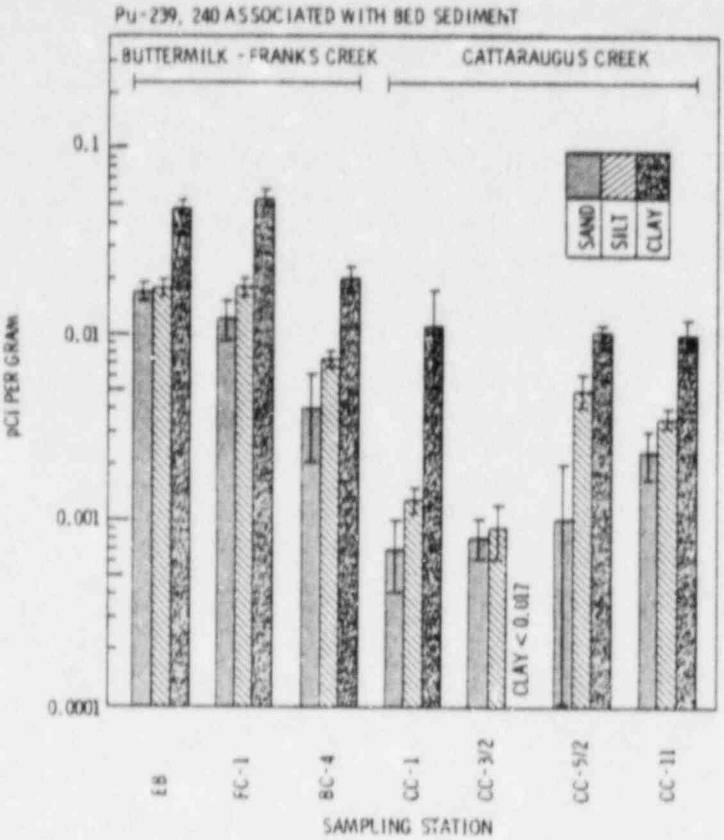

FIGURE 34. Phase 2 Plutonium-239,240 Concentrations in Bed Sediment

samples at other stations were below detection. However, detectable levels were found at both background stations BC-1 and CC-1.

LAKE ERIE

Phase 2

Lake Erie Bed Sediment

The Lake Erie samples were taken less than a mile outshore from the mouth of Cattaraugus Creek in an area where flood deposits of sediment from the creek would likely accumulate. The core samples were separated into two-inch sections for analysis. Gamma counting was performed on all three two-inch sections at each station (Table 7). Only the top two-inch sections were analyzed radiochemically because of the cost per sample (Table 8). All samples were analyzed as composites without separation into sand, silt, and clay.

The same gamma-emitting radionuclides that were prevalent in the Cattaraugus-Buttermilk Creek samples were found in Lake Erie sediment. There

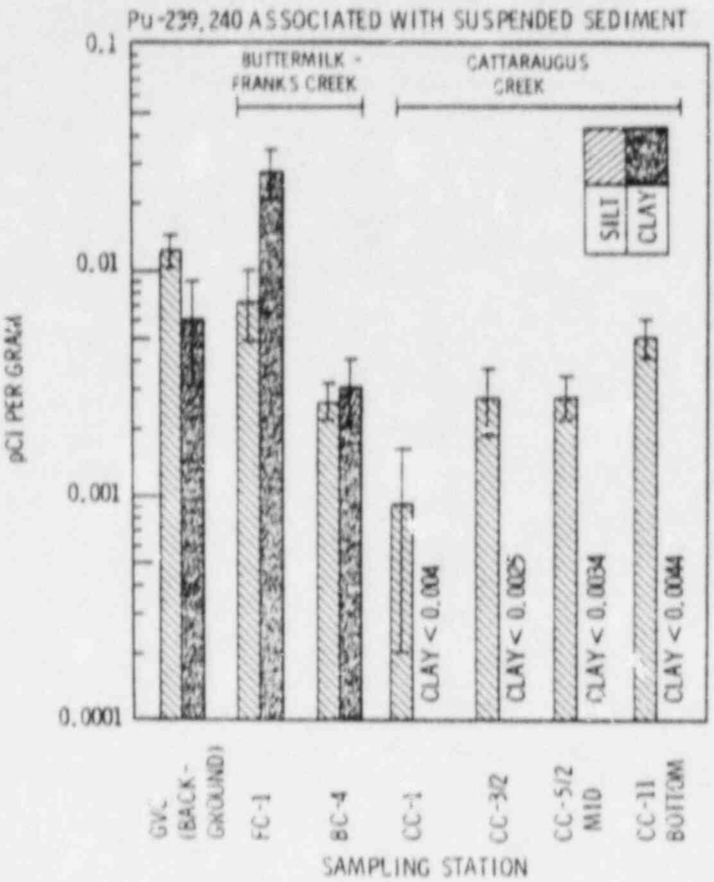

FIGURE 35. Phase 2 Plutonium-239,240 Concentrations in Suspended Sediment

was no trend indicated as to which section of the core samples had higher activity levels. However, sampling point four consistenty had lower overall activity levels than the other three sampling points.

The results of samples analyzed radiochemically indicated that Sr-90, Pu-238, and Pu-239,240 were all detected in the Lake Erie sediment. Sampling points 1 and 2 had the most consistent detectable levels of the five radionuclides. Plutonium-239,240 was detected at all four sampling points.

Phase 3

Lake Erie Core Samples

Results of gamma ray spectrometry analysis and alpha/beta analysis of Lake Erie core samples are shown in Tables 9 and 10. Detectable levels of

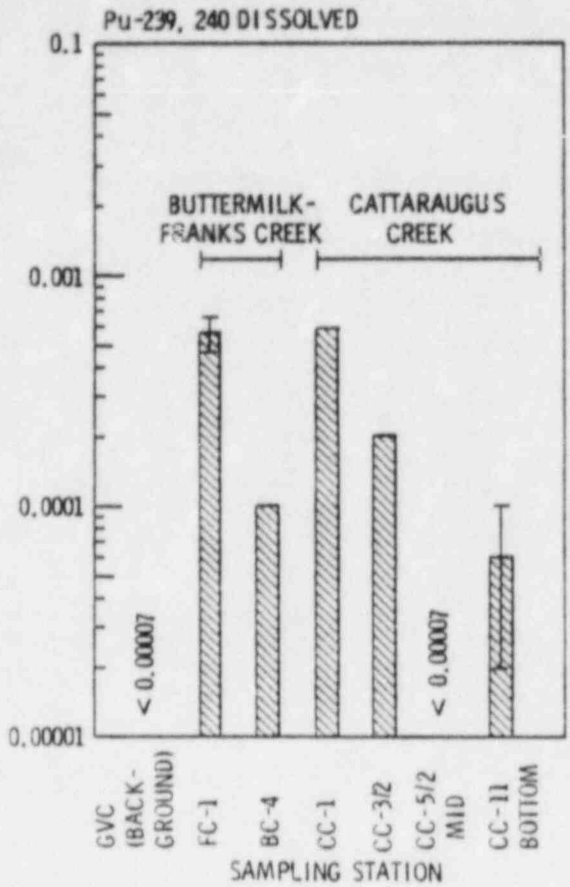

FIGURE 36. Phase 2 Plutonium-239,240 Concentrations in Water

Cs-137, Sr-90, Pu-238, and Pu-239,240 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.

FLOOD PLAIN SAMPLES

A series of nine surface sediment samples were collected during the supplementary data collection trip during May 1980. A set of seven samples was obtained from the flood plain and channel bar areas of Buttermilk Creek and two samples from the confluence area of Buttermilk and Cattaraugus Creeks (Figures 40 and 41). The samples were collected from the top two inches of the nine sampling stations. The radiological analysis results are shown in Tables B.1 and B.2 in Appendix B.

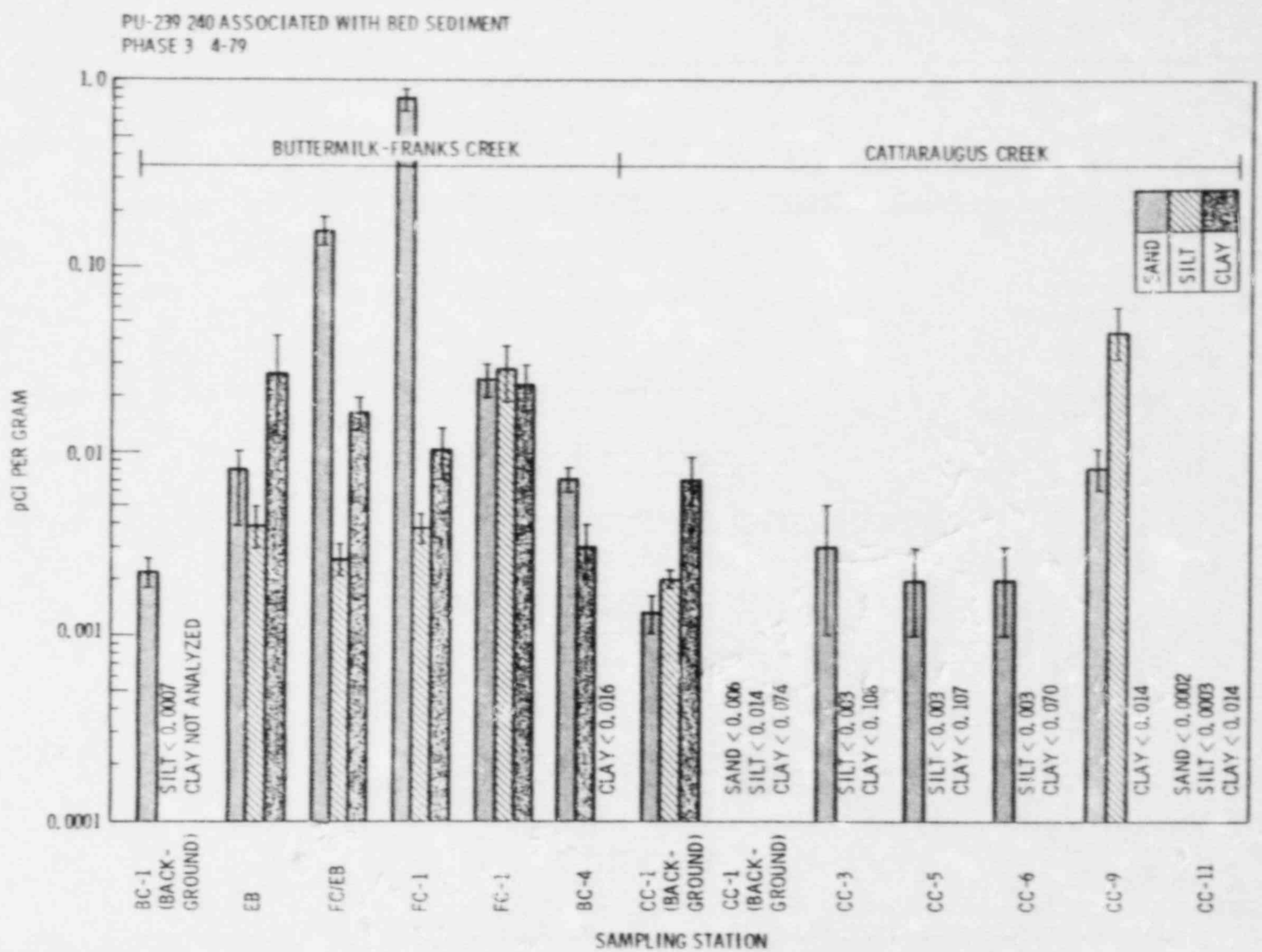

FIGURE 37. Phase 3 Plutonium-239,240 Concentrations in Bed Sediment

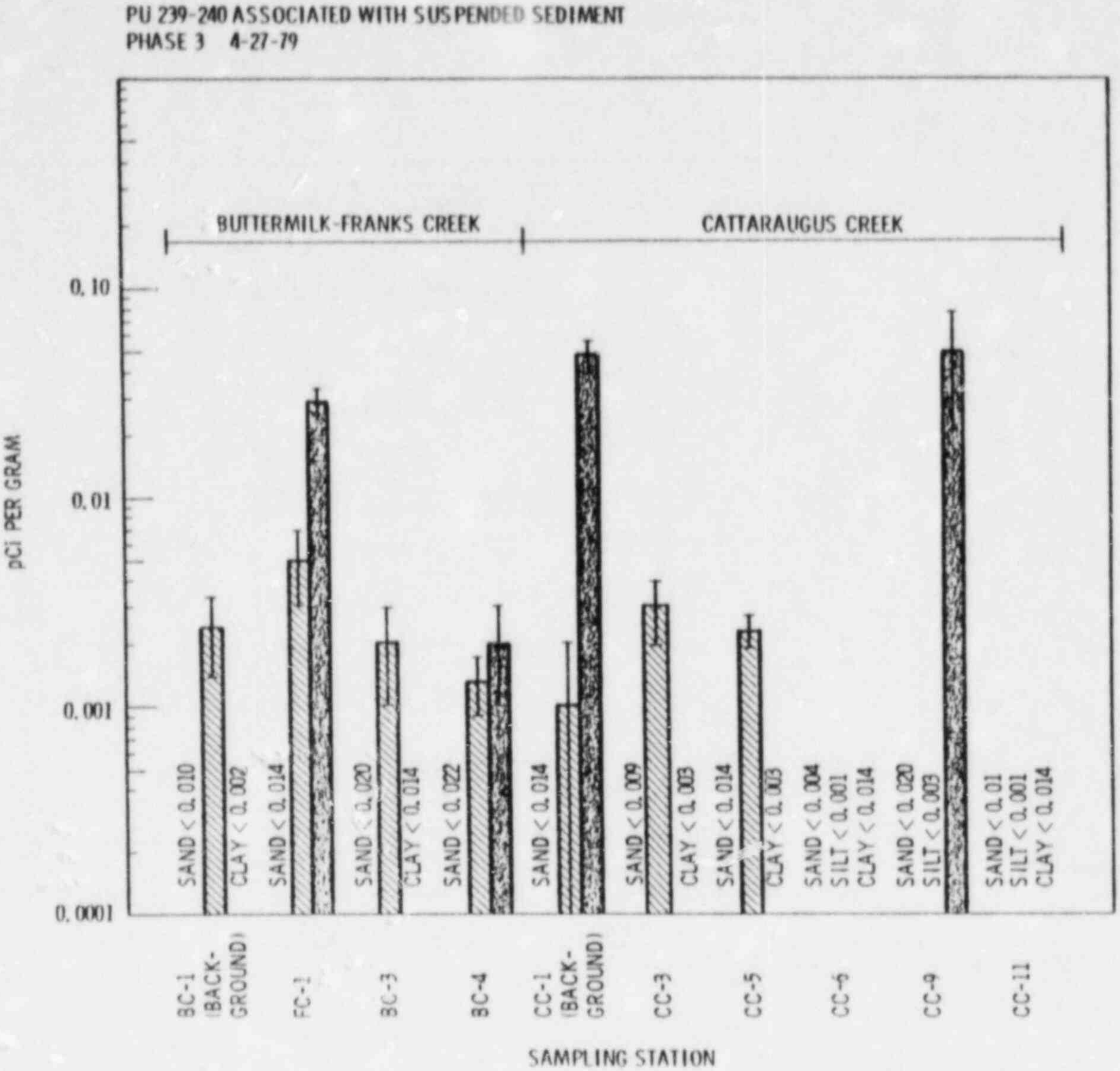

FIGURE 38. Phase 3 Plutonium-239,240 Concentrations in Suspended Sediment

Cesium-137 was found at all stations with the higher values associated with clay. The maximum value of 97.34 ± 0.94 pCi/gm (clay) was detected at station 1 which is a channel bar deposit in Buttermilk Creek. Cesium-134 was found only at station 4 where an activity level of 13.2 ± 0.2 pCi/gm was recorded for sand.

