Y/TS-417

# Y-12

## OAK RIDGE Y-12 PLANT

MARTIN MARIETTA

# RCRA FACILITY INVESTIGATION PLAN
# BEAR CREEK
# OAK RIDGE Y-12 PLANT
# OAK RIDGE, TENNESSEE


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December 1988

Document Prepared for
Environmental Management Department
Health, Safety, Environment, and
Accountability Division


Oak Ridge Y-12 Plant
Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
Under Contract No. DE-AC05-84OR21400

MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY


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## LIST OF ACRONYMNS AND ABBREVIATIONS

| | |
|---|---|
| AAS | Atomic Absorption Spectroscopy |
| ACL | Alternate Concentration Limit |
| ASTM | American Society for Testing and Materials |
| ATDL | NOAA Atmospheric Turbulence and Diffusion Laboratory |
| BOD | Biological oxygen demand |
| BCK | Bear Creek kilometer |
| BCV | Bear Creek Valley |
| °C | Degrees Centigrade |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| CLP | Contract Laboratory Program |
| DOE | U.S. Department of Energy |
| DQO | Data Quality Objective |
| ESD | Environmental Services Division |
| °F | Degrees Fahrenheit |
| ft | ft (ft) |
| GCK | Grassy Creek kilometer |
| hr | hour |
| HSEAD | Y-12 Plant, Health, Safety, Environment and Accountability Division |
| HSRD | Health and Safety Research Division |
| HSWA | Hazardous and Solid Waste Amendments of 1984 |
| ICP | Inductively Coupled Plasma |
| ID | Identification |
| in | inch(es) |
| $K_d$ | Distribution coefficient |
| kg | kilograms |
| K-25 | Oak Ridge Gaseous Diffusion Plant (ORGDP) |
| L/sec | liters per second |
| m | meter(s) |
| mg/L | milligrams per liter |

| | |
|---|---|
| $mg/m^3$ | milligrams per cubic meter |
| MCL | maximum contaminant levels |
| mi | mile(s) |
| mV | millivolts |
| NBS | National Bureau of Standards |
| NOAA | National Oceanic and Atmospheric Administration |
| NPDES | National Pollutant Discharge Elimination System |
| NT | North tributary to Bear Creek |
| ORNL | Oak Ridge National Laboratory |
| ORO | Oak Ridge Operations |
| ORP | Oil Retention Pond |
| ORR | Oak Ridge Reservation |
| OSHA | Occupational Safety and Health Administration |
| PCB | polychlorinated biphenyl |
| PCE | Tetrachloroethene |
| pCi/g | picocuries per gram |
| pCi/L | picocuries per liter |
| PEL | Permissible Exposure Limit |
| PSS | Plant Shift Superintendent |
| PVC | Polyvinyl chloride |
| QAPP | Quality Assurance Project Plan |
| QA | Quality Assurance |
| QC | Quality Control |
| RCRA | Resource Conservation and Recovery Act of 1976 |
| RFA | RCRA Facility Assessment |
| RFI | RCRA Facility Investigation |
| SHSO | Site Health and Safety Officer |
| SS | Spring on side side of Bear Breek |
| SWMUs | Solid Waste Management Units |
| TCE | Trichloroethene |
| TDHE | Tennessee Department of Health and Environment |
| TDPH | Tennessee Department of Public Health |

| | |
|---|---|
| TLV | Threshold Limit Value |
| TOC | Total Organic Carbon |
| TOX | Total Organic Halide |
| TSD | Treatment, storage and disposal |
| TVA | Tennessee Valley Authority |
| $\mu g/g$ | micrograms per gram |
| $\mu g/L$ | micrograms per liter |
| $\mu g/m^3$ | micrograms per cubic meter |
| $\mu R/h$ | microrem per hour |
| umhos/cm | micromhos per centimeter |
| USDA | U.S. Department of Agriculture |
| USEPA,EPA | U.S. Environmental Protection Agency |
| USGS | U.S. Geological Survey |
| VOC | Volatile organic compounds |
| WOM | White Oak Mountain |

# EXECUTIVE SUMMARY

Recently, as part of a Resource Conservation and Recovery Act (RCRA) permit for the Oak Ridge Reservation, the U.S. Department of Energy agreed to further investigate contamination of Bear Creek and its floodplain resulting from releases of hazardous waste or hazardous constituents from the Y-12 Plant solid waste management units (SWMU) located in the Bear Creek watershed. This investigation will be conducted through a RCRA Facility Investigation (RFI). Any corrective measures for this site will be based on the information gathered in this, and previous, investigations. Existing SWMUs located in the Bear Creek watershed which are, or have been, potential sources of hazardous releases include the S-3 Ponds (Unit T-004), Oil Retention Ponds (Units T-008 and T-009), Burial Grounds (D-024), Oil Landfarm (Unit T-014), Sanitary Landfill I (Unit D-101), Rust Spoil Area (Unit D-106), Spoil Area I (Unit D-107), White Wing Scrap Yard (Unit 11.1), and Hazardous Chemical Disposal Area-Burn Yard/Bone Yard (Unit D-024-HC). These SWMUs are currently in various stages of closure or post-closure activity. Three SWMUs (D-106, D-107, 11.1) will be investigated under RCRA in the near future. The S-3 Ponds (T-004) are being closed by capping and are currently under evaluation for demonstration of Alternate Concentration Limits (ACLs). The other SWMUs (T-008, T-009, T-014, portions of D-024 and D-024-HC) are also undergoing closure by capping and will be evaluated for demonstration of ACLs. The main component of post-closure monitoring of these SWMUs will address groundwater at each SWMU boundary and beyond.

This document is the RFI Plan for Bear Creek, including the flood-of-record floodplain. The following assumptions were made in the preparation of this RFI Plan: (1) that source area groundwater monitoring (boundary of each SWMU and beyond, as necessary) will be conducted as a part of the RCRA post-closure activity for each SWMU, and (2) that RCRA post-closure activities associated with each SWMU do not explicitly include a comprehensive assessment of surface water, sediment and floodplain soil contamination in Bear Creek and its tributaries. The RFI Plan is thus intended to provide a more comprehensive evaluation of Bear Creek and its floodplain than would occur if only the investigative monitoring and risk

assessment activities associated with the ten individual SWMUs were carried out. RFI activities will be carefully coordinated with other monitoring and assessment activities to avoid redundancy and to maximize the utility of data gathered during the investigation. Due to the existence of a large environmental database for Bear Creek, many facets of the Bear Creek RFI will be largely confirmatory in scope. Results of the RFI are also expected to be valuable in evaluating the effectiveness of the corrective measures (capping) currently being implemented at several of the SWMUs.

The voluminous extant environmental data on Bear Creek and its floodplain support the following preliminary conclusions regarding the nature, extent and effects of current and historic contaminant releases from the upstream SWMUs:

(1) In spite of the quantities and varieties of contaminants known to have been disposed of in the SWMUs, very few contaminants have been detected in Bear Creek surface water, sediment or floodplain soils at concentrations warranting human health or ecological concern. The chief contaminants and respective media of concern are restricted to polychlorinated biphenyl compounds (PCBs) and uranium in floodplain soil, PCBs in sediment and biota, and nitrate, aluminum, uranium and cadmium in surface waters. Volatile organic compounds (mainly industrial solvents such as trichloroethene and tetrachloroethene) occur in groundwater and certain tributaries at concentrations warranting human health concern, but a direct pathway to man has not been demonstrated due to the near absence of these compounds in mainstem Bear Creek and restriction of groundwater plumes to the immediate area of the SWMUs.

(2) Elevated levels of PCBs and uranium in Bear Creek floodplain soils appear to have resulted from historic releases from the upstream SWMUs and appear not to be related to recent or current releases.

(3) The distribution of PCBs, uranium and cadmium in Bear Creek surface water and sediments as a function of distance from the head of the creek suggest that current low releases of PCBs are derived chiefly from the Burial Grounds (tributaries 7 and 8) and that low releases of nitrate, uranium and cadmium are derived chiefly from the S-3 Ponds. In the latter case, concentrations of these contaminants exhibit a downstream decrease, which is generally consistent with a simple dilution model of contaminant distribution.

(4) The interaction of Bear Creek with shallow groundwater is characterized by alternating stream reaches of recharge and discharge, with two or more springs acting as important return conduits for groundwater recharged in upstream losing reaches of the creek.

(5) The benthic invertebrate community in Bear Creek has shown a pattern of increasing density, biomass and number of species with increasing distance downstream from the S-3 Ponds. Laboratory toxicity tests have shown that water from the headwater area near the S-3 Ponds is frequently toxic to fathead minnow larvae, and routine electrofishing surveys have documented the absence of a stable, resident fish population in the headwater area of Bear Creek.

The RFI surface water sampling plan will characterize contaminant transport during two low flow and four high flow periods to verify previous low flow findings and to determine whether, and to what extent, historically deposited contaminants are being transported further downstream during stormflow. The sediment and floodplain soil sampling plan will verify existing data on contaminant levels in these media in Bear Creek, and will more completely define the horizontal and vertical extent of soil contamination in the Bear Creek floodplain. Groundwater monitoring will address only the migration of contaminants from floodplain deposits into shallow groundwater near Bear Creek. As discussed above, groundwater migration of contaminants from the SWMUs and the interaction of Bear Creek surface water with groundwater in losing and gaining reaches will be addressed by post-closure monitoring of each SWMU and the ACL Demonstrations. Biological monitoring of Bear Creek has been on-going since 1984 and will continue in a coordinated manner with the RFI proposed herein. The biological monitoring program is at present adequately characterizing the ecological health of Bear Creek and monitoring ecological recovery associated with the corrective measures being undertaken in the watershed.

# 1.0 INTRODUCTION

Chemically hazardous wastes from currently operating facilities are regulated under the Resource Conservation and Recovery Act (RCRA), enacted in 1976. This federal statute created a management system for hazardous wastes that involves the permitting of treatment, storage, and disposal (TSD) facilities.