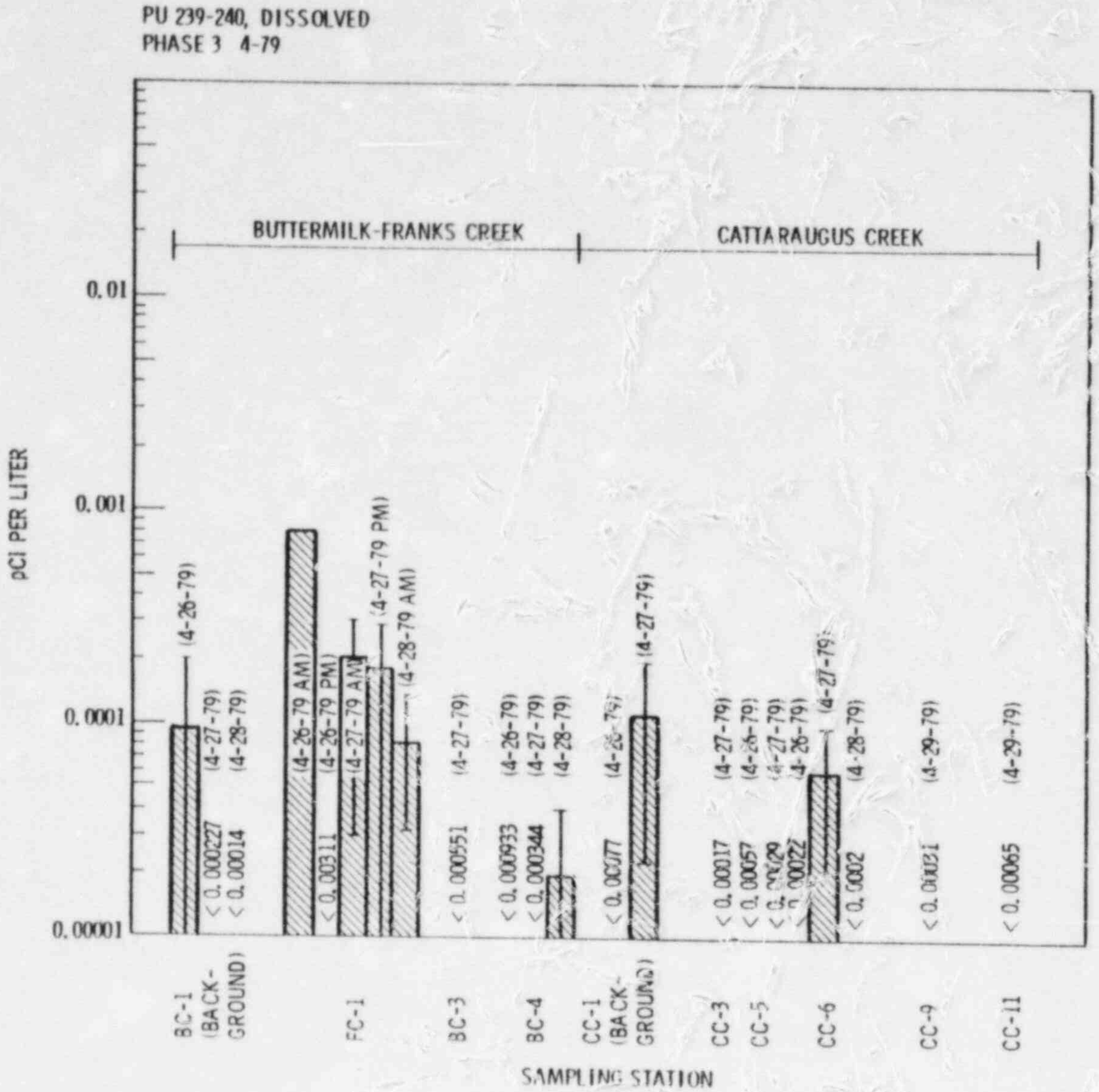

FIGURE 39. Phase 3 Plutonium-239,240 Concentrations in Water

Strontium-90 was detected at all stations except station 8. The maximum value of 12.29 $\pm$ 4.68 pCi/gm (clay) was detected at station 2 which is the same channel bar deposit where the maximum level of Cs-137 was detected.

Plutonium-238 was detected at five stations and plutonium-239,240 at two stations. The maximum levels for Pu-238 and Pu-239,240 were 0.058 $\pm$ 0.033 pCi/gm (station 3) and 1.75 $\pm$ 1.60 pCi/gm (station 4), respectively.

TABLE 7. Concentrations of Radionuclides in Lake Erie Bed Sediment at the Mouth of Cattaraugus Creek. Results of gamma-ray measurements. Values in parentheses are two standard deviations of the propagated counting error.

STATION: Lake Erie

	Sample Weight, Analysis (g)	Radionuclide Concentration (pCi/g) 40K	137Cs	114Ce	155Eu	226Ra	228Th	232Th	235U	238U	Others
Sampling Point 1											
Top 2 inches	25.0	14.7 (3.3)	1.02 (0.19)			1.09 (0.15)	1.24 (0.19)	1.16 (0.39)	0.20 (0.08)		
2nd 2 inches	67.5	14.6 (2.2)	0.74 (0.10)			1.07 (0.09)	1.19 (0.12)	1.10 (0.23)	0.20 (0.06)	1.73 (0.70)	4.0(3.4) Pb-210
3rd 2 inches	67.5	11.4 (1.3)	0.33 (0.05)			0.60 (0.05)	0.65 (0.06)	0.55 (0.17)	0.09 (0.03)	0.96 (0.37)	0.19(0.018) Rh-101
Sampling Point 2											
Top 2 inches	64.1	14.1 (2.2)	0.57 (0.09)	0.70 (0.37)	0.16(0.14)	0.94 (0.09)	1.11 (0.12)	0.86 (0.24)	0.18 (0.06)	1.84 (0.77)	
2nd 2 inches	67.5	12.3 (2.0)	0.57 (0.09)	0.54 (0.38)		0.88 (0.08)	1.02 (0.10)	0.92 (0.22)	0.11 (0.04)	1.03 (0.49)	
3rd 2 inches	50.0	,4.6 (2.6)	0.69 (0.11)			0.96 (0.10)	1.17 (0.13)	1.08 (0.29)	0.11 (0.06)	1.84 (0.82)	0.58(0.48) Nb-95, 0.05(0.033) Rh-101
Sampling Point 3											
Top 2 inches	50.0	14.2 (2.6)	0.72 (0.12)		0.19(0.16)	1.10 (0.10)	1.26 (0.13)	1.40 (0.27)	0.20 (0.06)	2.22 (0.82)	0.057(0.033) Rh-101
2nd 2 inches	67.5	16.9 (2.3)	0.67 (0.10		0.25 (0.14)	1.03 (0.09)	1.27 (0.12)	1.26 (0.24)	0.17 (0.06)	1.62 (0.74)	7.6(6.8) Ce-141
3rd 2 inches	64.9	12.3 (2.1)	0.49 (0.09)	0.5990.36)	0.13 (0.10)	0.90 (0.08)	1.04 (0.11)	0.71 (0.22)	0.14 (0.05)	1.64 (0.54)	0.048(0.034) Bi-207
Sampling Point 4											
Top 2 inches	67.5	11.2 (2.1)	0.58 (0.09)			0.66 (0.08)	0.67 (0.10)	0.61 (0.21)	0.11 (0.05)	0.88 (0.68)	0.42(0.36) Nb-95
2nd 2 inches	67.5	11.9 (2.0)	0.55 (0.10)			0.56 (0.07)	0.65 (0.09)	0.43 (0.20)			
3rd 2 inches	67.5	13.1 (2.1)	0.61 (0.10)			0.60 (0.07)	0.63 (0.09)	0.56 (0.19)	0.05 (0.04)	0.88 (0.42)	0.079(0.034) Cs-134

Note: Blanks indicate level was below detection
( ) parentheses represent two standard deviations

TABLE 8. Concentration of Radionuclides in Lake Erie Bed Sediment at the Mouth of Cattaraugus Creek. Results of radiochemical analysis of alpha and beta emitting radionuclides. Values in parentheses are one standard deviation of the propagated counting error.

STATION: Lake Erie

Radionuclide Concentration (pCi/g)

Sampling Point	Sampling wt., Analysis (g)	Sr-90	Pu-238
1	25.0	0.220(0.130)	0.0018(0.0005)
2	64.1	0.573(0.047)	0.003(0.0013)
3	50.0	<0.00027	0.0004(0.0001)
4	67.5	(a)	<0.00004

Sampling Point	Pu-239,240	Am-241	Cm-244
1	0.0067(0.0016)	0.019(0.005)	0.039(0.008)
2	0.0047(0.0018)	0.011(0.003)	0.0062(0.0017)
3	0.005(0.0005)	<0.0019	0.017(0.004)
4	0.0033(0.0016)	<0.0014	<0.0001

(a) Sample lost during analysis

TABLE 9. 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.[illegible]34	<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.[illegible]97	<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 10. Results of Analysis of Phase 3 Lake Erie Core Smples 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	0.282 (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)

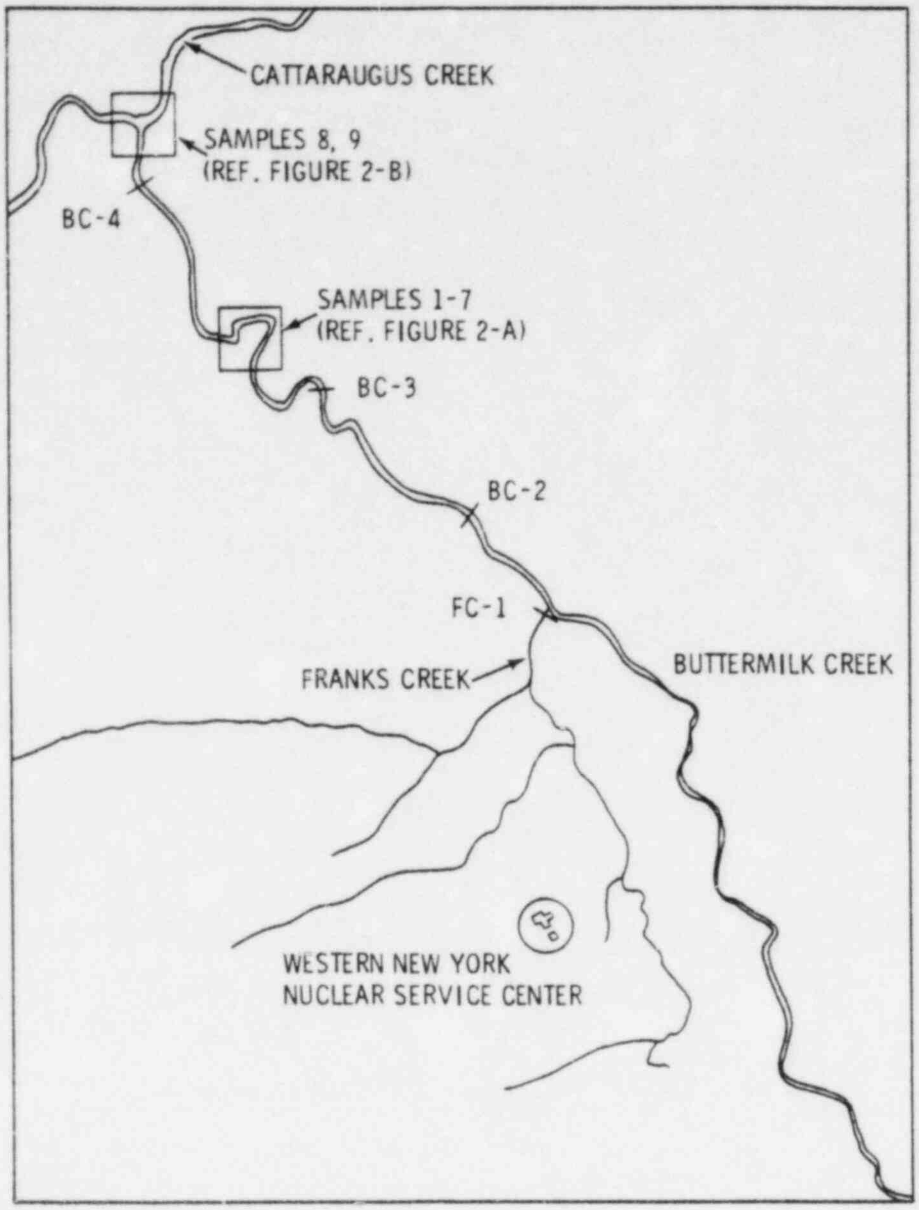

FIGURE 40. Flood Plain Sediment Sampling Locations for Buttermilk Creek

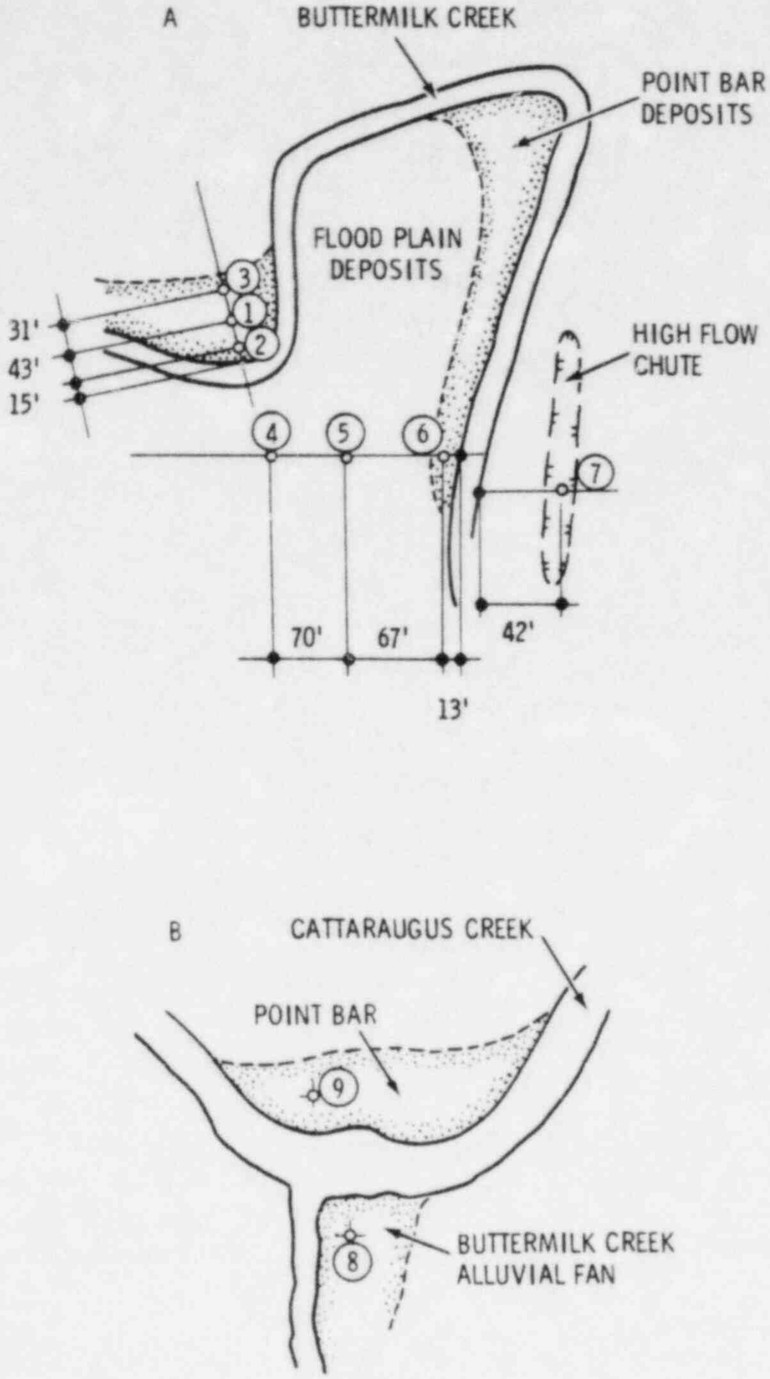

FIGURE 41. Sediment Sampling Location Details (see Figure 1 for location along Buttermilk Creek)

CONCLUSIONS

In many cases the radiological results indicated comparatively high activity levels at the background stations GVC, BC-1 and CC-1 relative to the other locations. All the background stations are located from the surface water drainage system of the NFS site but they are in close proximity of the facilities. This may be a result of fallout from the stacks at the NFS site that has accumulated on the surrounding watershed surface and is periodically washed into the creek system by overland flow due to rainfall and snowmelt runoff. By this process, higher background levels could be most anywhere upstream of the site and would depend to an extent on wind speed and direction. It seems probable that background activity levels near the NFS site are significantly higher than the more distant areas of the watershed.

The following conclusions are based on an evaluation of the radiological analysis results where the background stations are all in close proximity to the NFS site and could possiby be biased by fallout from the stacks:

1. The results of gamma-ray measurement for the bed sediment samples indicate that the NFS site is a possible source of Cesium-134 and Cesium-137.

2. The results of the radiochemical analyses on the bed sediment samples indicates that the NFS site is a possible source of Strontium-90, Plutonium-238, and Plutonium-239,240.

3. The same dominant radionuclides found in the bed sediment of Buttermilk and Cattaraugus Creeks are found to be dominant in Lake Erie sediments.

4. The same dominant radionuclides found in the bed sediment samples are also found associated with the suspended sediment. Those radionuclides analyzed by gamma-ray measurement showed generally lower levels for the suspended sediment as compared to the bed sediment. During Phase 2, the opposite was generally true for the alpha and beta-emitting radionuclides analyzed radiochemically where levels associated with suspended sediment are slightly higher than those for bed sediment.

5. For both suspended and bed sediment samples the clay fractions had the highest activity levels overall followed by silt and then sand.

6. Radionuclides were found more consistently in the bed sediment samples. Radionuclides were found much less frequently in the water than in either the bed sediment or suspended sediment samples.

7. The results of the gamma-ray measurement and radiochemical analysis of the water samples indicate tat the NFS site is a possible source of Cesium-137, Strontium-90, Plutonium-238, and tritium.

REFERENCES

Dana, R. H., Jr., and others. 1979. "General Investigation of Radionuclide Retention in Migration Pathways at the West Valley, New York Low-Level Burial Site." NUREG/CR-0794, NYSGS/79-2403.

Ecker, R. M., and Y. Onishi. 1979. "Sediment and Radionuclide Transport in Rivers, Phase 1 Field Sampling Program During Mean Flow, Cattaraugus and Buttermilk Creeks, New York." NUREG/CR-1030, PNL-3117.

Ecker, R. M., W. H. Walters and Y. Onishi. 1982. "Sediment and Radionuclide Transport in Rivers, Volume 3 - Phase 3, Field Sampling Program for Cattaraugus and Buttermilk Creeks, New York." NUREG/CR-1030, PNL-3117.

Onishi, Y. 1977. "Finite Element Models for Sediment and Contaminant Transport in Surface Water--Transport of Sediment and Radionuclides in the Clinch River." BNWL-2227. Submitted to the U.S. Nuclear Regulatory Commission, Washington, D.C.

Viessman, W., and others. 1977. Introduction to Hydrology. Harper and Row, New York.

Walters, W. H., R. M. Ecker and Y. Onishi. 1981. "Sediment and Radionuclide Transport in Rivers, Volume 2 - Phase 2, Field Sampling Program for Cattaraugus and Buttermilk Creeks, New York." NUREG/CR-1030, PNL-3117.