On November 8 1984, Congress enacted the Hazardous and Solid Waste Amendments (HSWA) to RCRA. These amendments provided the U.S. Environmental Protection Agency (EPA) with broad authorities for assuring corrective actions at facilities subject to RCRA and mandated the RCRA corrective action program. The primary objective of the program is to clean up releases of hazardous waste or constituents from solid waste management units (SWMUs) at TSD facilities. A SWMU is defined as any "discernible waste management unit at a RCRA facility from which hazardous waste or hazardous constituents might migrate, irrespective of whether the unit was intended for the management of solid or hazardous waste."

Among the most significant provisions of the HSWA are:

- Section 3004(u) - Corrective Action for Continuing Releases
  Section 3004(u) of the HSWA states that permits issued after November 8 1984, require corrective action for releases of hazardous waste or constituents from any SWMU at any TSD facility seeking a Part B Permit, regardless of when waste was placed in the unit.
- Section 3004(v) - Corrective Action Beyond the Facility Boundary
  Section 3004(v) authorizes EPA to require that corrective action be taken by the facility owner or operator for releases that have migrated beyond the facility boundary (off-site). Such action should be taken where necessary in order to protect human health and the environment unless the owner/operator demonstrates that permission to undertake such action was denied.

These authorities broaden the scope of the RCRA corrective action program from detecting and correcting releases from regulated units to cleaning up continuing problems resulting from other waste management units and

practices at RCRA facilities. Before passage of the HSWA, EPA's authority under Section 3004 to require corrective action for releases of hazardous constituents under RCRA was limited to groundwater releases from units that were covered by RCRA permits. The post-HSWA program extends RCRA authority to correct releases to all media (soil, surface water, groundwater, subsurface gas, and air), (EPA 1986a), and all units at RCRA facilities.

Corrective actions apply to past releases as well as to any releases presently occurring from these units. For any facility seeking a RCRA permit, schedules for compliance with corrective action requirements will become conditions of facility permits. Regulatory authority resides with the EPA and/or with state agencies that are authorized by EPA to implement equivalent hazardous waste management programs. The state of Tennessee has not, as yet, been authorized to implement the extensive changes to RCRA enacted in the HSWA.

Based on information provided in the EPA Draft RCRA Facility Investigation Guidance, Volume I (EPA 1986a), the corrective action program consists of three phases:

- the RCRA Facility Assessment (RFA), which identifies releases or potential releases requiring further investigation;
- the RCRA Facility Investigation (RFI), which fully characterizes the extent of releases; and
- a corrective measures (CM) assessment, which determines the need for, selects, and implements appropriate remedial actions.

An RFA was conducted for the Y-12 Plant (Welch et al. 1987), which resulted in the decision to perform RFIs or initiate closures for the following SWMUs which have received liquid plant discharges and/or solid wastes containing hazardous, or potentially hazardous, constituents:

| SWMU | Unit Number | RFI Plan Schedule |
|---|---|---|
| S-3 Ponds | T-004 | Closure Begun |
| Oil Retention Ponds | T-008,T-009 | Closure Begun |
| Oil Landfarm | T-014 | Closure Begun |

| | | |
|---|---|---|
| Bear Creek Burial Grounds | D-024 | Closure Begun |
| Sanitary Landfill I | D-101 | Closed |
| Rust Spoil Area | D-106 | 1987 |
| Spoil Area I | D-107 | 1987 |
| Hazardous Chemical Disposal Area-Burn/Yard-Bone Yard | D-024-HC | Closure Begun |
| Bear Creek | - | December 1988 |

In addition to these SWMUs listed by Y-12 in the RFA (Welch et al. 1987), Oak Ridge National Laboratory (ORNL) has listed one SWMU, the White Wing Scrap Yard (No. 11.1), which is located in the Bear Creek watershed. This RFI Plan will address surface water and groundwater releases from these SWMUs to Bear Creek.

The RFI Plan for Bear Creek shall, therefore, address, characterize, and define the following:

- methods and specific actions necessary to determine whether prior or continuing releases have occurred and/or to characterize the nature and extent of releases;
- pathways of contaminant transport (air, soil/sediment, surface water, or groundwater); and
- current and future receptors.

## 1.1 CURRENT REGULATORY STATUS

Major installations located within the Oak Ridge Reservation (ORR) which contain presently operating TSD units are the Oak Ridge Gaseous Diffusion Plant (ORGDP), the Oak Ridge National Laboratory (ORNL), and the Y-12 Plant.

The first RCRA permit to be approved for the ORR under the HSWA provisions became effective October 1986. The permit was for a hazardous waste storage building at ORNL. Section II.A.1 of this permit specified that general information for all ORR SWMUs was to be provided to the regulatory authority. For SWMUs at the Y-12 Plant, this information was to be provided by April 24 1987, as part of the Y-12 Plant RFA (Welch et al.

1987). Under Section II.A.2 of the permit, an RFI Plan and a proposed schedule for implementation and completion of the RFI is to be prepared for each SWMU which is known, suspected, or presumed to have released hazardous wastes or hazardous constituents to the environment.

In order to meet these requirements, two types of RFI Plans have been prepared for the Y-12 Plant. The RCRA Facility Investigation Plan-General Document, Volumes I through III (Welch 1987, Wiggins 1988, Wiggins et al. 1988) for the Y-12 Plant includes information applicable to all Y-12 Plant SWMUs and serves as a reference document for the second type of document, a site-specific RFI plan for each SWMU.

## 1.2 RFI PLAN FOR BEAR CREEK

This document is the site-specific RFI Plan for a predominantly off-site area (Bear Creek and its floodplain) contaminated by releases from the SWMUs located in the Bear Creek watershed. The Bear Creek watershed is located entirely within the boundaries of the Oak Ridge Reservation (Figure 1.1). Bear Creek originates as an on-site surface water drainage system near the S-3 Ponds (SWMU T-004) at the Y-12 Plant. The reach of Bear Creek from its origin immediately east of the S-3 Ponds to the first crossing of Bear Creek Road at km 11.97 (Mile 7.44) is referred to as Upper Bear Creek (UBC). UBC received historical releases of contaminants, including nitrate, uranium and heavy metals, from the S-3 Ponds via groundwater. Recent or historical releases from the other SWMUs (Rust Spoil Area and Spoil Area I) near this reach of Bear Creek may also have occurred. The reach of Bear Creek downstream of km 11.84 (Mile 7.36) and upstream of km 11.28 (Mile 7.01) may be receiving, or have received, releases from the Oil Landfarm, Sanitary Landfill I, and the Hazardous Chemical Disposal Area-Bone/Burn Yard located immediately north of this reach. These SWMUs were used for the disposal of a large variety of organic and inorganic contaminants. The reach of Bear Creek downstream of km 10.40 (Mile 6.46) and upstream of km 9.42 (Mile 5.86) may be receiving, or have received, releases from the Burial Grounds and Oil Retention Ponds located immediately north of this reach. These SWMUs were also used for disposals (or recoveries in the case of the ponds) of a wide variety of inorganic and

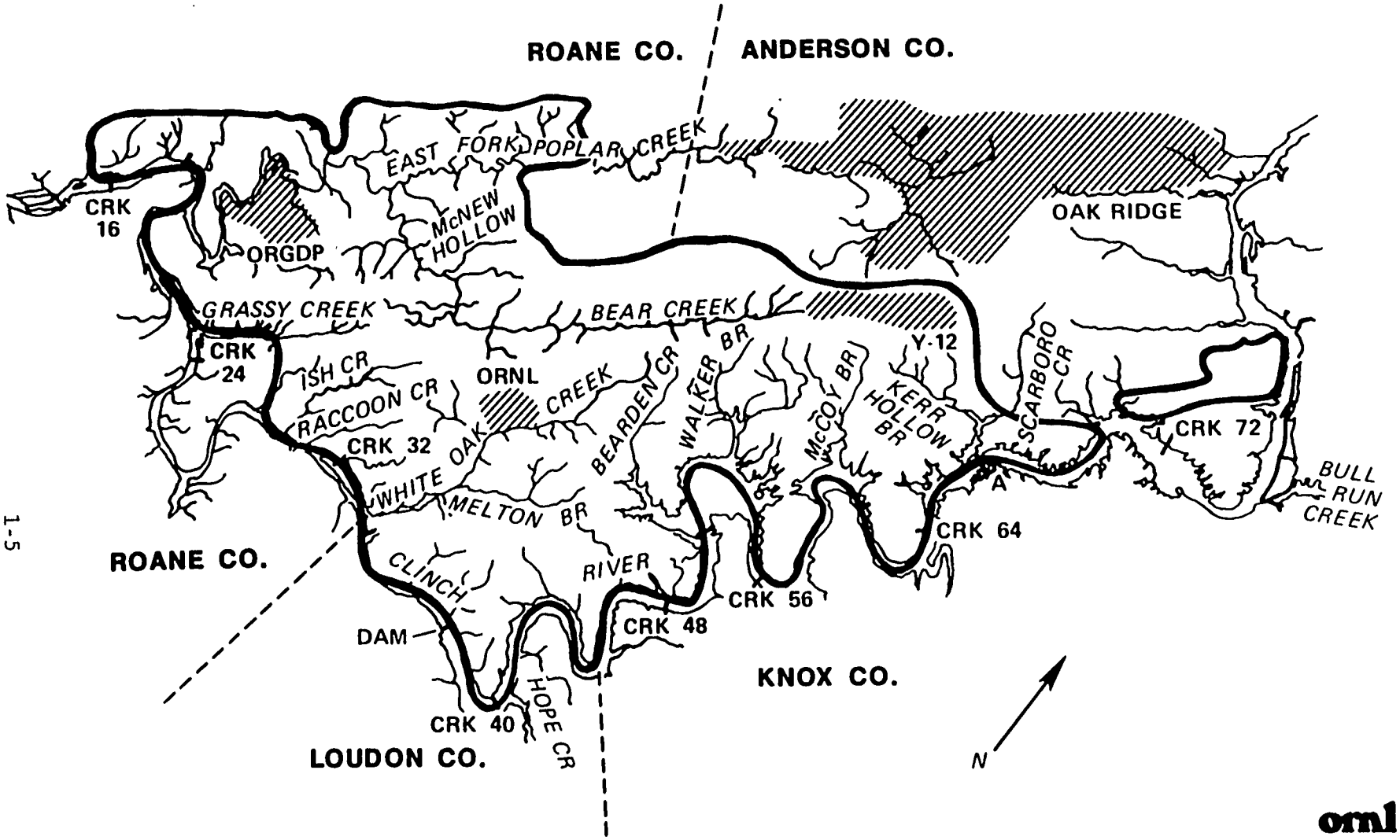


Fig. 1.1. General location of Bear Creek Watershed.

organic contaminants. The reach of Bear Creek downstream of km 2.27 (Mile 1.41) may be receiving, or have received releases from the White Wing Scrap Yard, which was used for the storage of contaminated scrap metals and other waste.