APPENDIX A

SAMPLING STATION CROSS-SECTION AND

SAMPLING POINTS FOR PHASES 1, 2, and 3

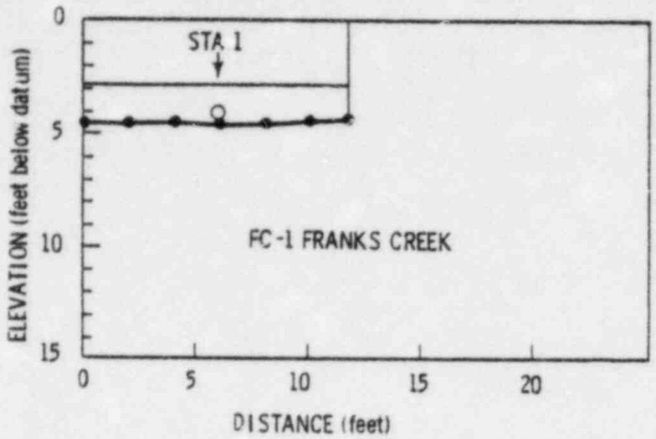

FIGURE A.1. Phase 1 Cross-Section of FC-1

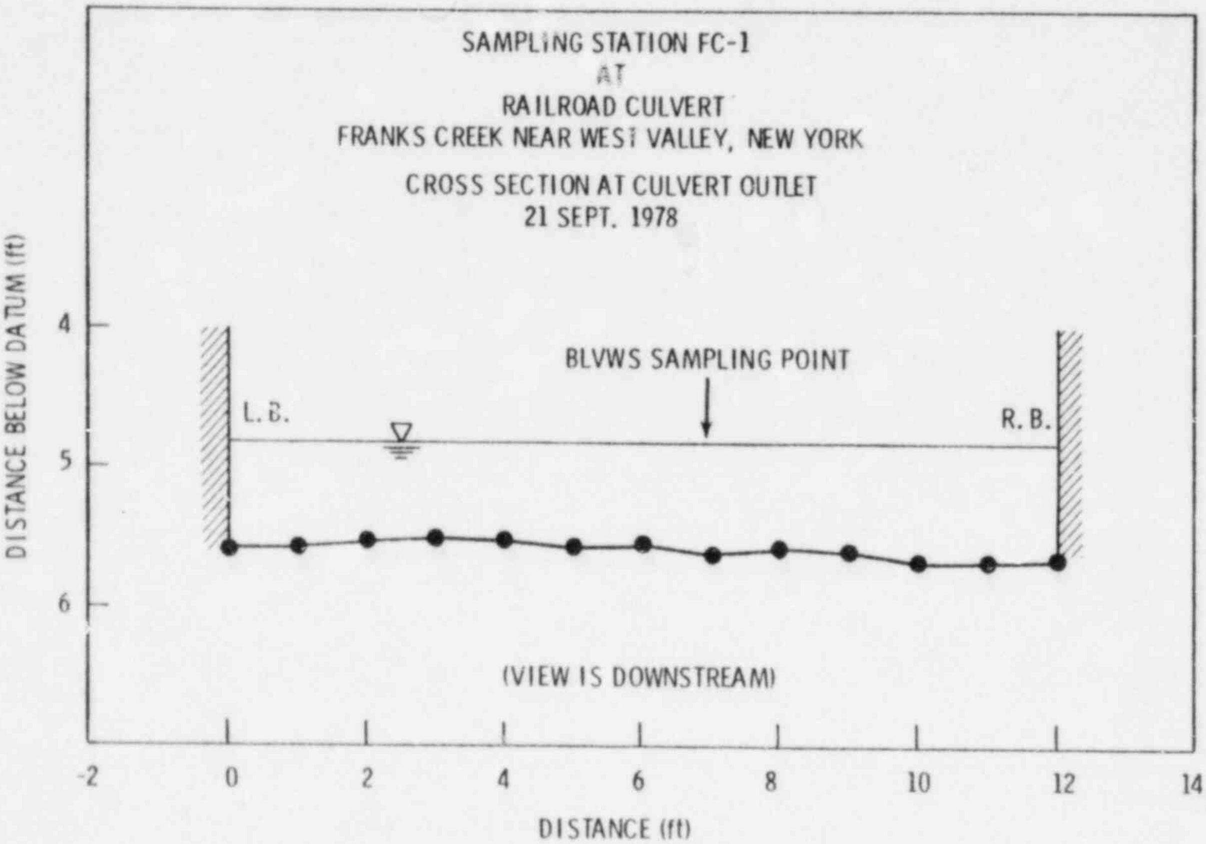

FIGURE A.2. Phase 2 Cross-Section at FC-1

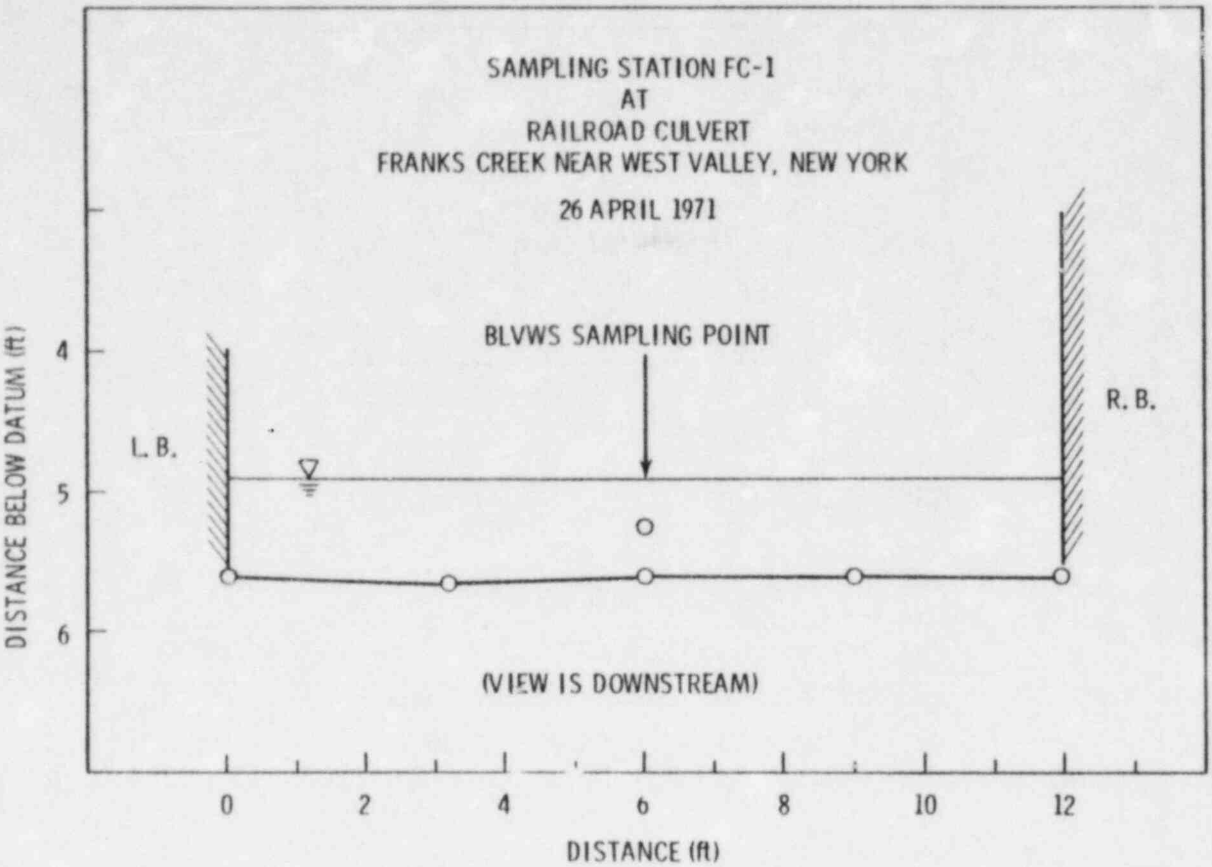

FIGURE A.3. Phase 3 Cross-Section at FC-1

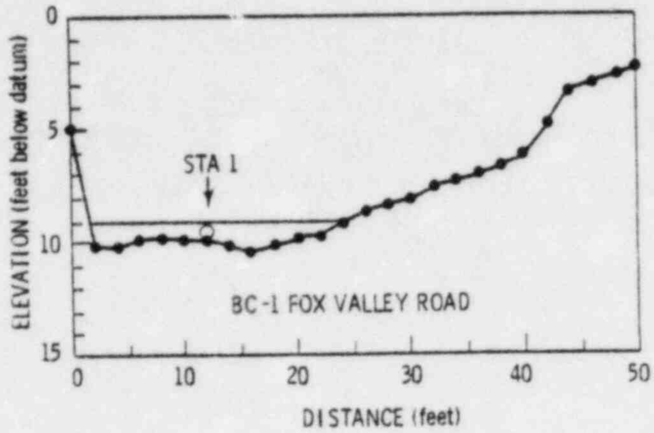

FIGURE A.4. Phase 1 Cross-Section at BC-1

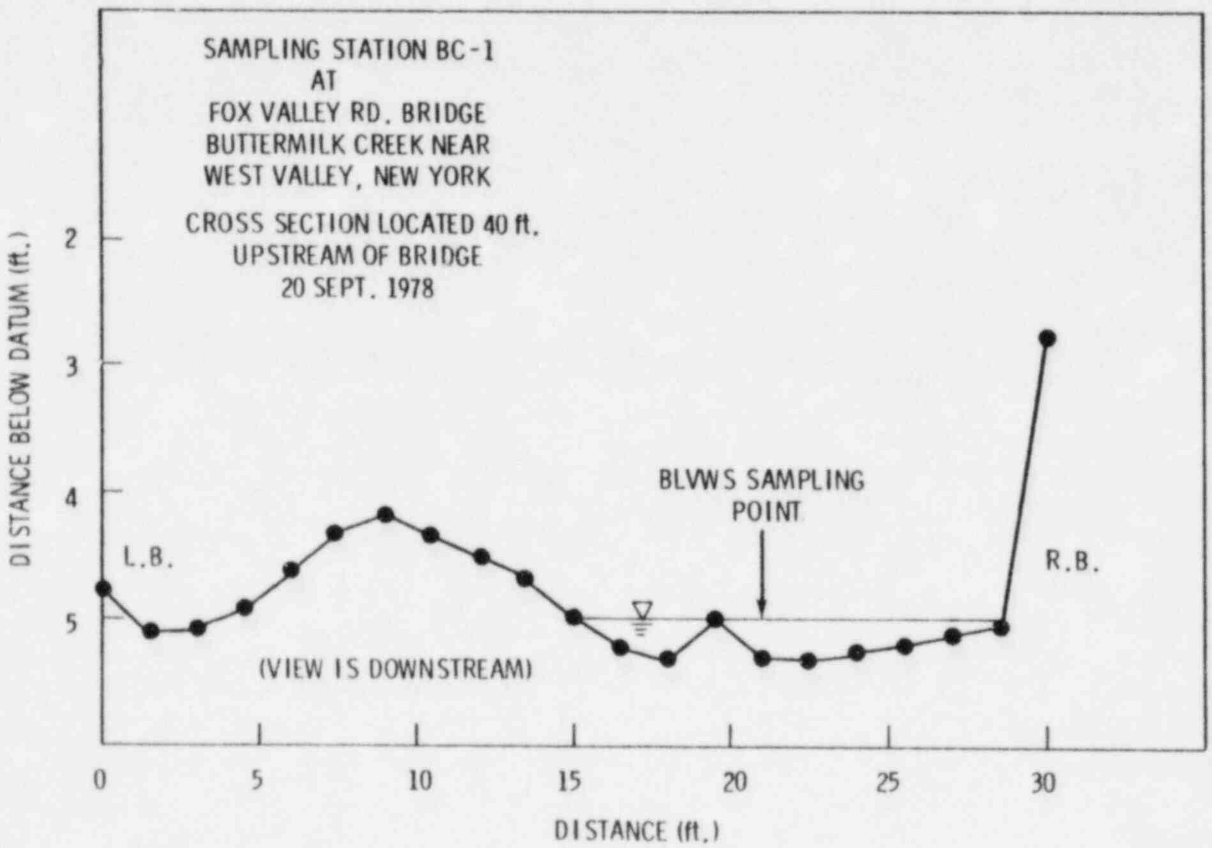

FIGURE A.5 Phase 2 Cross-Section at BC-1

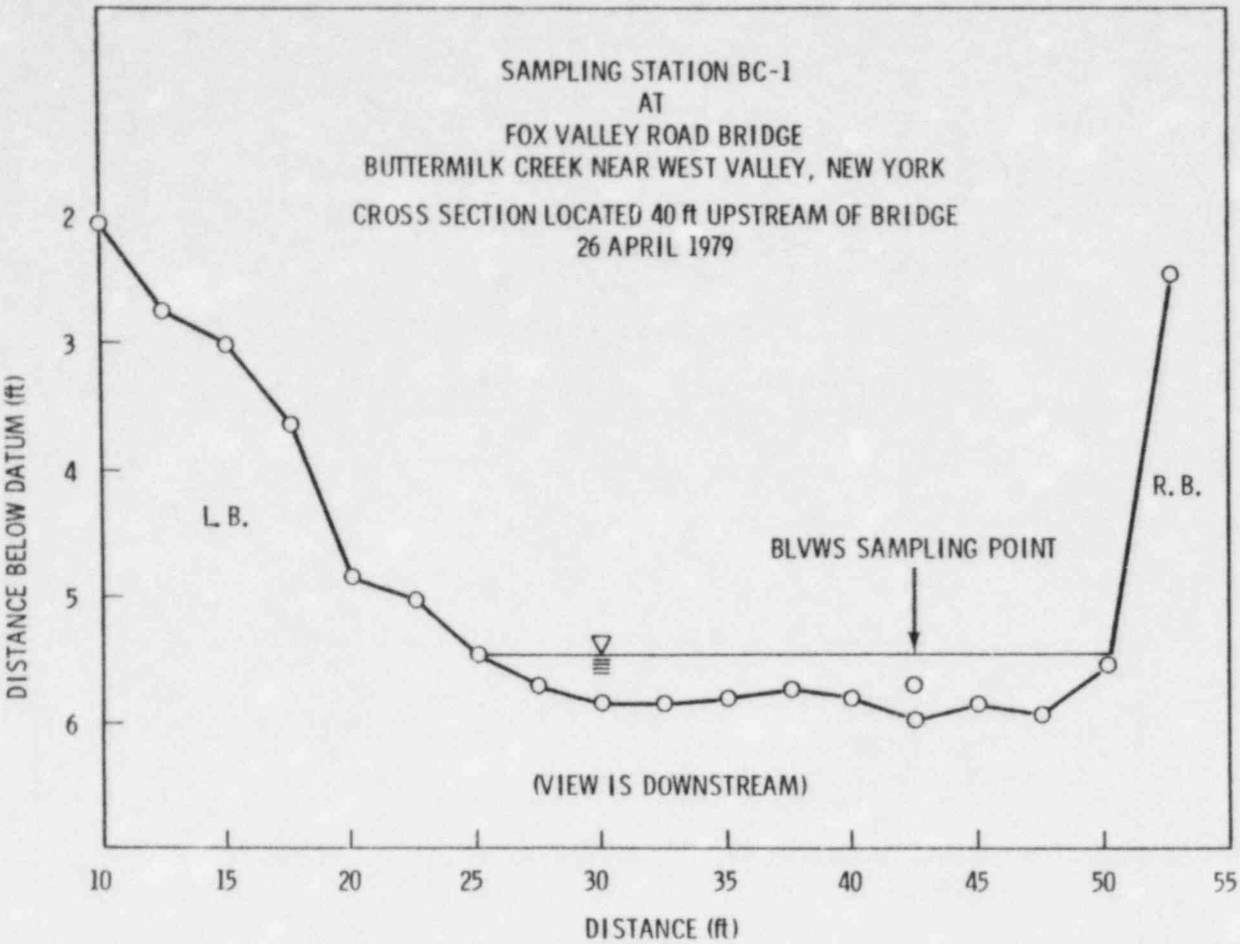

FIGURE A.6. Phase 3 Cross-Section at BC-1

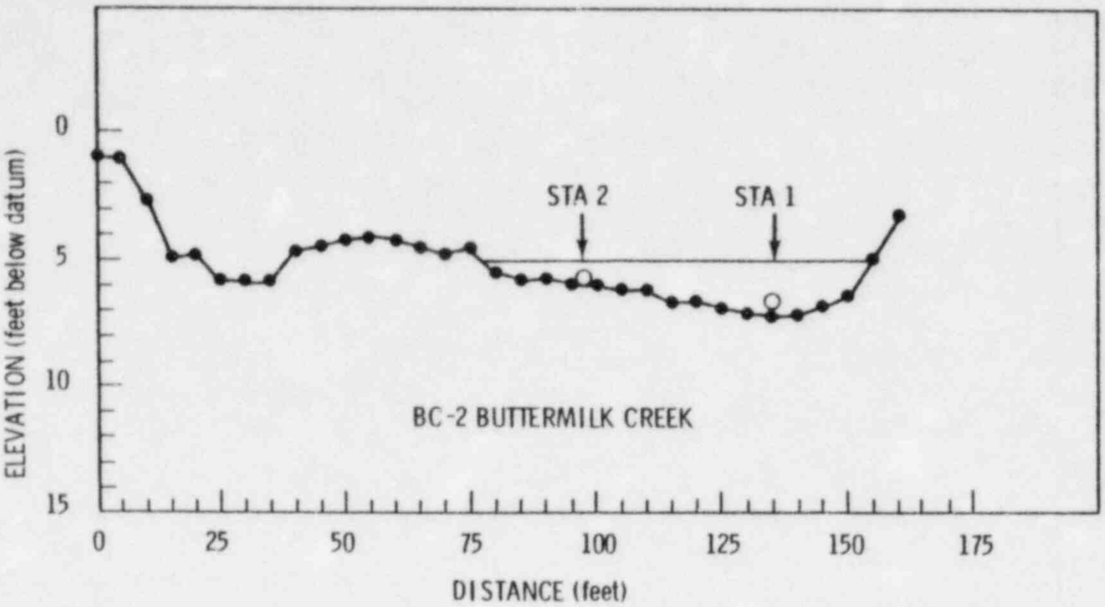

FIGURE A.7. Phase 1 Crooss-Section at BC-2

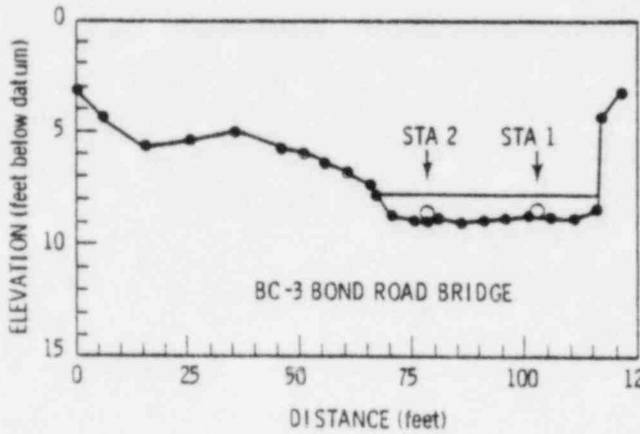

FIGURE A.8. Phase 1 Cross-Section at BC-3

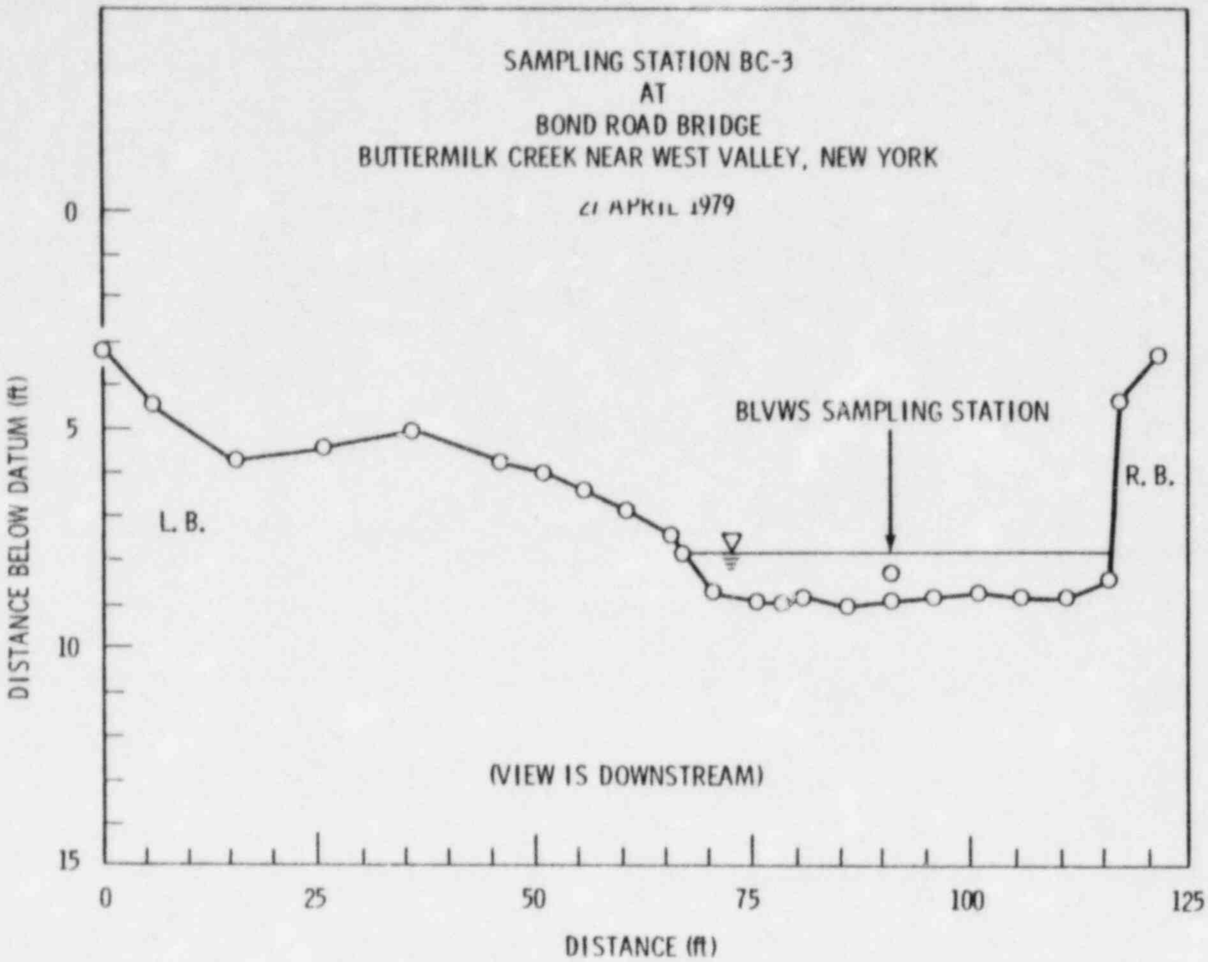

FIGURE A.9. Phase 3 Cross-Section at BC-3

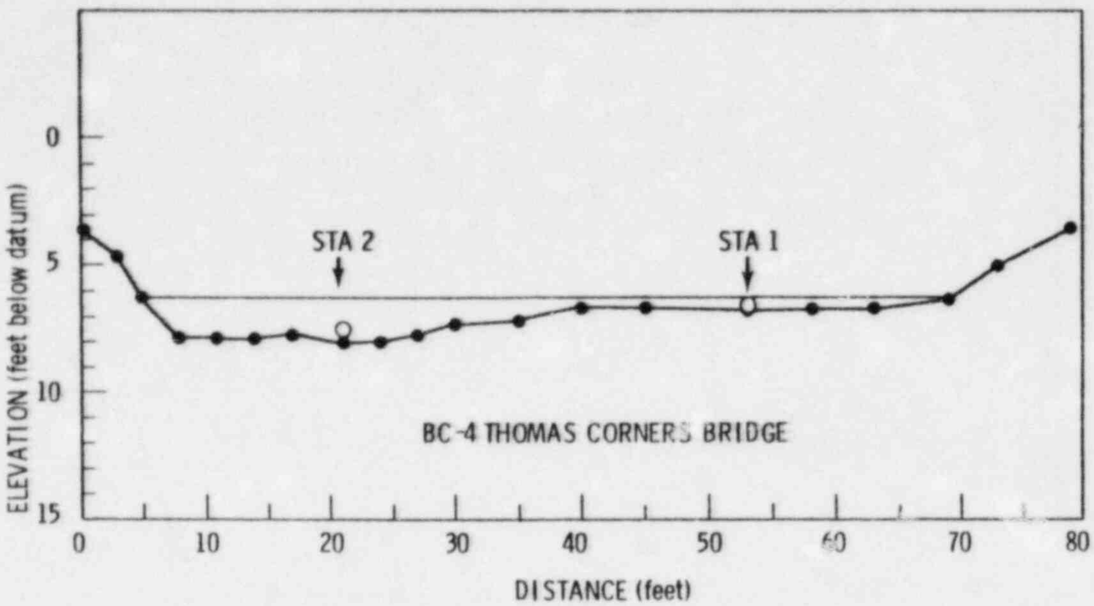

FIGURE A.10. Phase 1 Cross-Section at BC-4

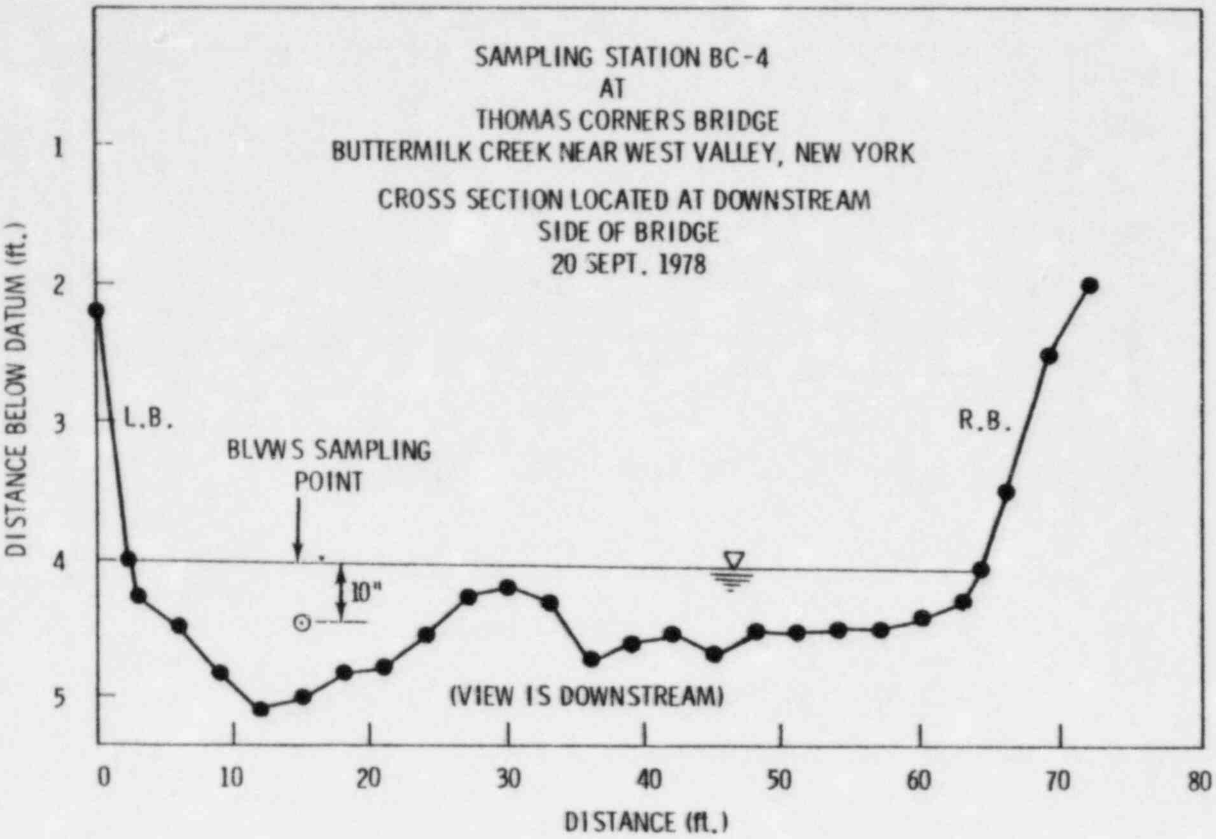

FIGURE A.11. Phase 2 Cross-Section of BC-4

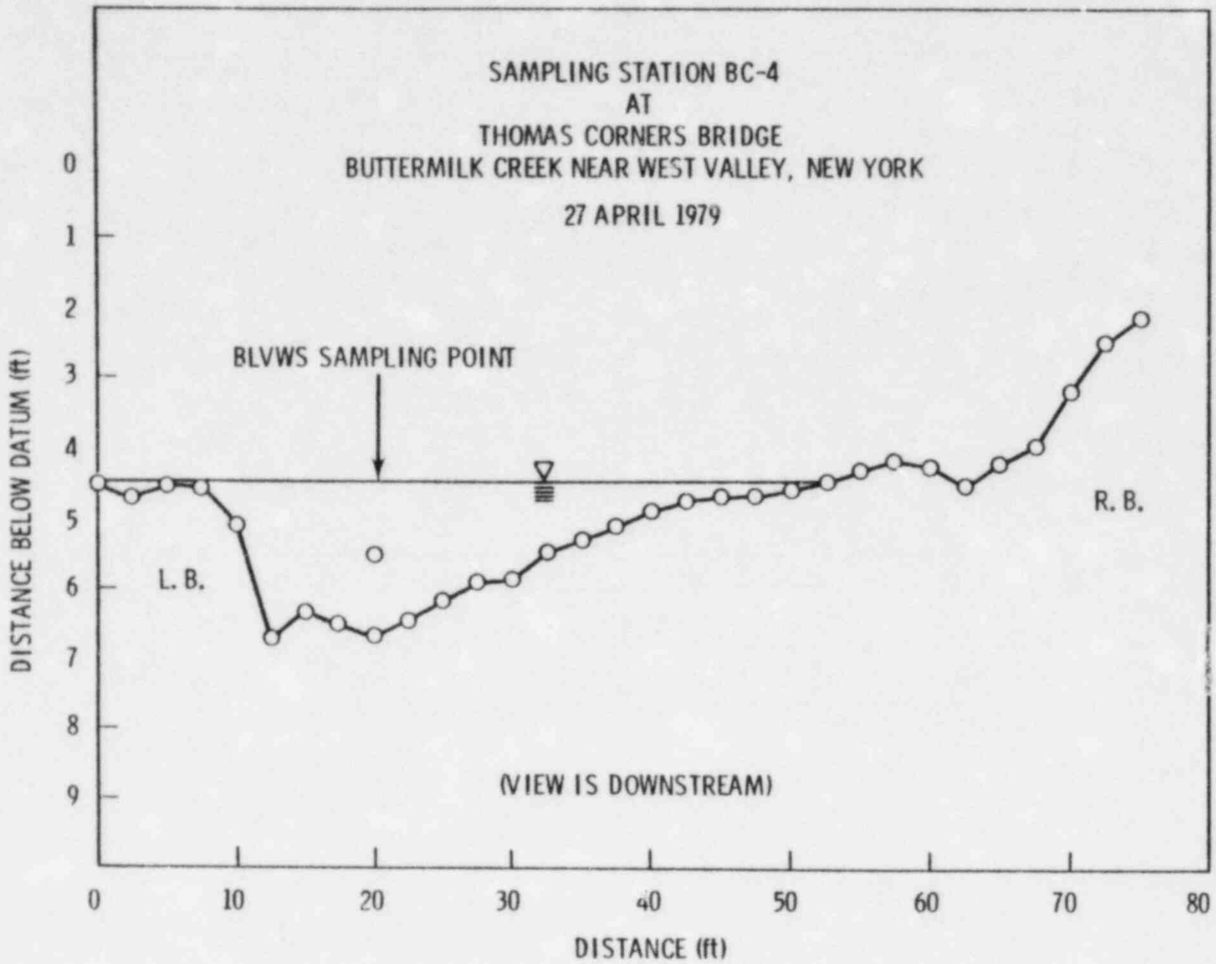

FIGURE A.12. Phase 3 Cross-Section at BC-4

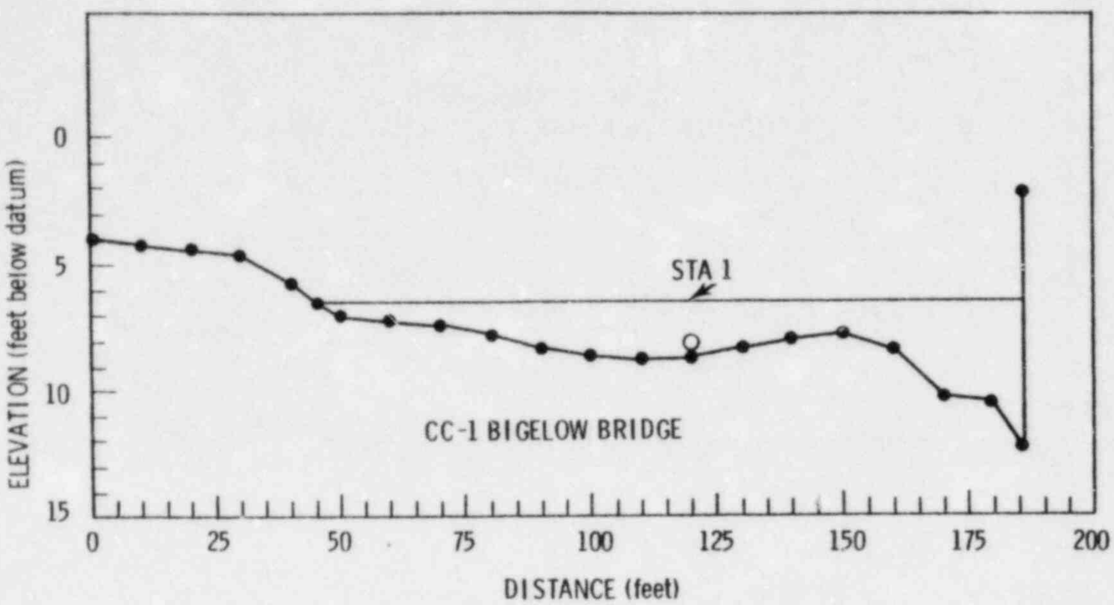

FIGURE A.13. Phase 1 Cross-Section at CC-1

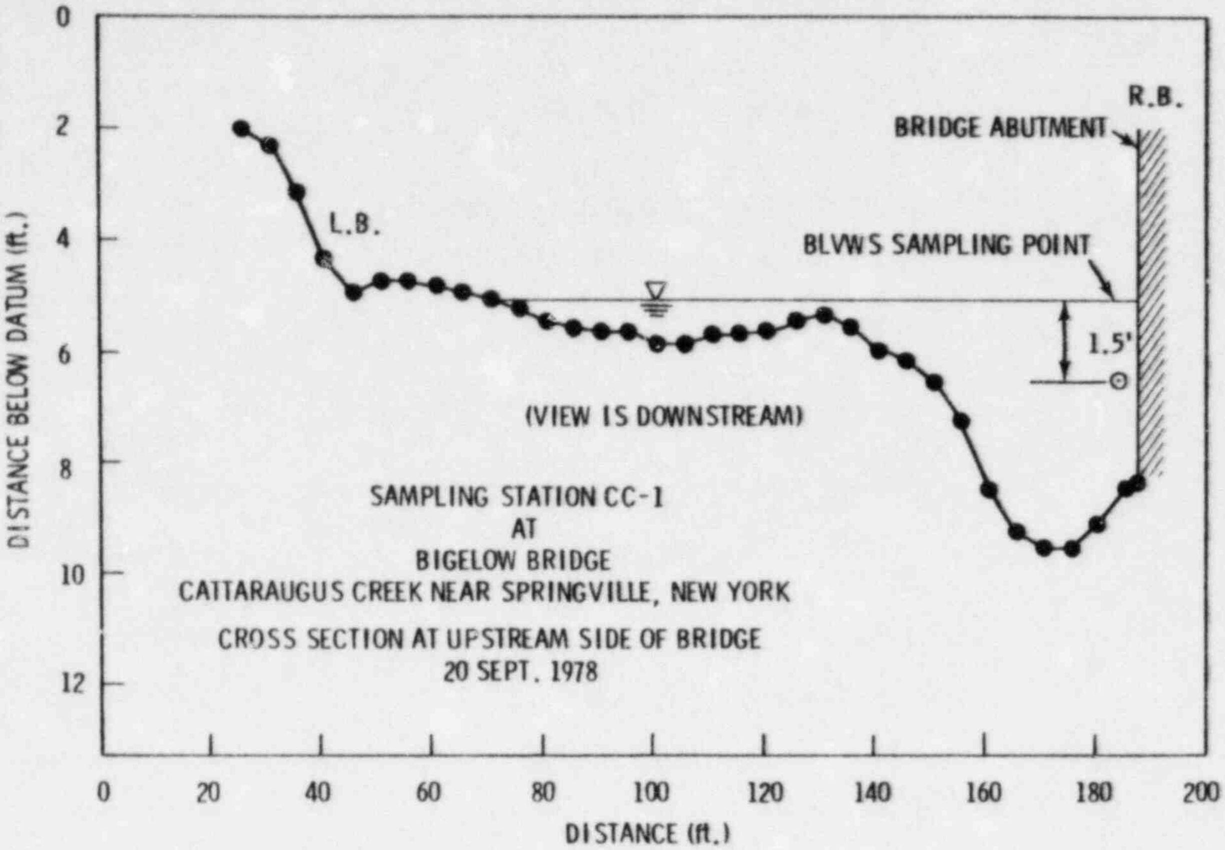

FIGURE A.14. Phase 2 Cross-Section at CC-1

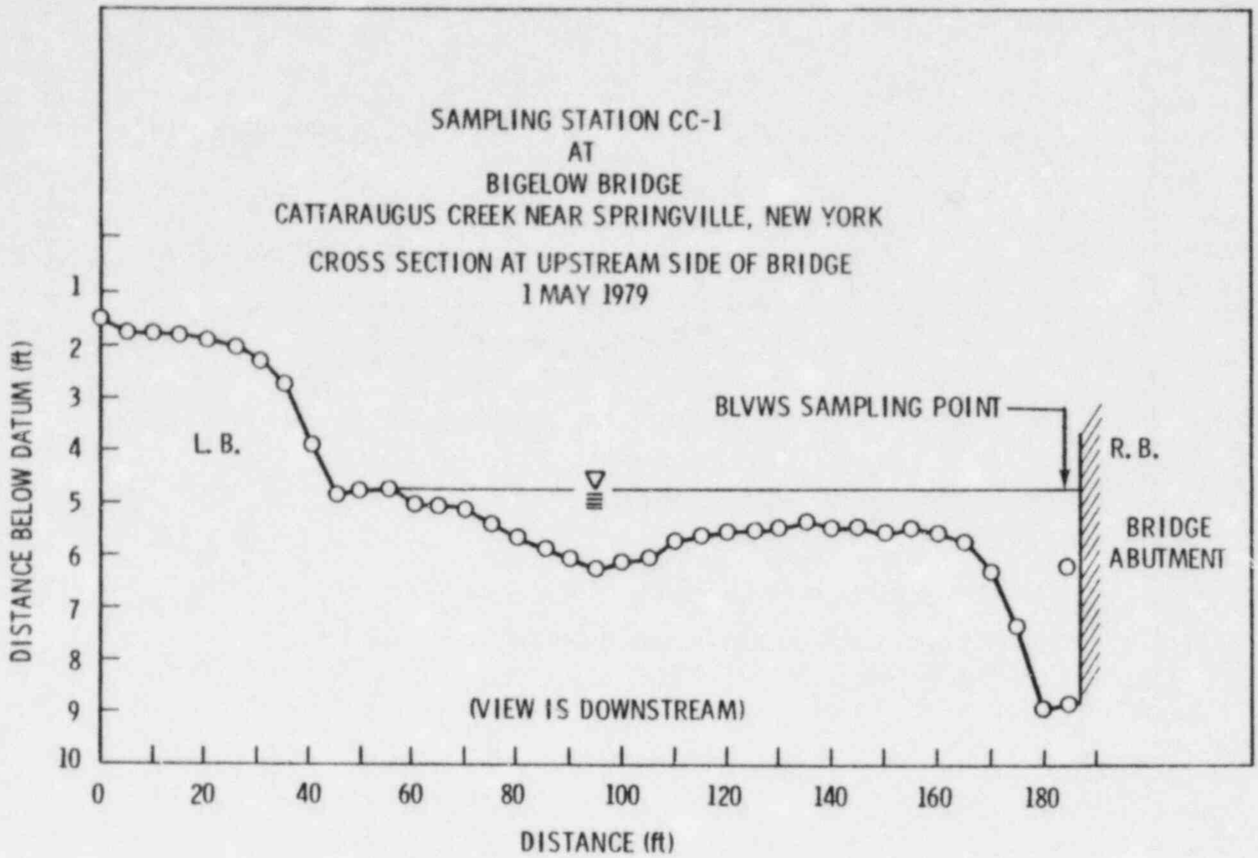

FIGURE A.15. Phase 3 Cross-Section at CC-1

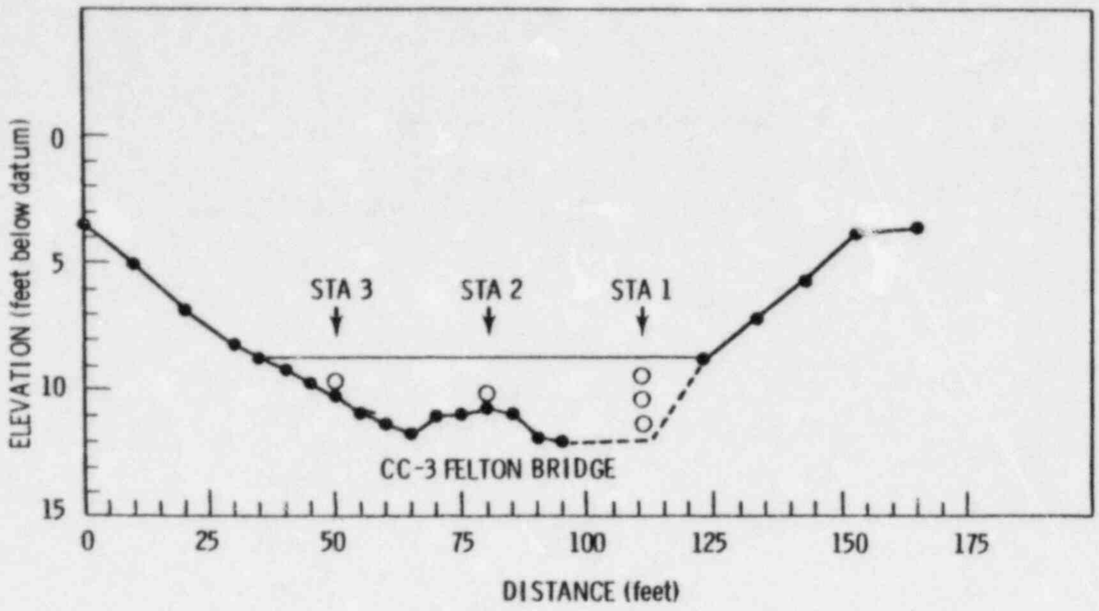

FIGURE A.16. Phase 1 Cross-Section at CC-3

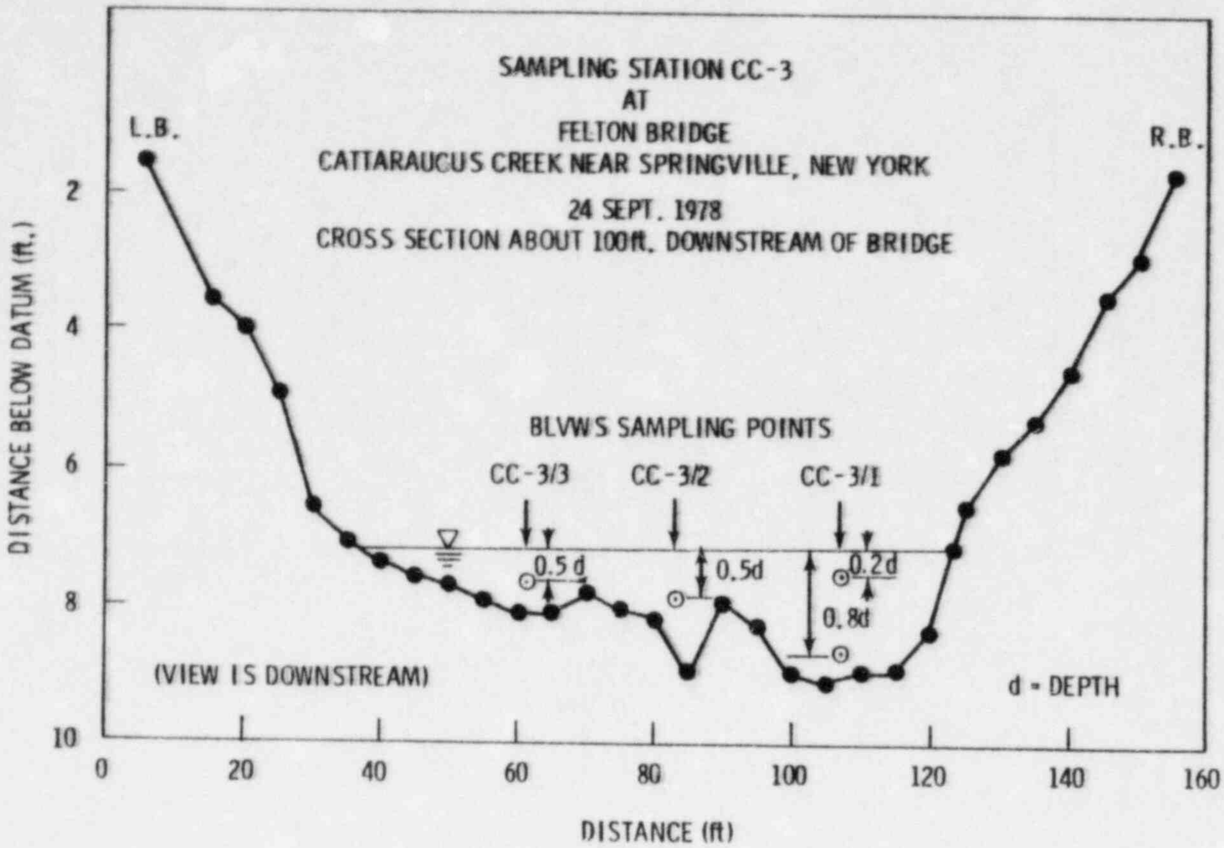

FIGURE A.17. Phase 2 Cross-Section at CC-3

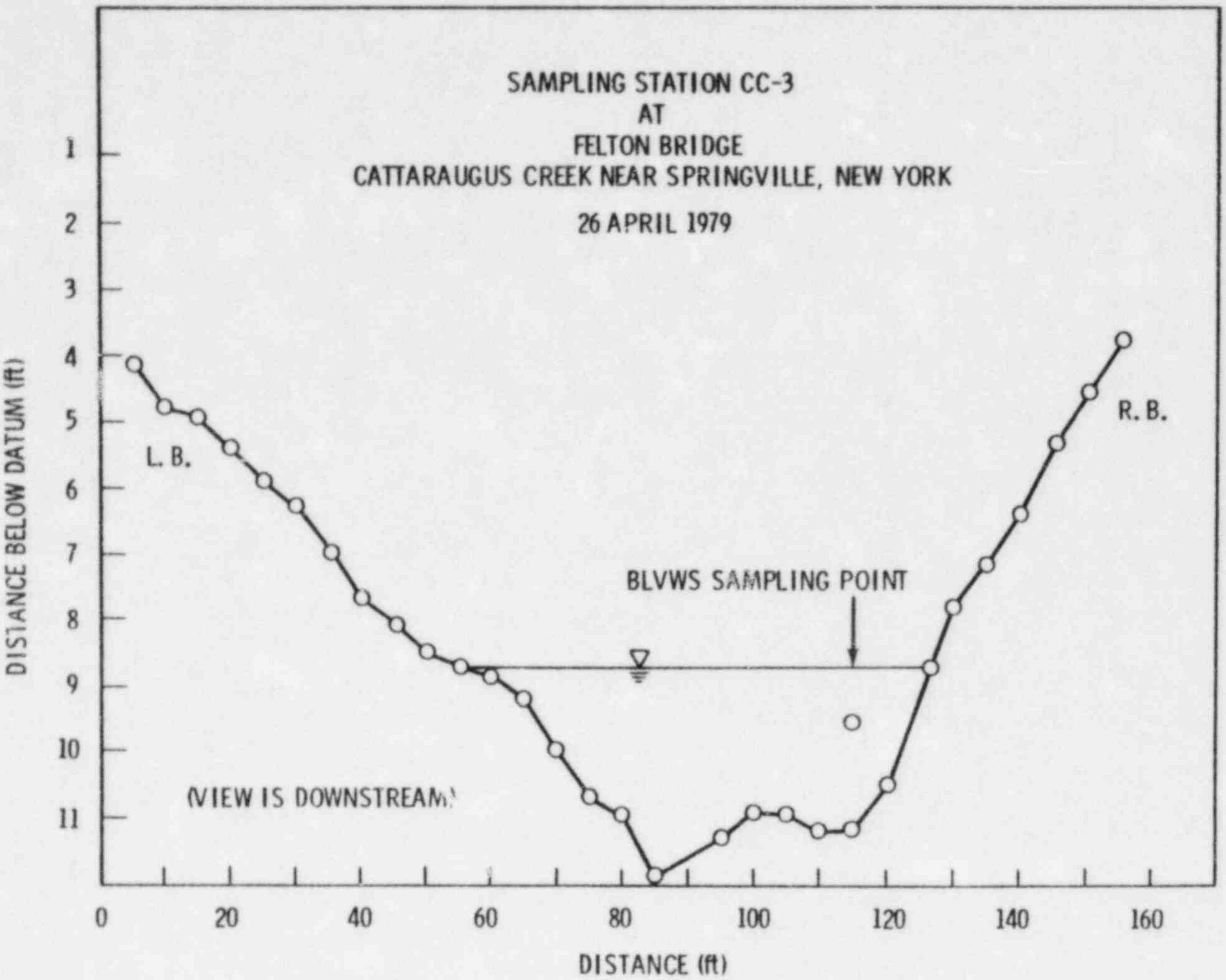

FIGURE A.18. Phase 3 Cross-Section at CC-3

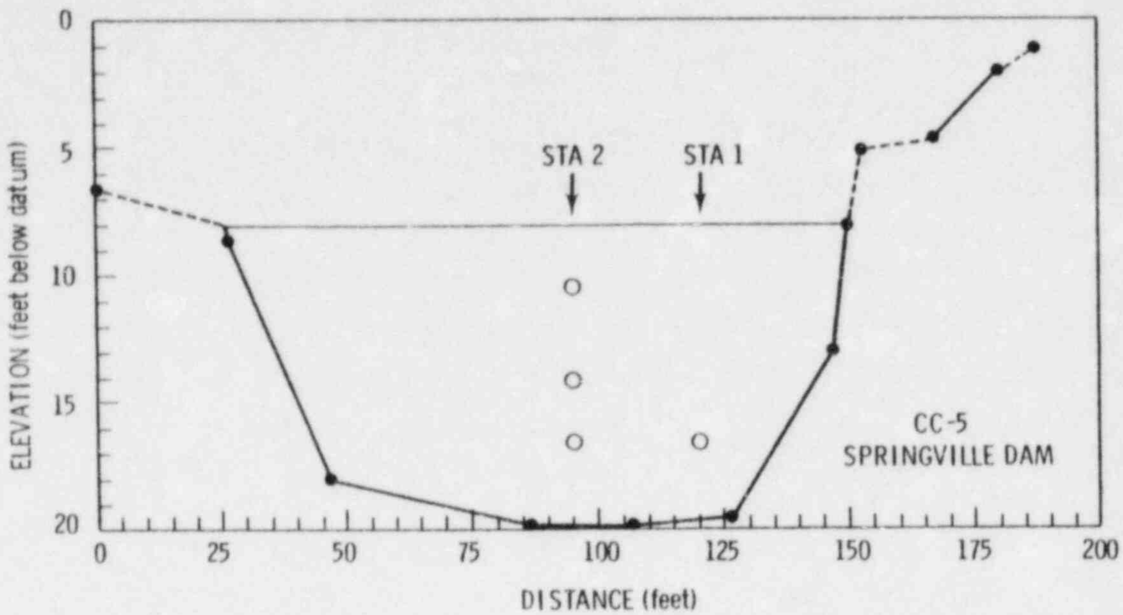

FIGURE A.19. Phase 1 Cross-Section at CC-5

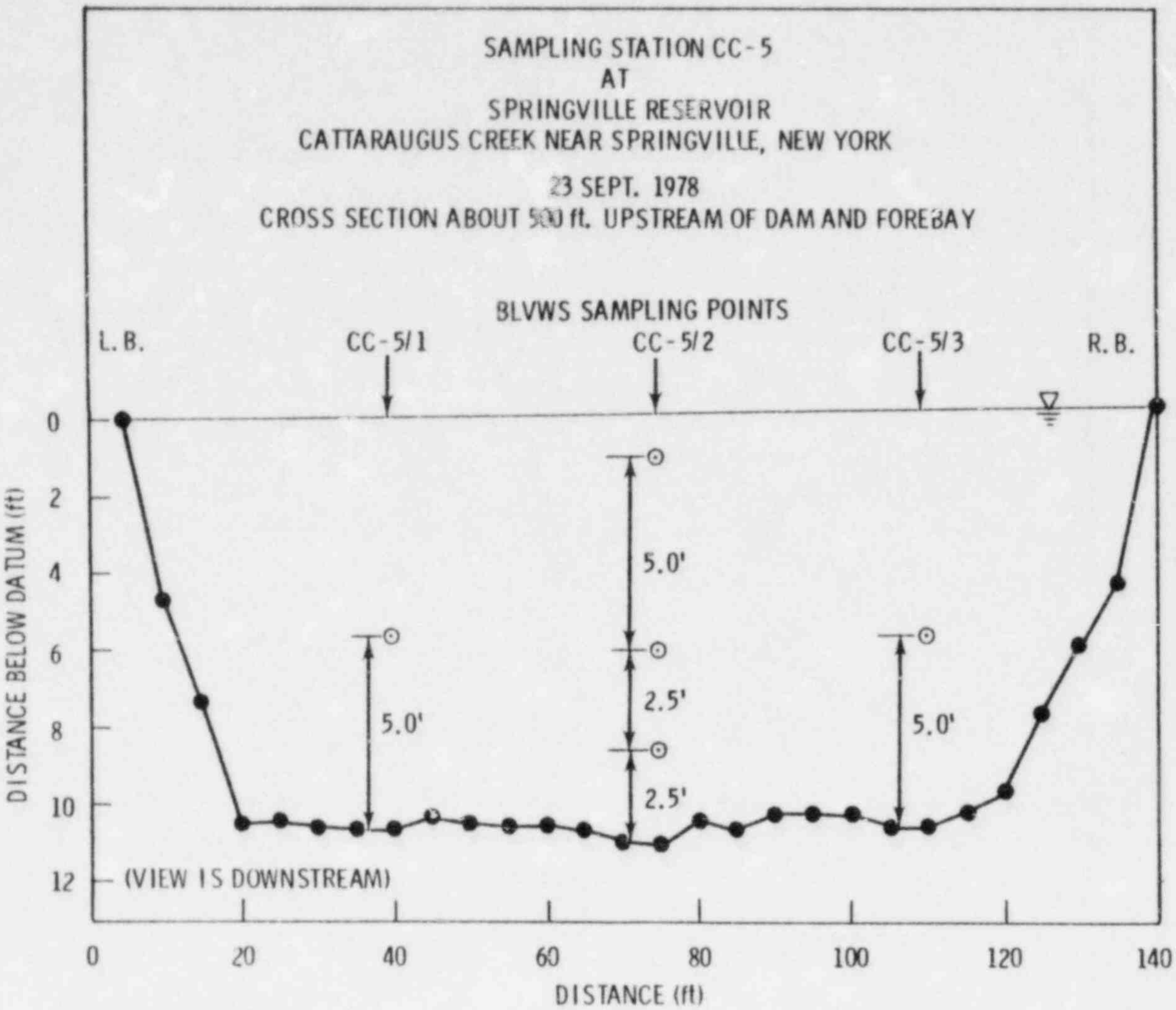

FIGURE A.20. Phase 2 Cross-Section at CC-5

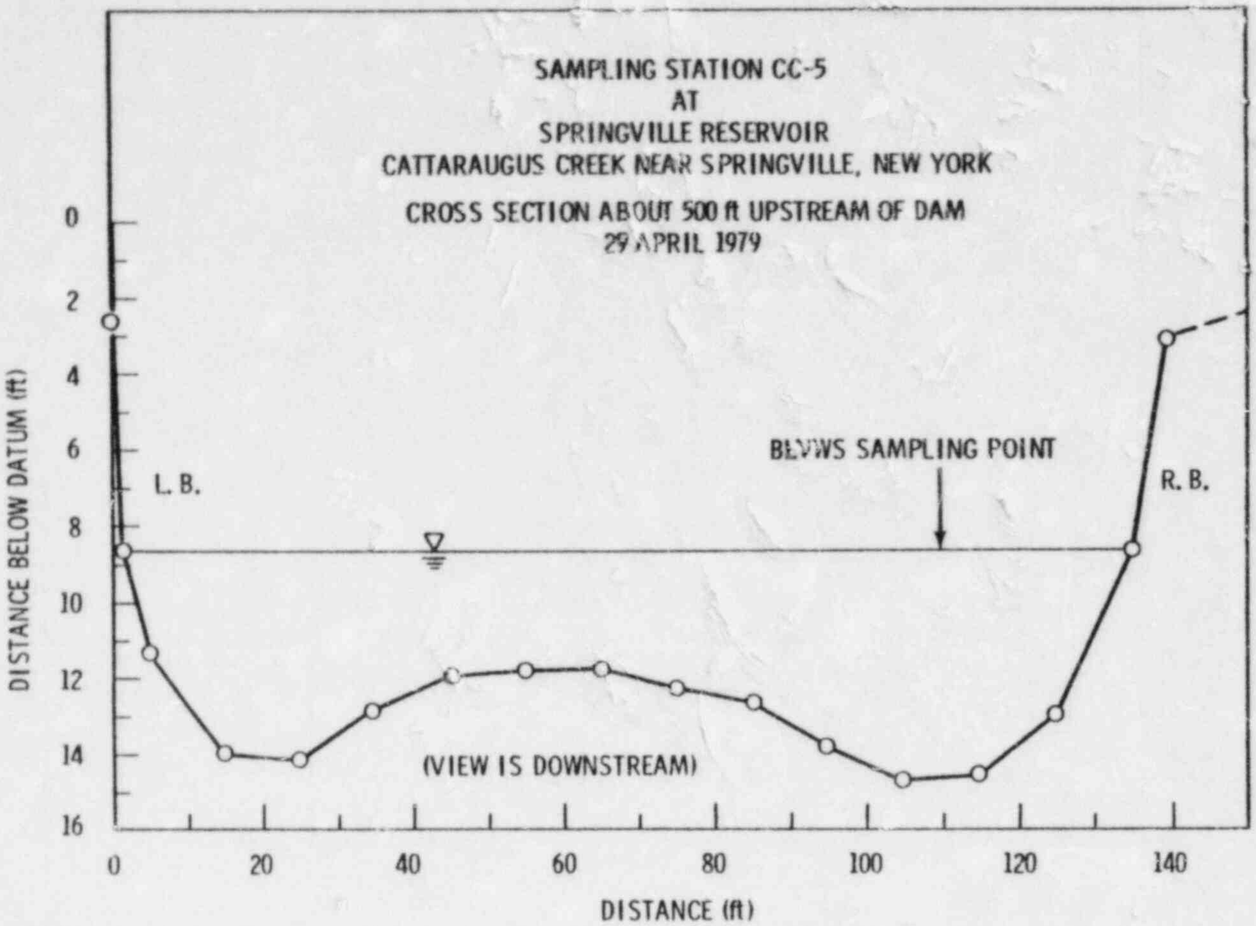

FIGURE A.21. Phase 3 Cross-Section at CC-5