This RFI Plan will (1) evaluate the available data relevant to determining whether releases from these SWMUs have contaminated, or are contaminating, Bear Creek or its floodplain, (2) characterize the nature and extent of any such contamination within the limits of the available data and (3) propose an investigative plan to verify earlier findings and to complete the characterization. Contained within this RFI Plan are geographical, historical, operational, geological, and hydrological data specific to Bear Creek and its floodplain. The potential for further release of contaminants from the Bear Creek floodplain through various media to receptors is addressed. A sampling and sample analysis plan is proposed to further determine the extent of contaminant release to the surrounding environment. Included are health, safety, quality assurance, and quality control procedures to be followed when implementing the sampling plan. Procedures for managing and displaying data collected for the RFI are also summarized.

## 1.3 SPECIAL PROBLEMS

Several factors contribute to the uniqueness of this site-specific RFI Plan. RFI Plans are generally prepared for SWMUs and report formats are arranged accordingly. However, this RFI Plan is being prepared for a creek (Bear Creek). The creek has received and continues to receive releases from several active and inactive SWMUs. The creek and its floodplain are not a SWMU. Fitting discussions for this site-specific RFI Plan into the standard RFI format for SWMUs is somewhat awkward, although attempts have been made to follow standard format throughout this document.

Second, the Y-12 Plant standard procedure for preparation of site-specific RFI Plans involves reliance upon a general RFI Plan which contains information relevant to all site-specific SWMUs. As a result, the general document contains mainly on-site information specific to the Y-12 Plant. The creek and its floodplain addressed by this RFI Plan are predominantly

located off-site, resulting in the inability to rely upon the general RFI Plan in many instances.

Third, several SWMUs are defined as being the source of contamination for Bear Creek, due to known, suspected or presumed releases. However, complete characterization of all of these SWMUs has not been completed. Several are currently undergoing closure activity, including assessment monitoring. For these reasons, the sampling and analytical plans presented in this site-specific RFI Plan may require revision pending future characterization of certain SWMUs.

# 2.0 OBJECTIVES OF THE RCRA FACILITY INVESTIGATION PLAN

The primary purpose of an RFI Plan is to identify actions necessary to enable adequate evaluation and characterization of the extent of contamination resulting from releases of hazardous waste or hazardous constituents (EPA 1986a). Information generated during the RFI will be used to determine the need for corrective measures and also as an aid in the selection and implementation of corrective measures. Due to extensive recent (1983-1988) environmental characterization completed prior to ongoing closures of several SWMUs, the RFI will also be used to evaluate the effectiveness of corrective measures already undertaken.

Generally, the RFI Plan is used as a basis for implementing an RFI at the individual SWMU. However, for the purpose of this project, an RFI Plan is being prepared for an area that has received releases from several SWMUs.

This RFI Plan for Bear Creek proposes, in detail, the manner in which the RFI will be conducted. The area of investigation encompasses the entire length of Bear Creek from the headwaters adjacent to the S-3 Ponds to the confluence of Bear Creek with East Fork Poplar Creek, including Bear Creek proper and its floodplain. Portions of tributary streams, defined by the flood-of-record floodplain of Bear Creek, are also included in this RFI Plan.

## 2.1 PROJECT SCOPE AND OBJECTIVES

### 2.1.1 Project Scope

The RFI Plan will summarize previous studies and present a strategy for collecting additional data, as necessary, in order to evaluate and characterize the extent of chemical and/or radioactive contamination in Bear Creek and its floodplain. Proposed groundwater monitoring will address only the migration of contaminants from floodplain deposits into shallow groundwater near Bear Creek. Groundwater monitoring of contaminants in the SWMUs and the interaction of Bear Creek surface water

with groundwater in losing and gaining reaches will be addressed by post-closure monitoring of each SWMU and Alternate Concentration Limit (ACL) demonstrations.

### 2.1.2 Project Objectives

The first objective of the Bear Creek RFI Plan is the review of data gathered from various studies of Bear Creek and its flood-of-record floodplain. Studies of the SWMUs which may have contributed contaminants to Bear Creek are reviewed only to the extent that contaminants of potential concern can be identified. Contaminants of potential concern include those known, suspected or presumed to have been disposed or spilled in a SWMU.

As a second objective of the RFI Plan, the data will be assessed and any additional data needs will be identified using the EPA Draft RCRA Facility Investigation Guidance, Volumes I, II, III, and IV, (USEPA 1987a.

## 2.2 EVALUATION CRITERIA

Existing data will be evaluated in terms of: (1) collection under appropriate standards and procedures, such as those described by EPA;
(2) pertinence to data needs established by this study; and
(3) applicability to appropriate government regulations.

Where additional data are needed in order to effectively prepare and implement a comprehensive sampling plan and evaluate analytical results, evaluation criteria must first be established. Criteria for evaluating the extent of contaminant release are generally based on existing federal and state regulatory guidance and best technical judgement.

The primary media of interest for the Bear Creek area, which includes the creek and its floodplain, are soil, sediment, groundwater, and surface water, as specified in the RFA. Criteria for evaluating the extent of release of contaminants are set forth in Section 7.0 of this RFI Plan. Characterization levels will be based on existing state and federal regulatory guidance, elevation of contamination above background levels or best technical judgment. Types of criteria which will be used include, but are not limited to, Maximum Contaminant Levels (MCLs) promulgated under the

Safe Drinking Water Act, Health-Based Criteria, or Water Quality Criteria (EPA 1987). If the selected criteria are exceeded, a risk assessment will be conducted.

## 2.3 SCHEDULES FOR SPECIFIC ACTIVITIES

A list of RFI sampling and analysis activities and their duration is provided in Table 2.1 for Bear Creek. Characterization of contamination during the RFI will be conducted using a phased approach. The initial sampling phase will serve to confirm existing data on contaminant levels in the Bear Creek floodplain (especially PCBs), identify additional contaminants of concern within Bear Creek and its floodplain, and to provide approximations of the vertical and horizontal extent of contamination within these areas.

Subsequent sampling phases will depend upon the information obtained during the initial sampling phase. It is expected that subsequent phases will involve:

1. expanding the number of soil sampling locations at particular sites to a larger area or depth, or increasing sampling density as needed;
2. institution of a random grid sampling approach to assess areas of contamination identified by first phase sampling;
3. addition or deletion of specific monitoring constituents; and/or
4. evaluation of storm flow erosion and transport of floodplain contaminants.

Although formal initiation of the RFI schedule (Table 2.1) is expected to be delayed until ongoing closure activities at several SWMUs are completed, preparatory activities, such as establishment of permanent hydrologic monitoring sites, will commence as soon as practical after regulatory approval of the RFI Plan.

## 2.4 GENERAL RISK ASSESSMENT

The public health risk associated with existing contamination in Bear Creek and its floodplain will be evaluated in a separate study.

Table 2.1. Schedule of Phase I RFI Activities for Bear Creek

| Activities | Duration |
|---|---|
| 1. Site preparation and establishment of sampling locations | |
| (a) Soil/Sediment | 1-2 days/site |
| (b) Groundwater | 0.5-3.5 days/site |
| (c) Surface Water | 66 days/quarter |
| 2. Collection of samples | |
| (a) Soil/Sediment | 0.2-0.3 days/site |
| (b) Groundwater | 0.75 days/site |
| (c) Surface Water | 5 days/quarter |
| 3. Analysis of samples | |
| (a) Soil/Sediment | 6 weeks |
| (b) Groundwater | 6 weeks |
| (c) Surface Water | 6 weeks/quarter |
| 4. Compilation of data and data presentation | 6 weeks |
| 5. Evaluation of results and recommendations | 4 weeks |
| 6. Preparation of RFI report and submittal to EPA | 10 weeks |
| 7. Additional sampling phases as needed | TBD |

TBD = To be determined

## 2.5 FEASIBLE ALTERNATIVES

The RFI Plan is designed to obtain information necessary to support feasibility studies. The remedial action alternatives that will be evaluated will include those addressed in the EPA Handbook, Remedial Action at Waste Disposal Sites (Revised) (EPA 1985a). Evaluation of feasible alternatives for remediation of contaminated areas within Bear Creek and its floodplain should include:

(1) methods for elimination of the contaminant source(s),

(2) methods for control of migration and redisposition of floodplain soils and creek sediments,

(3) potential environmental impacts of proposed alternatives, and

(4) provision of worker health and safety during all phases of characterization and remediation.

Currently, Bear Creek receives tributary and groundwater inflows, which originate in several SWMUs which have been, or may be, sources for a variety of contaminants. In addition, uranium and PCB contamination exists along Bear Creek, primarily in floodplain soil. Other toxic metals are also present in lesser quantities. Concentrations are generally higher in the floodplain than the main channel due to water movement that continuously erodes and transports these sediments downstream. Some channel bank areas also contain high PCB and uranium concentrations. These areas are particularly sensitive to erosion due to minimal stabilization by vegetation. Under existing site conditions, significant amounts of contaminated sediments and floodplain soils will remain in Bear Creek and its floodplain for many years and may continue to serve as a source of contaminants to downstream waters.

Three general types of response actions exist for Bear Creek remediation:

(1) source removal,

(2) application of in situ corrective measures, and

(3) no action.

Different actions or combinations of actions may be appropriate at varying locations within Bear Creek and its floodplain. However, guidance for selection of specific actions is not provided in this document. Instead,

knowledge of feasible response actions was used during preparation of this RFI Plan. These response actions will be re-evaluated following completion of the RFI.

### 2.5.1 Source Removal

The current primary sources of contaminant contribution are the upstream SWMUs, while the Bear Creek floodplain serves as a secondary contaminant source. For Bear Creek, this response includes partial or complete removal and appropriate treatment/disposal of PCB- and uranium-contaminated soil and sediment. However, removal of contaminated soil/sediment in Bear Creek and its floodplain will not be effective unless the current sources of contaminant contribution are also eliminated. Therefore, source removal must also include closure of the contributing SWMUs.

### 2.5.2 Application of In Situ Corrective Measures

For Bear Creek, corrective measures that minimize erosion of source constituents (soil/sediment) or incidental direct contact include the use of protective covers and lateral erosion barriers at selected locations.

Protective covers can include the following:

- bituminous compounds,
- vegetation,
- clay, and
- polyethylene or polyvinyl chloride sheeting.

Lateral erosion barriers can include the following:

- riprap,
- sheet piling, and
- concrete.

### 2.5.3 No Action

For Bear Creek, the no action alternative can be enacted in areas where the source effect is minimal when compared to the effect on human health and the environment if removal or corrective action were employed. For example, certain regions of contaminated soil/sediment may not be

removed from Bear Creek or the floodplain if dredging would result in resuspension and redistribution of contaminants when none are currently being released from the area.

### 2.5.4 Alternatives Risk Assessment

The environmental and public health risks resulting from the remedial action alternatives presented in Section 2.5 will be evaluated by characterizing contaminant sources, the associated environmental setting, the magnitude of the release, and pathways to human exposures. Risk assessment will begin early in the RFI process since it will be useful for determining data requirements and may influence site sampling plans.

# 3.0 DESCRIPTION OF CURRENT CONDITIONS

## 3.1 GEOGRAPHICAL INFORMATION

Extensive geographical information concerning the Y-12 Plant, its facilities within Bear Creek watershed and the surrounding area are given in Welch (1987a). The Bear Creek watershed is located entirely within the boundaries of the DOE Oak Ridge Reservation (Fig. 1.1) and contains no privately owned lands. The watershed occupies portions of both Roane County and Anderson County. The creek originates at the western margin of the Y-12 Plant. The hydrologic divide between Bear Creek and East Fork Poplar Creek is just east of the S-3 Ponds. Land use in the headwater area is characterized by a network of paved and unpaved roads, parking lots, waste water storage and treatment facilities, construction fill and borrow areas and forested lands. Appendix M contains a detailed topographic map set on a 1:100 scale and 2-ft contour interval.

Bear Creek flows southwestward from its origin 4.8 miles to the junction of Bear Creek Road and State Route 95 (White Wing Road). Land use over this reach of the creek is predominantly (65%) forest, with open land areas composed of old fields, roads, utility corridors and waste disposal areas. At State Route 95 the creek turns northward and flows approximately 3.2 miles through a water gap in Pine Ridge to the confluence with East Fork Poplar Creek. Except for roads, utility corridors and one small waste storage area, this portion of the Bear Creek watershed is entirely forested.

The Bear Creek watershed has a drainage area of 7.4 square miles (18.3 $km^2$). The stream channel is characterized by steep banks and cuts about 5 ft into the unconsolidated clays and silty soils of the floodplain. Underlying shale and limestone beds are visible as outcrops along the mainstem of Bear Creek and its tributaries. The average gradient of the creek from the headwaters at mi 8.0 (BCK 12.87) to the confluence with East Fork Poplar Creek is 30 ft/mi (5.6 m/km). Most of the drainage area is bounded by Pine Ridge on the northwest and Chestnut Ridge on the southeast.

Table 3.1 provides a listing of creek landmarks referenced to kilometers or miles above the confluence of Bear Creek with East Fork Poplar Creek. The use of creek kilometers to describe monitoring and sampling sites along the creek and its tributaries is applied throughout this document. TVA maps showing mi markings were used originally to establish the kilometer locations. Sites are designated as 'BCK', for 'Bear Creek Kilometer', plus the kilometer value, e.g., BCK-4.55. As indicated in the footnote to Table 3.1, tributaries are designated as NT, ST, WT or ET plus a value representing the tributary number counting from the headwaters. Thus NT-14 is the 14th tributary originating on the north side of Bear Creek. Tributaries can also have a second identifier that shows the direction off the main tributary and the distance from the confluence with Bear Creek. For example, BCK-6.23 N0.32 refers to a point that is 0.32 km up a tributary that enters Bear Creek at Kilometer 6.23 from the north. This site also has the common name NT-14. Springs follow an identical naming convention. Figures 3.2 and 3.3 show some important localities using this site naming system.

## 3.2 HISTORICAL BACKGROUND

At the time that the federal government acquired the Oak Ridge Reservation in 1941, approximately 50% of the Bear Creek watershed was cultivated, including both row crops and pasture. Aerial photographs from 1939 show far more open lands than exist today and numerous homesites. Most of these homesites were razed or simply allowed to collapse and be taken over by the forest.

### 3.2.1 Engineered Modifications

Engineered modifications of Bear Creek have included road crossings (See Table 3.1), channel relocations and small impoundments. Comparing the trace of Bear Creek on 1939 aerial photographs with modern photographs revealed at least three sections of the creek channel that were relocated since 1939 (Fig. 3.4). Construction of a sanitary landfill adjacent to the reach between BCK-11.15 and BCK-11.83 resulted in relocation of the creek channel to the south of its original location. Improvements to Bear Creek

Table 3.1. Bear Creek Kilometer (mile) Locations

| Kilometer | Mile | Landmark[a] |
|---|---|---|
| 12.87 | 8.00 | Headwaters near S-3 Ponds |
| 12.46 | 7.74 | Road (gravel) crossing between "lagoons" |
| 12.39 | 7.70 | Confluence with tributary NT-1 |
| 12.38 | 7.69 | Confluence with spring SS-1 |
| 11.97 | 7.44 | Bear Creek Road crossing |
| 11.96 | 7.43 | Confluence with tributary NT-2 |
| 11.84 | 7.36 | Road (gravel) crossing at east end of Oil Landfarm |
| 11.68 | 7.26 | Confluence with spring SS-2 |
| 11.67 | 7.25 | Confluence with spring SS-3 |
| 11.59 | 7.20 | Confluence with tributary NT-3 |
| 11.28 | 7.01 | Road (gravel) crossing at west end of Oil Landfarm |
| 11.15 | 6.93 | Confluence with tributary NT-4 |
| 10.94 | 6.80 | Confluence with tributary ST-1 |
| 10.78 | 6.70 | Confluence with tributary NT-5 |
| 10.40 | 6.46 | Confluence with tributary NT-6 |
| 10.27 | 6.38 | Road (gravel) crossing at entrance to Burial Grounds |
| 10.14 | 6.30 | Confluence with spring SS-4 |
| 9.99 | 6.21 | Confluence with tributary NT-7 |
| 9.98 | 6.20 | Road (gravel) crossing at west end of Burial Grounds |
| 9.45 | 5.87 | Confluence with tributary NT-8 |
| 9.42 | 5.86 | Road (asphalt) crossing (Bear Creek Rd) |
| 9.41 | 5.85 | Confluence with spring SS-5 |
| 9.06 | 5.63 | Confluence with tributary NT-9 |
| 8.67 | 5.39 | Confluence with tributary NT-10 |
| 7.92 | 4.92 | Confluence with tributary ST-2 |
| 7.89 | 4.90 | Road (asphalt) crossing (Bear Creek Rd) |
| 7.77 | 4.83 | Confluence with tributary NT-11 |
| 7.44 | 4.62 | Confluence with tributary NT-12 |
| 7.11 | 4.42 | Confluence with spring SS-6 |
| 6.89 | 4.28 | Road (gravel crossing |
| 6.76 | 4.20 | Confluence with tributary NT-13 |
| 6.66 | 4.14 | Confluence with tributary ST-3 |
| 6.23 | 3.87 | Confluence with tributary NT-14 (Gum Hollow Branch) |
| 6.21 | 3.86 | Road (gravel) crossing |
| 5.54 | 3.44 | Confluence with tributary ST-4 |
| 5.33 | 3.31 | Confluence with tributary NT-15 |
| 4.68 | 2.91 | Road (asphalt) crossing east of S.R.95 (White Wing Rd) |
| 4.65 | 2.89 | Confluence with spring SS-7 |
| 4.56 | 2.84 | Confluence with spring SS-8 |
| 4.55 | 2.83 | Cipolletti weir (NPDES monitoring site) |

Table 3.1. (continued)

| Kilometer | Mile | Landmark[a] |
|---|---|---|
| 4.47 | 2.78 | Road (asphalt) crossing at S. R.95 |
| 4.44 | 2.76 | Confluence with tributary ST-5 |
| 4.38 | 2.72 | Confluence with tributary WT-1 |
| 4.09 | 2.54 | Confluence with tributary ET-1 |
| 4.06 | 2.52 | Confluence with tributary WT-2 |
| 3.60 | 2.24 | Confluence with tributary ET-2 (McNew Hollow) |
| 3.30 | 2.05 | Confluence with tributary ET-3 |
| 2.41 | 1.50 | Road (asphalt) crossing east of junction S.R.95 and S.R.58 |
| 2.27 | 1.41 | Confluence with tributary WT-3 and ET-4 |
| 2.01 | 1.25 | Road (asphalt) crossing at junction of S.R.95 and S.R.58 |
| 1.82 | 1.13 | Confluence with tributary WT-4 |
| 1.74 | 1.08 | Road (gravel) crossing |
| 1.48 | 0.92 | Road (gravel) crossing |
| 0.88 | 0.55 | Road (gravel) crossing |
| 0.63 | 0.39 | Road (gravel) crossing |
| 0.0 | 0.0 | Confluence with East Fork Poplar Creek |

[a]Naming convention: ET = eastern tributary, WT = western tributary, NT = northern tributary, ST = southern tributary, SS = south side spring, NS = north side spring.