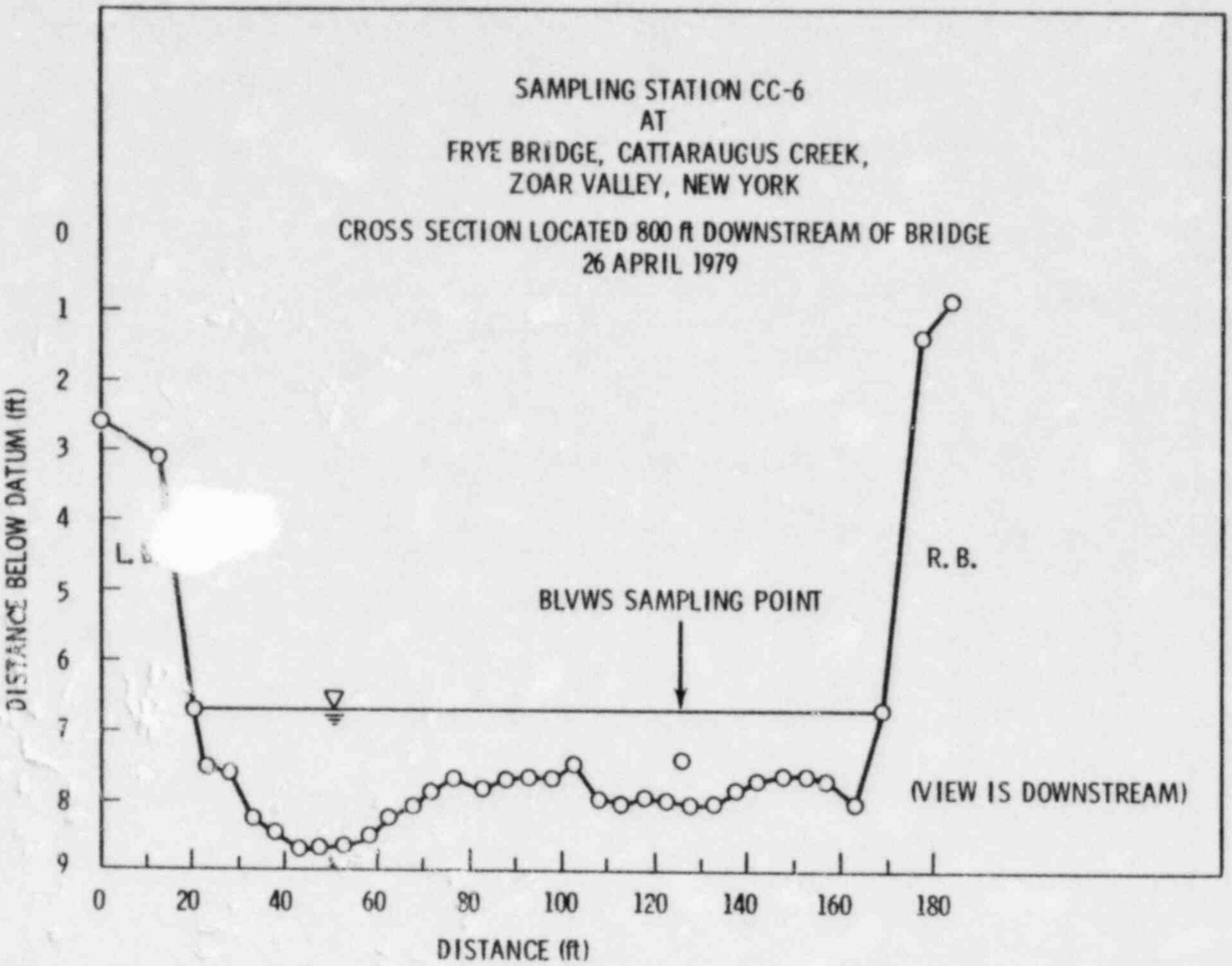

FIGURE A.22. Phase 3 Cross-Section at CC-6

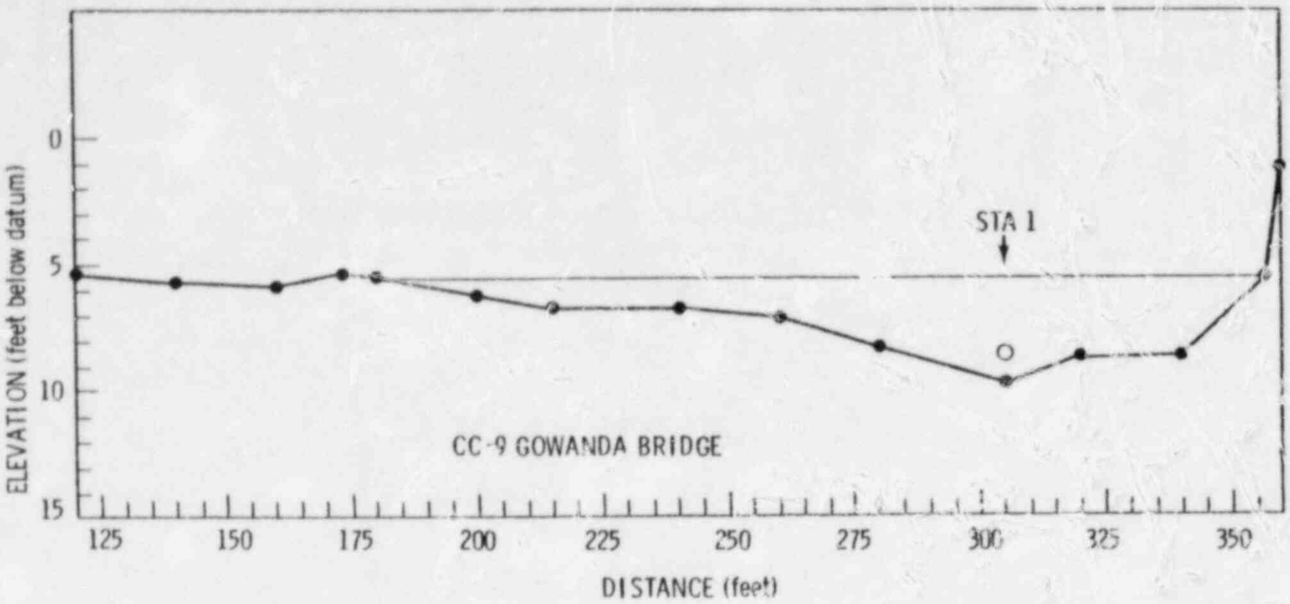

FIGURE A.23. Phase 1 Cross-Section at CC-9

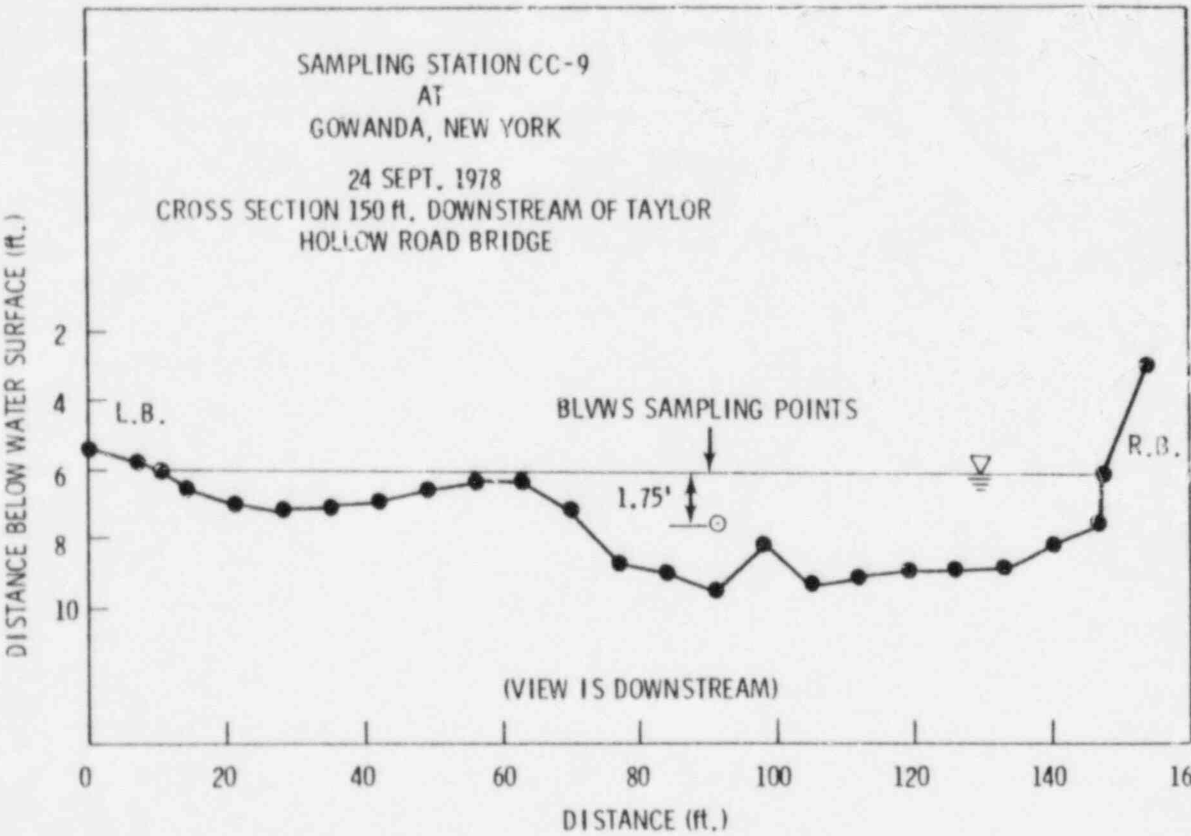

FIGURE A.24. Phase 2 Cross-Section at CC-9

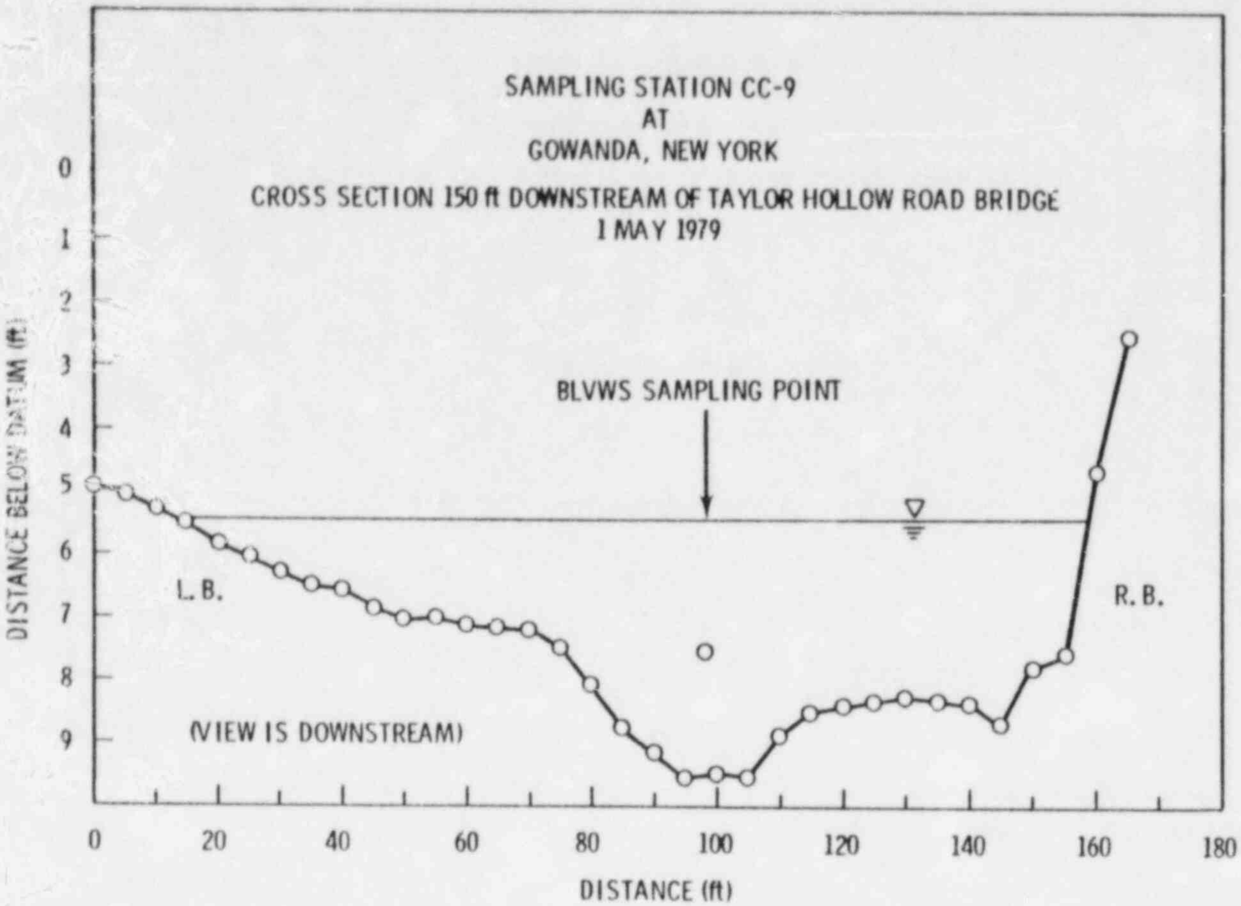

FIGURE A.25. Phase 3 Cross-Section at CC-9

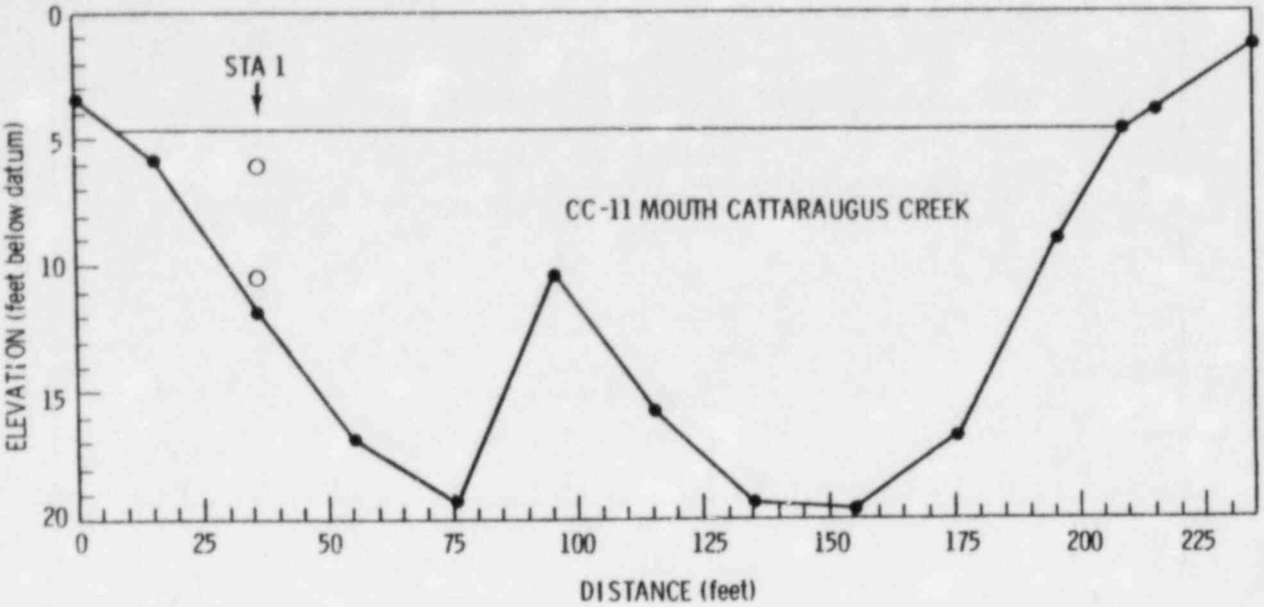

FIGURE A.26. Phase 1 Cross-Section at CC-11

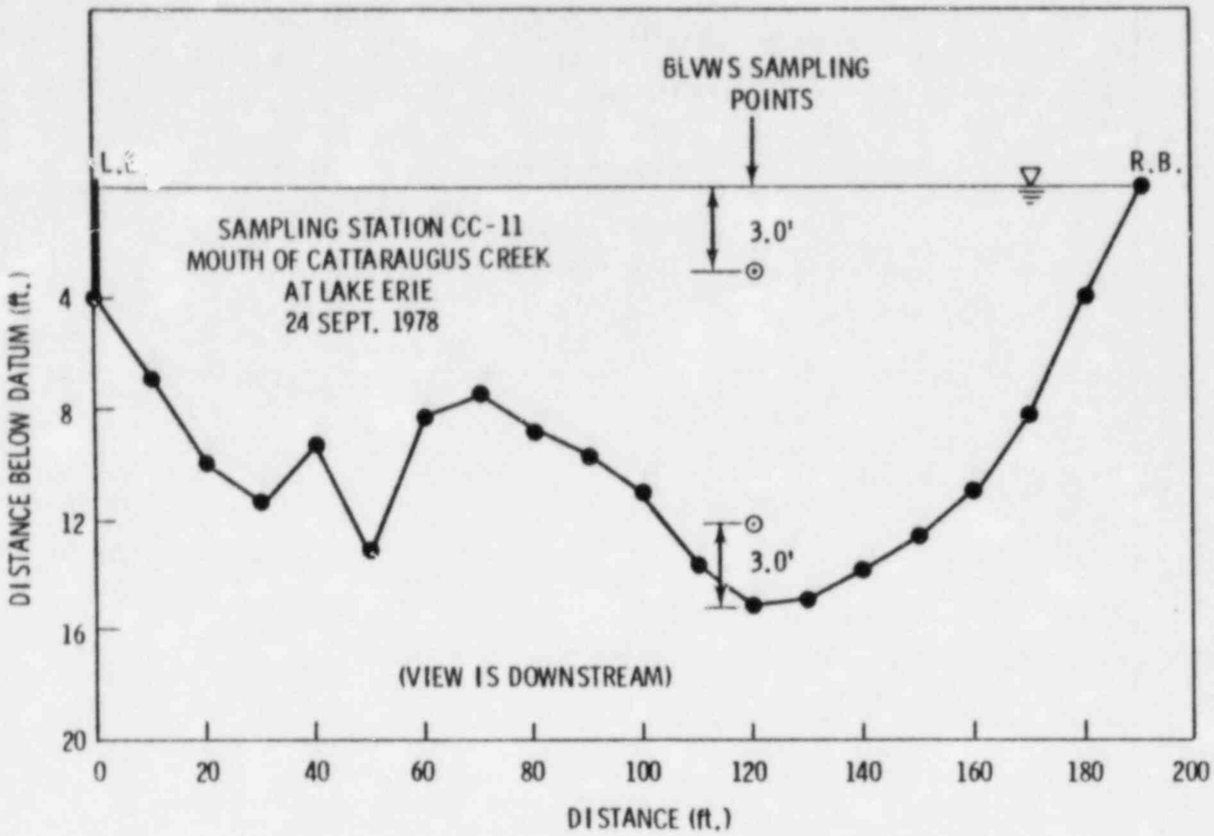

FIGURE A.27. Phase 2 Cross-Section at CC-11

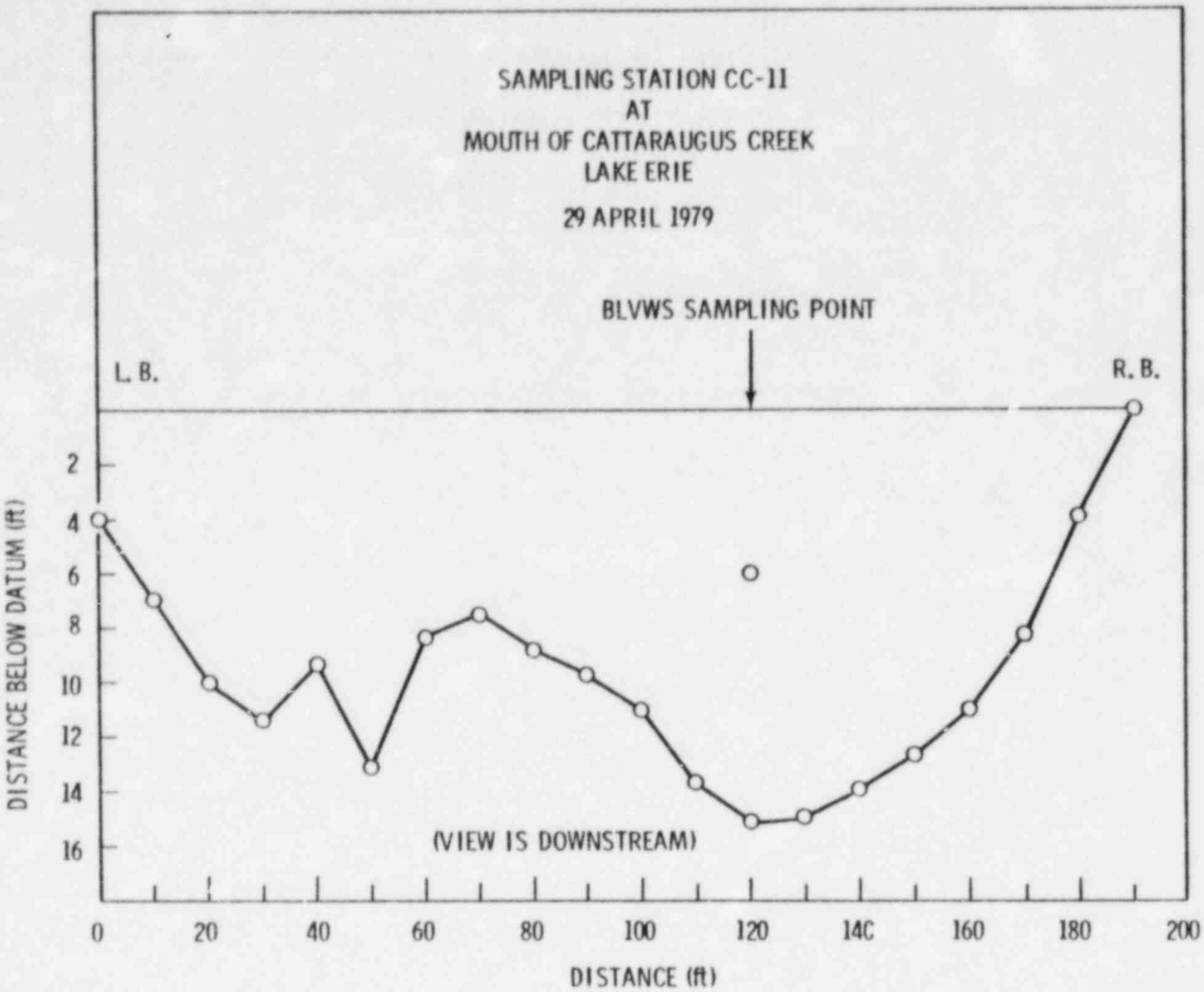

FIGURE A.28. Phase 3 Cross-Section at CC-11

APPENDIX B

RESULTS OF RADIOLOGICAL

ANALYSIS OF FLOOD PLAIN SEDIMENT SAMPLES

TABLE B.1. Results of Gamma Ray Spectrometry Analysis of Flood Plain and Channel Bar Deposits

STATION: 1

Radionuclide Concentration - Flood Plain Sediment
pCi/gm

	Sand	Silt I	Silt II	Clay
Sample Weight Analysis (gms)	68.17	18.56	18.56	2.13
Sample Weight Field (gms)	189.7	45.8	45.8	2.13
K-40	11.57 (0.49)	11.0 (1.6)	11.60 (0.74)	37.6 (4.3)
Co-60	<0.08	<0.21	<0.13	<0.83
Cs-134	<0.08	<0.22	<0.14	<0.92
Cs-137	9.15 (0.07)	13.27 (0.15)	13.37 (0.14)	97.34 (0.94)
Ce-144	<0.51	<1.22	<0.80	<4.7
Bi-207	<0.05	<0.14	<0.09	<0.56
Bi-214	0.43 (0.04)	<0.41	0.66 (0.03)	<1.47
Ra-226	0.42 (0.04)	0.55 (0.13)	0.64 (0.08)	<1.4
Ra-228	0.78 (0.11)	1.32 (0.29)	1.52 (0.17)	<3.5
Th-228	0.61 (0.03)	0.95 (0.12)	1.53 (0.07)	3.22 (0.46)
U-235	<0.33	<0.85	<0.55	<3.3
U-238	0.25 (0.25)	<1.9	<1.4	<8.7
Am-241	<0.27	0.50 (0.09)	<0.24	<1.4

TABLE B.1. (contd)

STATION: 2

Radionuclide Concentration - Flood Plain Sediment
pCi/gm

	Sand	Silt	Clay
Sample Weight Analysis (gms)	70.04	22.06	0.19
Sample Weight Field (gms)	96.7	29.5	0.2
K-40	12.76 (0.53)	8.54 (0.54)	--
Co-60	<0.09	<0.09	<11.4
Cs-134	<0.09	<0.10	<11.3
Cs-137	7.40 (0.07)	2.90 (0.06)	30.2 (2.6)
Ce-144	<0.55	<0.56	<60.6