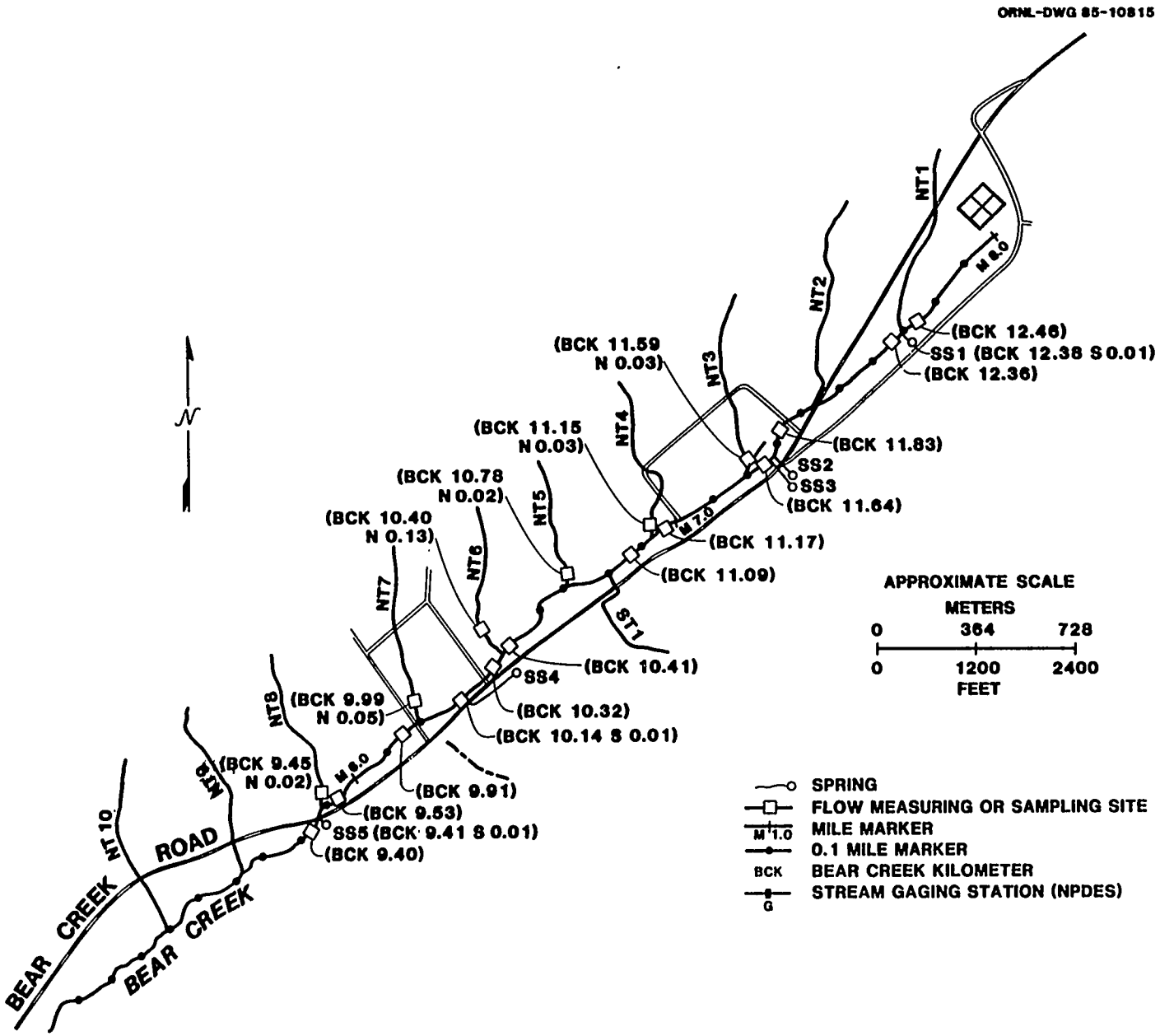


Fig. 3.2. Nomenclature for Upper Bear Creek mainstem and tributary locations.

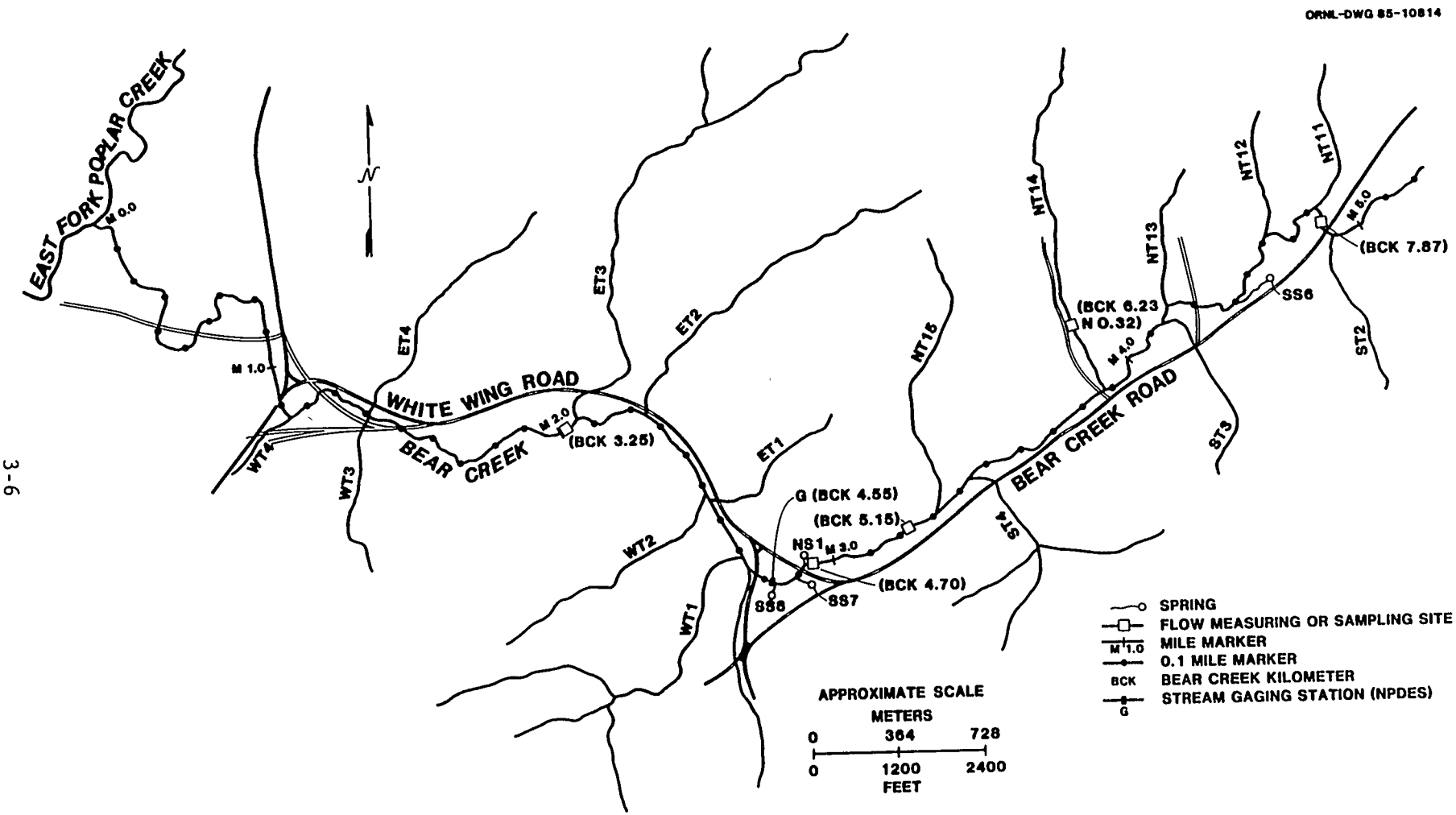


Fig. 3.3. Nomenclature for Lower Bear Creek mainstem and tributary locations.

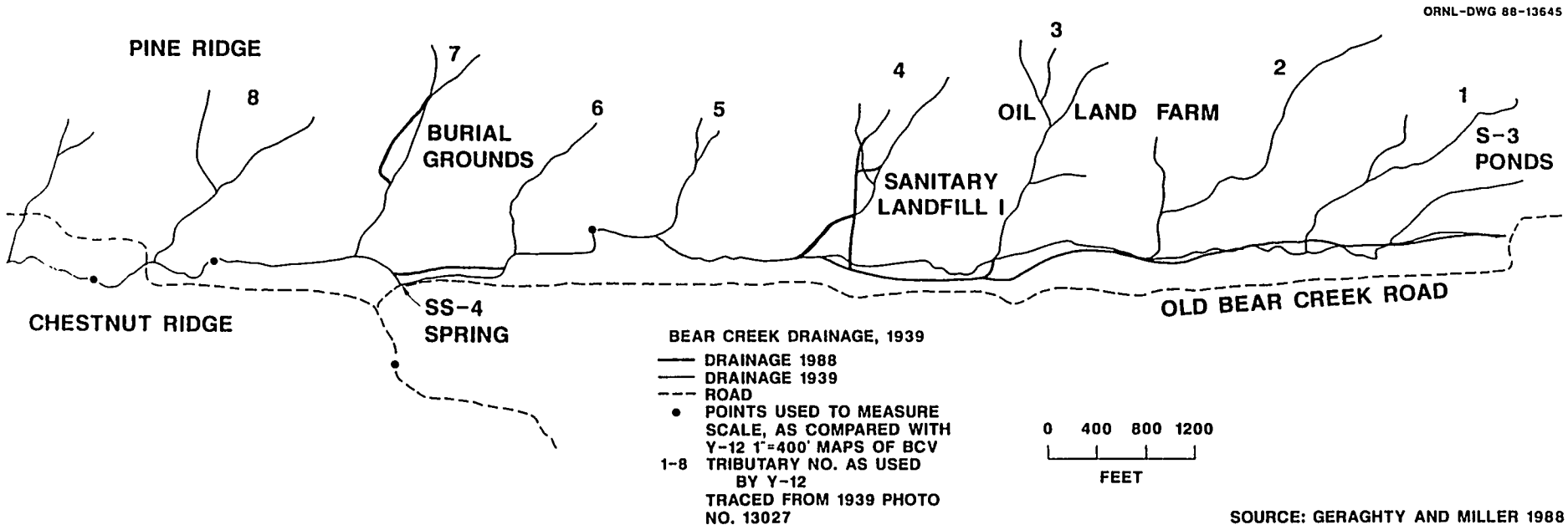


Fig. 3.4. Comparison of Bear Creek Drainage in 1939 with present-day drainage.