Bi-207	<0.06	<0.06	<6.9
Bi-214	<0.16	0.55 (0.06)	<18.49
Ra-226	0.33 (0.04)	0.54 (0.06)	2.98 (2.98)
Ra-228	<0.37	0.79 (0.14)	<48.3
Th-228	0.97 (0.05)	1.05 (0.06)	<15.6
U-235	<0.36	<0.39	<42.7
U-238	<1.07	0.37 (0.32)	<92.6
Am-241	<0.29	<0.17	<15.9

TABLE B.1. (contd)

STATION: 3

Radionuclide Concentration - Flood Plain Sediment
pCi/gm

	Sand	Silt I	Silt II	Clay
Sample Weight Analysis (gms)	70.61	19.9	19.9	0.11
Sample Weight Field (gms)	168.0	19.9	19.9	0.1
K-40	13.01 (0.54)	7.77 (1.48)	8.17 (0.63)	--
Co-60	0.12 (0.03)	<0.18	<0.10	<20.2
Cs-134	<0.09	<0.20	<0.11	<20.0
Cs-137	10.08 (0.08)	2.87 (0.08)	2.76 (0.06)	43.74 (5.5)
Ce-144	<0.58	<1.1	<0.63	<107.0
Bi-207	<0.06	<0.12	<0.07	<12.0
Bi-214	0.31 (0.05)	<0.35	<0.21	<32.68
Ra-226	0.30 (0.04)	<0.34	<0.20	<31.7
Ra-228	0.55 (0.11)	<0.78	<0.44	<86.3
Th-228	0.51 (0.04)	0.45 (0.09)	0.78 (0.06)	<27.9
U-235	<0.38	<0.73	<0.44	75.8
U-238	<1.1	<1.7	<1.1	<164.9
Am-241	<0.30	0.47 (0.08)	<0.18	<28.2

TABLE B.1. (contd)

STATION: 4

Radionuclide Concentration - Flood Plain Sediment
pCi/gm

	Sand I	Sand II	Sand III	Silt	Clay
Sample Weight Analysis (gms)	86.1	86.1	86.1	21.89	0.25
Sample Weight Field (gms)	201.4	201.4	201.4	21.9	0.2
K-40		9.39 (0.4)	11.2 (0.48)	8.59 (0.97)	2.5 (2.5)
Co-60		0.08 (0.02)	<0.09	<0.12	<4.1
Cs-134			13.2 (0.2)	<0.12	<4.4
Cs-137	9.11 (0.9)	8.49 (0.08)	9.28 (0.08)	7.78 (0.07)	71.1 (2.1)
Ce-144			<0.53	<0.67	<22.9
Bi-207			<0.06	<0.08	<2.8
Bi-214			0.46 (0.04)	0.74 (0.08)	<6.98
Ra-226			0.44 (0.04)	0.72 (0.08)	<6.8
Ra-228			0.68 (0.10)	1.51 (0.20)	<16.8
Th-228		0.72 (0.04)	0.69 (0.05)	1.18 (0.06)	14.4 (2.6)
U-235			<0.35	<0.46	<15.9
U-238			<1.0	1.17 (0.37)	<40.8
Am-241			<0.28	0.41 (0.05)	<6.9

TABLE B.1. (contd)

STATION: 5

Radionuclide Concentration - Flood Plain Sediment
pCi/gm

	Sand	Silt	Clay
Sample Weight Analysis (gms)	20.0	69.47	1.06
Sample Weight Field (gms)	55.1	130.3	1.6
K-40	8.07 (0.52)	11.70 (0.51)	30.1 (5.6)
Co-60	<0.08	<0.08	<0.83
Cs-134	<0.08	<0.09	<1.0
Cs-137	2.71 (0.05)	3.77 (0.05)	17.41 (0.04)
Ce-144	<0.49	<0.53	<5.2
Bi-207	<0.06	<0.05	<0.61
Bi-214	0.27 (0.05)	0.65 (0.05)	<1.54
Ra-226	0.27 (0.05)	0.63 (0.04)	<1.5
Ra-228	0.24 (0.13)	1.36 (0.13)	<4.1
Th-228	0.75 (0.06)	1.02 (0.04)	5.4 (0.51)
U-235	<0.35	<0.35	<3.7
U-238	<0.89	<1.04	—
Am-241	<1.5	<0.28	<1.6

TABLE B.1. (contd)

STATION: 6

Radionuclide Concentration - Flood Plain Sediment
pCi/gm

	Sand I	Sand II	Silt	Clay
Sample Weight Analysis (gms)	21.02	21.02	65.12	0.34
Sample Weight Field (gms)	41.3	41.3	86.2	0.3
K-40	8.92 (0.50)	10.41 (1.4)	9.52 (0.58)	--
Co-60	<0.07	<0.18	<0.09	<7.7
Cs-134	<0.08	<0.18	<0.09	<7.7
Cs-137	2.20 (0.04)	2.04 (0.07)	1.41 (0.04)	7.03 (1.9)
Ce-144	<0.46	<1.04	<0.58	<42.2
Bi-207	<0.06	<0.12	<0.06	<4.8
Bi-214	<0.16	<0.33	0.62 (0.07)	<12.66
Ra-226	<0.15	<0.32	<0.18	<12.3
Ra-228	0.32 (0.12)	0.49 (0.28)	<0.43	<31.7
Th-228	0.72 (0.06)	0.54 (0.10)	1.09 (0.05)	<10.9
U-235	<0.32	<0.72	<0.38	<29.6
U-238	<0.84	<1.6	<1.2	13.3 (13.3)
Am-241	<0.14	0.56 (0.03)	<0.31	<11.2

TABLE B.1. (contd)

STATION: 7

Radionuclide Concentration - Flood Plain Sediment
pCi/gm

	Sand	Silt I	Silt II	Clay
Sample Weight Analysis (gms)	71.63	65.58	1.08	0.63
Sample Weight Field (gms)	91.7	133.9	133.9	0.7
K-40	11.67 (0.49)	11.16 (0.54)	8.38 (6.2)	28.4 (10.5)
Co-60	<0.09	<0.09	<1.1	<1.7
Cs-134	<0.08	<0.09	<1.1	<1.9
Cs-137	5.79 (0.05)	3.42 (0.54)	4.97 (0.59)	28.19 (0.88)
Ce-144	<0.49	<0.54	<6.0	<9.9
Bi-207	<0.05	<0.06	<0.68	<1.2
Bi-214	0.39 (0.04)	<0.17	<1.84	<3.08
Ra-226	0.38 (0.04)	0.65 (0.05)	<1.79	<3.0
Ra-228	0.69 (0.10)	0.84 (0.12)	<4.80	<7.5
Th-228	0.71 (0.03)	1.35 (0.05)	2.99 (0.67)	<3.3
U-235	<0.32	<0.36	<4.21	<7.1
U-238	<0.95	<1.1	<11.4	<18.5
Am-241	<0.26	<0.29	<1.8	<3.1

TABLE B.1. (contd)

STATION: 8

Radionuclide Concentration - Flood Plain Sediment
pCi/gm

	Sand	Silt	Clay
Sample Weight Analysis (gms)	69.00	20.40	0.11
Sample Weight Field (gms)	121.1	28.2	0.2
K-40	13.08 (0.55)	7.70 (0.55)	--
Co-60	<0.10	<0.09	<18.4
Cs-134	<0.09	<0.11	<17.8
Cs-137	9.94 (0.08)	4.04 (0.06)	39.6 (4.7)
Ce-144	<0.58	<0.57	<96.7
Bi-207	<0.06	<0.06	<11.1
Bi-214	0.33 (0.05)	0.73 (0.06)	<29.77
Ra-226	0.32 (0.05)	0.71 (0.06)	<28.9
Ra-228	0.72 (0.12)	1.21 (0.14)	<78.2
Th-228	0.89 (0.05)	1.23 (0.06)	<25.2
U-235	<0.38	<0.40	<66.7
U-238	<1.12	<1.04	<149.1
Am-241	<0.31	<0.17	<25.1

TABLE B.1. (contd)

STATION: 9

Radionuclide Concentration - Flood Plain Sediment
pCi/gm

	Sand	Silt I	Silt II	Clay
Sample Weight Analysis (gms)	70.42	0.20	20.32	
Sample Weight Field (gms)	187.0	57.8	57.8	0.2
K-40	11.78 (0.43)	--	8.01 (1.29)	
Co-60	<0.06	<9.1	<0.16	
Cs-134	<0.06	<9.6	<0.17	
Cs-137	0.05 (0.01)	--	0.12 (0.04)	
Ce-144	<0.38	<50.2	<0.95	
Bi-207	<0.04	<5.7	<0.11	
Bi-214	0.41 (0.04)	<15.62	0.64 (0.10)	
Ra-226	0.40 (0.03)	<15.2	0.62 (0.10)	
Ra-228	0.82 (0.09)	<41.1	1.07 (0.25)	
Th-228	0.77 (0.03)	<13.0	0.65 (0.10)	
U-235	<0.25	<35.2	<0.67	
U-238	<0.72	<79.1	1.00 (0.49)	
Am-241	<0.19	<13.2	0.50 (0.07)	

TABLE B.2. Results of Radiochemical Analysis of Flood Plain and Channel Bar Deposits for Alpha/Beta Emitter

STATION: 1

Radionuclide Concentration - Flood Plain Sediment
pCi/gm

	Sand	Silt	Clay
Sample Weight, Analysis (gms)	68.17	18.56	2.13
Sample Weight, Field (gms)	189.7	45.8	2.13
Sr-90			0.024 (0.007)
Pu-238	0.0024 (0.0002)	<0.0004	0.042 (0.004)
Pu-239, 240	0.0062 (0.0004)	<0.0016	0.046 (0.004)
Am-241	<0.0001	0.35 (0.006)	0.174 (0.059)
Cm-244	0.043 (0.011)	<0.0001	<0.0001

TABLE B.2. (contd)

STATION: 2

Radionuclide Concentration - Flood Plain Sediment
pCi/gm

	Sand	Silt	Clay
Sample Weight, Analysis (gms)	70.04	22.06	0.19
Sample Weight, Field (gms)	96.7	29.5	0.2
Sr-90			12.29 (4.68)
Pu-238	0.0042 (0.0004)	0.0015 (0.0005)	0.016 (0.015)
Pu-239, 240	0.0047 (0.0005)	0.0028 (0.0006)	<0.074
Am-241	0.04 (0.014)	<0.0001	1.6 (0.76)
Cm-244	0.021 (0.011)	<0.00001	<0.001

TABLE B.2. (contd)

STATION: 3

Radionuclide Concentration - Flood Plain Sediment
pCi/gm

	Sand	Silt	Clay
Sample Weight, Analysis (gms)	70.61	19.90	0.11
Sample Weight, Field (gms)	168.0	19.90	0.1
Sr-90		0.034 (0.022)	
Pu-238	0.0055 (0.0005)	0.0026 (0.0005)	0.058 (0.033)
Pu-239, 240	0.0081 (0.0008)	0.0037 (0.0005)	<0.13
Am-241	0.012 (0.008)	<0.0002	4.39 (1.13)
Cm-244	<0.0001	0.132 (0.055)	1.05 (0.45)

TABLE B.2. (contd)

STATION: 4

Radionuclide Concentration - Flood Plain Sediment
pCi/gm

	Sand	Silt	Clay
Sample Weight, Analysis (gms)	86.1	21.89	0.25
Sample Weight, Field (gms)	201.4	21.9	0.2
Sr-90			
Pu-238	0.352 (0.023)	0.0056 (0.0007)	0.028 (0.008)
Pu-239, 240	0.445 (0.025)	0.0078 (0.0008)	<0.056
Am-241	0.013 (0.002)	0.147 (0.097)	1.75 (1.60)
Cm-244	0.0015 (0.0007)	<0.001	<0.0008

TABLE B.2. (contd)

STATION: 5

Radionuclide Concentration - Flood Plain Sediment
pCi/gm

	Sand	Silt	Clay
Sample Weight, Analysis (gms)	20.0	69.47	1.06
Sample Weight, Field (gms)	55.1	130.3	1.6
Sr-90			2.92 (1.29)
Pu-238	0.0026 (0.0004)	0.0022 (0.0002)	0.0132 (0.004)
Pu-239, 240	0.0028 (0.0005)	0.0033 (0.0002)	<0.013
Am-241	0.018 (0.008)	0.012 (0.005)	<0.0028
Cm-244	<0.0001		<0.0002

TABLE B.2. (contd)

STATION: 6

Radionuclide Concentration - Flood Plain Sediment
pCi/gm

	Sand	Silt	Clay
Sample Weight, Analysis (gms)	21.02	65.12	0.34
Sample Weight, Field (gms)	41.3	86.2	0.3
Sr-90			3.82 (1.75)
Pu-238	0.0024 (0.0006)	<0.0001	<0.008
Pu-239, 240	0.003 (0.0006)	<0.0003	<0.041
Am-241	0.033 (0.021)	<0.0001	1.95 (1.07)
Cm-244	<0.00001	0.118 (0.111)	1.64 (0.69)

TABLE B.2. (contd)

STATION: 7

Radionuclide Concentration - Flood Plain Sediment
pCi/gm

	coarse sand-fine gravel	Sand	Silt	Clay
Sample Weight, Analysis (gms)	1.08	71.63	65.58	0.34
Sample Weight, Field (gms)	1.2	91.7	133.9	0.7
Sr-90		0.062 (0.039)		2.39 (1.25)
Pu-238	0.029 (0.16)	0.0044 (0.0002)	0.0027 (0.0002)	0.024 (0.006)
Pu-239, 240	<0.013	0.0053 (0.0003)	0.0034 (0.0003)	<0.022
Am-241	<0.003	<0.0001	4.0 (0.28)	1.12 (0.31)
Cm-244	<0.0002	0.16 (0.12)	0.16 (0.14)	<0.0003

TABLE B.2. (contd)

STATION: 8

Radionuclide Concentration - Flood Plain Sediment
pCi/gm

	Sand	Silt	Clay
Sample Weight, Analysis (gms)	69.00	20.40	0.11
Sample Weight, Field (gms)	121.1	28.2	0.2
Sr-90			
Pu-238	0.0054 (0.0007)	0.0013 (0.0003)	<0.028
Pu-239, 240	0.0065 (0.0007)	0.0011 (0.0002)	<0.127
Am-241	0.013 (0.002)	0.025 (0.004)	<0.027
Cm-244	0.0015 (0.0007)	<0.00001	<0.027

TABLE B.2. (contd)

STATION: 9

Radionuclide Concentration - Flood Plain Sediment
pCi/gm

	Sand	Silt	Clay
Sample Weight, Analysis (gms)	70.42	20.32	0.2
Sample Weight, Field (gms)	187.0	57.82	0.2
Sr-90		1.79 (1.34)	
Pu-238	<0.0001	<0.0002	0.031 (0.24)
Pu-239, 240	0.0005 (0.0002)	0.0012 (0.0004)	0.064 (0.30)
Am-241	0.005 (0.003)	<0.0002	<0.015
Cm-244		<0.0001	<0.001

DISTRIBUTION

No. of Copies	

OFFSITE

408 U.S. Nuclear Regulatory Commission
Division of Technical Information and Document Control
7920 Norfolk Avenue
Bethesda, MD 20014

2 DOE Technical Information Center

Phillip R. Reed
U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Health and Environmental Research Branch
Washington, DC 20555

Paul Lohaus
U.S. Nuclear Regulatory Commission
Low Level Waste Branch
Office of Nuclear Materials Safety and Safeguards
Washington, DC 20555

3 Dr. Robert H. Fakundiny
New York State Geological Survey
The State Education Department
Albany, NY 12234

J. P. Duckworth
General Manager
Nuclear Fuel Services, Inc.
P.O. Box 124
West Valley, NY 14171

Mina Hamilton
Direction
Sierra Club Radioactive Waste Campaign
3164 Main St.
Buffalo, NY 14214

John B. Robertson
Office of Hazardous Waste Hydrology
U.S. Geological Survey
Reston, VA 22092

William Schell
University of Washington
College of Fisheries
Seattle, WA 98195

James Thomas
U.S. Nuclear Regulatory Commission
Low Level Waste Branch
Office of Nuclear Materials Safety and Safeguards
Washington, DC 20555

Peter Van Voris
Battelle Columbus Laboratories
505 King Avenue
Columbus, OH 43201

Dr. L. Skoski
West Valley Nuclear Service Co.
West Valley, NY 14171

P. Moskowitz
West Valley Nuclear Service Co.
West Valley, NY 14171

ONSITE

50 Pacific Northwest Laboratory

S. M. Brown
D. B. Cearlock
D. W. Dawson
R. M. Ecker (11)
Y. Onishi (11)
R. J. Serne
W. H. Walters (12)
Technical Information (5)
Publishing Coordination (BE) (2)
Geosciences, Research and Engineering Dept. Library (5)

NRC FORM 335 (11-81) U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

1. REPORT NUMBER (Assigned by DDC)
NUREG/CR-1030, Vol. 4
PNL-3117

2. (Leave blank)

3. RECIPIENT'S ACCESSION NO.

4. TITLE AND SUBTITLE (Add Volume No., if appropriate)
Sediment and Radionuclide Transport in Rivers: Summary Report; Field Sampling Program for Cattaraugus and Buttermilk Creeks, New York

5. DATE REPORT COMPLETED
MONTH September | YEAR 1982

DATE REPORT ISSUED
MONTH November | YEAR 1982

6. (Leave blank)

7. AUTHOR(S)
W. H. Walters, R. M. Ecker, and Y. Onishi

8. (Leave blank)

9. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
Pacific Northwest Laboratory
Post Office Box 999
Richland, Washington 99352

10. PROJECT/TASK/WORK UNIT NO.

11. FIN NO.
B2275

12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Division of Health, Siting, and Waste Management
Washington, DC 20555

13. TYPE OF REPORT
Summary

PERIOD COVERED (Inclusive dates)

14. (Leave blank)

15. SUPPLEMENTARY NOTES

16. ABSTRACT (200 words or less)

A three-phase field sampling program was conducted on the Buttermilk-Cattaraugus Creek system 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. Phase 1 of the sampling program was conducted during November and December 1977; Phase 2 during September 1978; and Phase 3 during April 1979. Bed sediment, suspended sediment, and water samples were collected over a 45-mile reach of the creek system. Bed sediment samples were also collected at the mouth of Cattaraugus Creek in Lake Erie. A fourth sampling trip was conducted during May 1980 to obtain supplementary channel geometry data and flood plain sediment samples. 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.

17. KEY WORDS AND DOCUMENT ANALYSIS

Radionuclides
Rivers
Sediments
Cattaraugus Creek New York
Buttermilk Creek, New York
West Valley, New York
Cesium-137
Strontium-90
Plutonium
Americium
Tritium
Curium

17a. DESCRIPTORS

17b. IDENTIFIERS/OPEN-ENDED TERMS

18. AVAILABILITY STATEMENT
Unclassified

19. SECURITY CLASS (This report)
Unclassified

20. SECURITY CLASS (This page)
Unclassified

21. NO. OF PAGES

22. PRICE
$

NRC FORM 335 (11-81)