Road and construction of a utility corridor adjacent to Bear Creek Road resulted in relocation of the reach of Bear Creek between BCK-10.14 and BCK-10.36 to the north of its original location.

In 1972 two lagoons were dug in the channel of Bear Creek near BCK-12.46 to collect sufficient water contaminated with nitrate for an experimental forest fertilization project. In 1988 these lagoons were again excavated to remove contaminated sludges which had accumulated since their construction. The lagoons were then filled and stabilized with stone riprap (HSEAD 1988).

In 1970 a concrete and steel weir was constructed at BCK 4.55 to serve as a discharge monitoring station for Bear Creek. This structure permanently flooded a small upstream area.

In 1978 the intersection of State Route 58 and State Route 95 was improved by construction of an overpass and ramps. This activity necessitated some disturbance and minor relocation of the channel of Bear Creek in this area (near BCK-2.01).

In 1986 the Bear Creek Road crossing at BCK-9.42 was improved by installing new steel culvert in the existing wood-roofed concrete culvert and grouting. This operation resulted in the removal of sediment in the original culverts and minor disturbance of the adjacent floodplain.

In 1988 a 100 m reach of Bear Creek at BCK-6.89 was temporarily relocated to allow construction of an improved road crossing for a haul road associated with closure of the waste disposal areas. Although Bear Creek was returned to its original channel, the channel was widened and stabilized with stone riprap.

### 3.2.2 Sources of Contamination

For the purpose of this RFI Plan, the Y-12 and ORNL waste disposal facilities located in the Bear Creek watershed are considered to be the primary contaminant sources. As discussed previously, the Y-12 RFA listed nine SWMUs associated with Y-12, including two construction spoil areas, liquid waste percolation ponds, a sanitary landfill, an oil landfarm, a hazardous chemical disposal/storage area, a solid waste burial area and two ponds used to capture any oil which might seep from the burial grounds

(Fig. 3.5). In addition, ORNL has listed a contaminated metal scrapyard as existing within the Bear Creek watershed. The following section briefly describes the operational history of each of these facilities.

While the facilities are, or were, the original sources of contamination, secondary sources now exist in the sediments and floodplain deposits of Bear Creek. These secondary sources may continue to release contaminants into Bear Creek surface water and groundwater even after upstream releases from the SWMUs are eliminated.

## 3.3 OPERATIONAL BACKGROUND

### 3.3.1 S-3 Ponds

The S-3 Ponds are located adjacent to the west end of the Y-12 Plant (Figs. 1.1 and 3.5). The S-3 Ponds, constructed in 1951, consist of four unlined impoundments covering an area of roughly 400 ft x 400 ft. The original pond excavations penetrated residual soil and fill materials but did not extend down to bedrock. Prior to closure in 1988, the Ponds were approximately 17 ft deep and contained variable amounts of sludge ranging from 2 ft to 5 ft in thickness. The sludges were produced by the neutralization and in situ denitrification of wastewater in the Ponds. While in operation, each pond had a storage capacity of 2.5 million gallons (McCauley 1985a).

Waste products were discharged into the Ponds from tank trucks, small containers, and an underground pipeline, which was abandoned and plugged in 1983. The wastes consisted primarily of nitric acid, nitrate waste, pickling and plating wastes, and miscellaneous liquid wastes associated with routine clean-up operations (mop water). Other wastes included dilute acid, machine coolants, caustic solutions, biodentrification sludges, and acids with a pH of less than 2.0. During the mid-1950s, uranyl nitrate solutions containing small amounts of plutonium were discharged into the Ponds. Depleted uranium in nitric acid solution and technetium contained in raffinate and condensate also may have been placed in the Ponds while they remained in operation. All waste discharges into the Ponds terminated in March 1984 (McCauley 1985a).

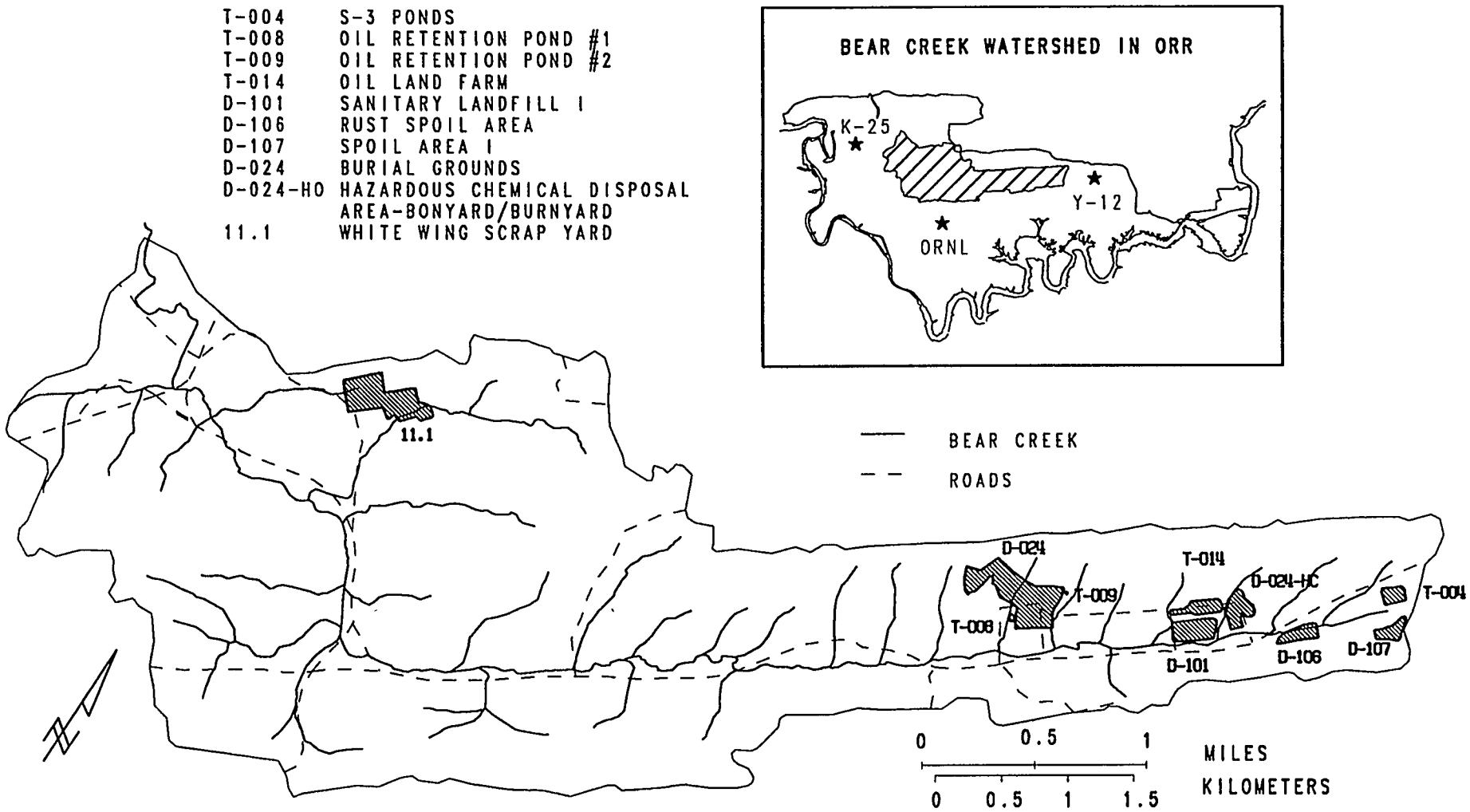


Fig. 3.5. Locations of solid waste management units in Bear Creek Watershed.

Influent discharge rates varied throughout the period of operation, but the amount of waste was significantly reduced when a nitric-acid recovery system became operational in 1976. In 1983, the annual quantity of liquid waste entering the Ponds was reported to be about 2.7 million gallons. The annual loss from the Ponds due to evaporation was estimated to be one-half to two-thirds the annual input from direct rainfall, or about 3 million gallons (HSEAD 1987a).

In-situ treatment of wastewater in the S-3 Ponds began in 1983 and continued until September 1984. Between May and November 1983, liquids in all four of the Ponds were neutralized. Biodenitrification of the liquids occurred from May 1983 to September 1984, causing nitrate levels in the pond water to decrease to about 100 parts per million (ppm). Nutrients continued to be added to the Ponds to maintain the bioreaction and aerators agitated the sludge to denitrify the residuals. Subsequently, nitrate levels were maintained below 50 ppm in the pond water (McCauley 1985a). A detailed discussion of the in-situ denitrification process is provided in Makarewicz et al. (1985).

After denitrification, the contents of the Ponds were allowed to settle and the supernatant was pumped to the S-3 Ponds Treatment Facility for removal of trace metals and organics. A flexible hose attached to the suction side of the pump allowed decanting of remaining small pockets of liquid on the surface of the sludge. The treatment steps for the supernatant included pH adjustment, precipitation, coagulation, flocculation, carbon adsorption, filtration, and chlorination. Treated effluent was discharged to East Fork Poplar Creek in accordance with a National Pollutant Discharge Elimination System (NPDES) permit. The supernatant treatment began in 1985 and was completed by the spring of 1986. In April and May 1988, precipitates and contaminated sediment from two artificial lagoons (see Section 3.2.1) in Upper Bear Creek adjacent to the S-3 Ponds were transferred by sludge tanker and dump trucks to the southwest cell of the Ponds. Immediately following this operation, closure of the Ponds by filling and capping began (HSEAD 1988a) and was still underway at the time this report was prepared.

### 3.3.2 Rust Spoil Area

Rust Engineering, a DOE prime contractor, conducts various renovation, maintenance, and construction operations at the Y-12 Plant. Solid waste (spoil material) generated during these operations has been disposed of in an area on the DOE Reservation known as the Rust Spoil Area. The Rust Spoil Area was operated during the period 1975 to 1983. The 5.4-acre site measures approximately 300 ft x 900 ft in area and 10 ft in depth (Welch 1987b).

The Rust Spoil Area was operated as a dump with periodic grading (typically once per month) to promote positive drainage. Dumping progressed northward from Old Bear Creek Road. As dumping occurred, the natural topography was elevated and a portion of the Bear Creek Channel was filled. Eventually, the stream channel course was relocated to the north to compensate for the outslope progression. Based on a review of maps depicting the topography before and after the disposal operations, it is estimated that less than 100,000 cubic yards of construction debris and spoil were disposed of at the site. The spoil material apparently was not covered with soil. Because routine compaction of the soil was not intended but occurred only as grading took place, it is likely that the compaction operations at the site were somewhat deficient. No formal design plans were developed for the disposal area (Welch 1987b).

Site closure activities began in the fall of 1983 with the preparation of the site's closure plan. The plan called for grading and shaping the existing fill, capping the entire fill area with a minimum of 2 ft of soil, and establishing vegetative growth over all the disturbed areas. The species of the capping plan called for a minimum of 1.5 ft of compacted clay and 0.5 ft of topsoil to be placed over the site. The clay layer would be compacted in maximum 8-inch lifts. Closure began in late 1983 and was completed in mid-1984 (Welch 1987b).

### 3.3.3 Spoil Area I

Spoil Area I is located west of the Y-12 Plant on Old Bear Creek Road near the junction with West Patrol Road (Fig. 3.5). Various renovation, maintenance, and construction operations at the Y-12 Plant have produced

construction debris that includes concrete, asphalt, brick, brush, rock, and tile. Solid waste (spoil material) generated during these operations has been disposed of in Spoil Area I. Spoil Area I has been in operation since about 1980 as a nonhazardous, non-radioactively contaminated construction spoil disposal area. The site is approximately 5 acres in size. Since 1985, Spoil Area I has had a permit from the Tennessee Department of Health and Environment as a landfill for rubble and non-combustible, non-putrescible solid waste. It is estimated that roughly 100,000 cubic yards of non-uranium contaminated construction debris have been disposed at the site (Welch 1987c).

### 3.3.4 Hazardous Chemical Disposal Area-Bone/Burn Yard

The Hazardous Chemical Disposal Area is directly southwest of the Boneyard and is on top of the Burnyard (Fig. 3.5). The site received solid, liquid, and gaseous waste materials from 1975 to 1981. It is estimated that during this period less than five tons of waste per year were deposited. The material was broadly characterized as ignitable, reactive, corrosive, toxic, highly flammable, or, in some instances, inert (HSEAD 1987b).

Generally, the Hazardous Chemical Disposal Area received waste which posed safety hazardous within the Y-12 Plant. The material came from two sources: gas cylinders with leaking or damaged valves and lab chemicals considered to be reactive or explosive. Gas cylinders containing noncorrosive gases were allowed to leak into the atmosphere or were bled off to expedite the process. Those containing corrosive gases were bled through neutralizing slurries. Empty gas cylinders then were either destroyed or transported to another location for repair. The lab chemicals included acids, bases, organics, water-reactive compounds, and explosive compounds such as picric acid, benzoyl peroxide, and ether. Bottle chemicals were broken under water spray in a concrete vessel open to the atmosphere. After the explosion or chemical reaction had taken place,the effluent was discharged into a small unlined surface impoundment and allowed to percolate through the soil. The chemical residue remaining in

the concrete vessel was removed periodically and transported to the Bear Creek Burial Grounds (HSEAD 1987b).

The Boneyard is located east of the Oil Landfarm (Fig. 3.5). This area was an active waste-disposal site from 1943 to 1970. The wastes have been characterized as ranging from ignitable and possibly radioactive to inert. They are known to have included organics, metals, debris, acids, and beryllium; the total quantity of material is unknown.

Magnesium chips were disposed of in the southwest corner of the Boneyard, south of the gravel road. The metal chips were placed in burn pans in unlined earthen trenches. Ignitable solvents were used to initiate the burn. The residue remaining in the trench was covered with soil and compacted until the trench was filled. The trench then was covered with top soil and seeded with grass. The remaining land in the Boneyard was used to dispose of construction spoil material such as concrete and rebar. Neither a leachate-collection system nor a treatment system (other than the burning described above) was installed at the site (HSEAD 1987b).

The Burnyard consists of two trenches approximately 300 ft (ft) long and 40 ft wide. The site is no longer visible because the Chemical Storage Area was built on top of it (Fig. 3.5). The Burnyard functioned as an active waste site from 1943 to 1968. It is estimated that the site received approximately 350 tons per month (4,000 tons per year) of sanitary refuse from plant operations, including solids, liquids, and sludges. The waste materials may have contained empty pesticide containers, metal shavings, solvents, oils, and lab chemicals. The wastes were placed in unlined earthen trenches and burned. Oils and other flammable liquids were used to start and sustain combustion. When filled, the trenches were covered with soil. No collection or treatment systems other than burning have been used on this site (HSEAD 1987b).

### 3.3.5 Oil Landfarm

The Oil Landfarm is located north of the Sanitary Landfill as shown on Figure 3.5. Disposal activity ended in 1982 after nine years of operation during which approximately one million gallons of waste oil were disposed (McCauley 1985a). The facility was used for the biological degradation of

waste oil and machine coolants via landfarming, a process involving the application of waste oils and coolants to nutrient-adjusted soil during the dry months of the year (April to October). After application, the plots were cultivated frequently to maintain aerobic conditions to enhance biodegradation of the wastes. Waste was not applied immediately before or after periods of precipitation.

The waste composition was approximately 85 percent oil and 15 percent water, and the wastes have been characterized as ignitable and toxic. The oils and coolants disposed of at the Oil Landfarm are known to have been contaminated with beryllium compounds, depleted uranium, polychlorinated biphenyls (PCBs), tetrachloroethene, and 1,1,1-trichloroethane (HSEAD 1987b).

### 3.3.6 Sanitary Landfill I

The Sanitary Landfill I is located approximately 0.8 mi west of the Y-12 Plant just north of Bear Creek and immediately south of the Oil Landfarm as shown on Figure 3.5. The site was used between 1968 and 1980 for the disposal of combustible and decomposable solid wastes. Materials for which the landfill was permitted consisted of paper and cardboard, plastics, rubber, wood, brush, animal bedding, organic garbage, textile products, and asphalt roofing materials. Although administrative controls were used to exclude the disposal of toxic chemicals and other contaminated materials, it is likely that some of these materials were disposed of in the landfill (HSEAD 1987b).

Trenches were excavated to depths of approximately 20 ft and backfilled to approximately 15 ft above grade. Approximately 105,000 tons of refuse were disposed of at the landfill. The landfill was closed in 1983 by grading to promote drainage, capping with 2 ft of clay and topsoil, and establishing a vegetative stand (HSEAD 1987b).

### 3.3.7 Oil Retention Ponds

The Oil Retention Ponds consist of two ponds (No. 1 and No. 2) located immediately west (No. 1) and immediately east (No. 2) of Burial Ground A (Fig. 3.5). Pond No. 1 was constructed in May 1971 and measures 180 ft

long by 10 ft wide, with a maximum water depth of 6 ft. The pond was equipped with underflow pipes to permit water discharge while it retained floating oils in the impoundment. Simultaneously a drainage ditch was constructed west of, and parallel to the natural tributary to the pond. The ditch rejoined the natural tributary (NT-7) about 50 ft south of the pond, where it diverted uncontaminated surface runoff around the pond.

At a later time (not known) a sump was dug at the western end of one of the trenches east of Pond 1 in order to collect oil, which was pumped into the pond; a pipe was also installed between the end of a second trench and the pond to permit direct oil transfer to the pond. In 1974 approximately 15,000 gal of oil was removed from the surface on Pond 1; 5000 gal of oil was removed.

Oil seepage was observed on a steep slope above Tributary 6 (NT-6) at the eastern end of trenches A-14 and A-15 prior to 1972,and in May 1972 a smaller impoundment (Oil Retention Pond 2; see Fig. 3.5) was constructed on NT-6. No significant oil accumulation has been reported on the surface of Pond 2 since 1975.

### 3.3.8 Burial Grounds

The Burial Grounds are located approximately two miles west of the Y-12 Plant (Fig. 3.5). The Burial Grounds consist of several principal waste-disposal units designated as Burial Grounds A, B, C, D, E, and J. Collectively, these units are referred to in this document as the Burial Grounds.

Each waste-disposal unit consists of a series of trenches used for disposal of liquid and solid wastes. The trenches are between 14 and 25 ft deep. Perforated standpipes were installed vertically into some trenches for liquid-waste disposal; rock and gravel were backfilled around the standpipes for support and to maximize the rate of drainage.

The first trench in Burial Ground A was excavated in August 1955 for the disposal of solid wastes. In July 1959, the Y-12 Plant began using this facility for the disposal of certain types of liquid waste. Prior to 1959, liquids generated at the Y-12 Plant from floor-cleaning operations, known as mop waters, had been placed in the burial facilities at the

Oak Ridge National Laboratory. Since that time, several types of wastes have been disposed of in the Burial Grounds; Table 3.2 lists the major types of wastes. The actual quantity and identity of materials is uncertain, and other materials may have been disposed of that are not listed in any inventory (McCauley 1985a).

An estimated 600,000 gallons annually of mop waters were disposed of in Burial Ground A between 1971 and 1978; the quantities disposed of prior to 1971 were not recorded. Disposal of mop waters in Burial Ground A was terminated in 1979; after that date, these waters were placed in the S-3 Ponds (McCauley 1985a).

Burial Ground A also was used for the disposal of oils and coolants. Prior to 1961, these wastes and solid wastes were placed into unlined trenches within the Burial Grounds. In 1961, a surface tank was installed in Burial Ground A to hold waste oils and coolants; the accumulations then were burned, and liquids that did not burn were drained into adjacent trenches. An estimated 180,000 gallons of oils and coolants were disposed of by this method between 1961 and 1968, when the practice was terminated. In January 1969, a new procedure was adopted; the oils and coolants were poured into standpipes installed in the trenches. By 1976, most of the waste oils and coolants were being disposed of at the Oil Landfarm, and in 1979, oil disposal ceased in the Burial Grounds (McCauley 1985a).

Prior to July 1970, waste solvents were disposed of by burning in an open tank located east of Burial Ground A. Between July 1970 and October 1981, approximately 100,000 gallons of waste solvents were poured onto rock piles and into waste-filled trenches in the southern part of Burial Ground A (McCauley 1985a).

Burial Ground B was opened in 1962 for the disposal of depleted uranium metal and oxides. Burial Ground C was opened in 1962 for the disposal of beryllium, beryllium oxide, thorium, and solid waste contaminated with these materials; other materials contaminated with enriched uranium also were disposed of in Burial Ground C. Burial Ground D was used after 1968 for the disposal of depleted uranium metals and oxides after Burial Ground B had reached its capacity. An area of the Burial Grounds referred to as the Walk-In Pits was used from 1966 to 1981 for the

Table 3.2 Partial summary of Waste Materials Deposited in the Burial Grounds

| Constituent | Burial Grounds | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | Walk-In Pits |
| Heavy Metals[1] | P | P | P | P | P |
| Oils and Coolants | P | P[2] | P | P[2] | P |
| Salts | P | NI | P | NI | P |
| Debris | P | NI | P | NI | P |
| Solvents | P | NI | P | NI | P |
| Ethylenediaminetetracetic Acid (ETDA) | P[3] | NI | NI | NI | NI |
| Asbestos | P[4] | NI | P | NI | P |
| Material Contaminated with Radioisotopes | P | P | P | NI | P[5] |
| Mop Water | P | NI | NI | NI | NI |

Note: P = Listed in the records as having been deposited. NI = Not identified in the records as having been deposited.

[1]Includes beryllium and uranium.

[2]Trace quantities only.

[3]In A-South only.

[4]In A-North only.

[5]In northern walk-in pit only.

From: McCauley 1985a.

disposal of chemicals and uranium metal saw fines. Since 1981, the Walk-In Pits have been used solely for the disposal of uranium metal saw fines (McCauley 1985a).

Burial Grounds E and J were used primarily for the disposal of uranium. Through 1983, Burial Ground E had received a total of 190.7 tons of uranium. In addition to the uranium, disposals to Burial Ground J made by 1983 were estimated to include approximately 29 tons of debris and 14 tons of inorganic salts (Martin Marietta Energy Systems, Draft Report 1986).

Per agreement with the Tennessee Department of Health and Environment (TDHE) and the U.S. Environmental Protection Agency (EPA), several of the new trenches continue to be active disposal sites for some waste materials.

### 3.3.9 White Wing Scrap Yard

The White Wing Scrap Yard is a roughly 30.4 acre, largely wooded area, that is located in the McNew Hollow area on the western edge of East Fork Ridge. It is 1 mi (1.6 km) east of the junction of White Wing Road (S.R. 95) and the Oak Ridge Turnpike, and is roughly contained within administrative grid coordinates N34,500-E29,250 (see Fig. 3.5). The approximate area used for scrap storage was 25 acres.

White Wing Scrap Yard was used for the above ground storage of contaminated material from the Oak Ridge Gaseous Diffusion Plant (ORGDP), the Y-12 Plant, and ORNL (Boegly and Moore 1988). The material stored at the site by ORNL (estimated to be 500,000 $ft^3$) was reported to consist of mild steel tanks 10 ft in diameter and 40 ft long, dump trucks, two pieces of earth-moving equipment (one weighing approximately 22 tons), large glass lined tanks, carcasses of walk-in hoods, small stainless steel and mild steel support frames, and mild steel, stainless steel, and aluminum of many sizes and shapes (Gissell 1968). Reprocessing cell vessels removed during the clean up of Building 3019 at ORNL were also stored at the site. No description exists for the materials stored by ORGDP or Y-12.

The site began receiving material in the early 1950s; however, the precise dates of material storage are uncertain, as is the time when the area was closed to further storage. During active use, one part of the

scrap yard (north of "Hot Yard" road) was enclosed by a chain link fence and the remaining part (south of the road) with a barbed wire fence; however, these fences were removed during the site cleanup and the area is currently unfenced. It is reported that the area north of the road was used by the ORGDP and Y-12, and that the area south of the road was used by ORNL. The area is currently overgrown with weeds, trees, and other types of vegetation. The amount of material remaining in the area is not known; however, small pieces of scrap (metals and plastic) appear on the surface over much of the site.

In 1966, efforts were begun to clean up the area. The apparent reason for the clean up was the proposed relocation of White Wing Road. Contaminated scrap materials were removed and buried in ORNL's SWSA-5, and the uncontaminated material was sold to a contractor for scrap recovery. Site clean up continued into March of 1970, and in October 1970 removal of about 6,000 $yd^3$ of contaminated soil from the southern portion of the site was initiated. Following removal of the contaminated soil, the entire site was surveyed for residual radionuclide contamination and then abandoned. An aerial (helicopter) gamma survey of the area in November 1974 indicated the presence of $^{137}Cs$ and $^{234m}Pa$ above background, with an inferred exposure rate at 1 m in the range of 2-4 $\mu R/h$ (Burson 1976).

# 4.0 CHARACTERIZATION OF THE CONTAMINANT SOURCES

This section will summarize the available information on the nature, quantity and concentration of contaminants in each of the SWMUs located in Bear Creek watershed. In the absence of direct evidence (measurements) of the contents of each SWMU, the nature and concentration of contaminants in receiving media (surface water, soil/sediment, groundwater) immediately adjacent to each SWMU will be summarized. The purpose is to identify those contaminants which have, or may have, been released from each SWMU.

## 4.1 S-3 PONDS

Accurate records of the types and amounts of waste disposed in the S-3 Ponds are not available. However, three different sources of waste, generally classified as toxic, corrosive, and radioactive, are known to have been disposed in the S-3 Ponds. The three sources are: (1) liquid wastes generated from Y-12 Plant operations and other facilities, (2) sludges generated from the in situ neutralization and biodenitrification of the pond waters and sludges generated from the treatment of acid raffinate, and (3) contaminated sediments from upper Bear Creek. Table 4.1 is a generic summary of the waste materials, not all of which are hazardous, known to have been disposed in the S-3 Ponds.

Water and sludges in the S-3 Ponds have been extensively characterized on several occasions (Francke 1973, Jeter and Napier 1978, Saunders and Napier 1986, Jeter 1983, Kimbrough and Turner 1987). Although the pond water chemistry varied from pond to pond and from year to year, in general, pond water chemistry remained highly acidic, dominated by nitrate anion, with extremely high concentrations of the major cationic constituents (Ca, Mg, K, Mg, Al), and moderately high concentrations of trace metals. The few organics analyses available for the pond waters indicate that concentrations of organics could have been highly variable over the period of operation. Sludges in the ponds were characterized both prior to, and following, neutralization/biodenitrification (Jeter 1983; Kimbrough and Turner 1987). Appendix B gives selected results of investigations of the composition of water and sludges in the S-3 Ponds.

Table 4.1. Waste Disposed in the S-3 Ponds

| SUBSTANCE | CLASSIFICATION |
|---|---|
| LIQUID WASTE: | |
| Nitrate Wastes | Corrosive |
| Machine Coolants | Toxic |
| Caustic Solutions | Corrosive |
| Pickling Wastes | Toxic |
| Plating Wastes | Toxic |
| Mop Water | Toxic |
| Nitric Acid | Corrosive |
| Miscellaneous Dilute Acids | Corrosive |
| Miscellaneous Acids (pH<2) | Corrosive |
| Depleted Uranium (in nitrate solutions) | Radioactive |
| Plutonium (in uranyl nitrate solutions) | Radioactive |
| Technetium (in raffinate and condensate) | Radioactive |
| BIODENITRIFICATION SLUDGES | Toxic |
| CONTAMINATED BEAR CREEK SEDIMENTS | Toxic |

NOTES:

a. Annual volume of waste was 2.7 million gallons in 1983. This volume is reduced from pre-1976 quantities.

b. Presently, a variable thickness of sludge rests on the pond bottoms.

c. Ponds operated from 1951-1984.

Immediately prior to structural stabilization and filling associated with closure of the S-3 Ponds in 1988, sludge which had accumulated in two "lagoons" in upper Bear Creek adjacent to the S-3 Ponds was placed in the southwest cell of the S-3 Ponds. Turner and Kamp (1985) characterized this material in place and each truckload of sludge placed in the ponds was also characterized by sampling and laboratory analyses. Appendix B summarizes the data from Turner and Kamp (1985). The data from the 1988 sampling and characterization has been tabulated by McMahon (1988).

## 4.2 RUST SPOIL AREA

The RFI Plan for this SWMU (Welch 1987b) indicates that no detailed disposal records are available for the wastes disposed at the Rust Spoil Area. The bulk of the waste is reported to consist of demolition debris, including soil, masonry materials and metal (steel rebar in concrete). The RFI Plan also indicated the possibility that minor amounts of solvent-contaminated material, and material containing asbestos, mercury and uranium may have been disposed of in this area.

The RFI Plan for the Rust Spoil Area includes soil core sampling and chemical analysis to characterize material in the fill.

## 4.3 SPOIL AREA I

The RFI Plan for this SWMU (Welch 1987c) indicates that no detailed disposal records are available for the waste disposed at the Spoil Area I. The bulk of the waste consists of demolition debris, including asphalt, masonry materials, roofing materials, brush, metal (e.g. steel rebar in concrete), rock and tile. The waste was determined to be nonradioactively contaminated according to health physics requirements established for the Y-12 Plant. Construction material disposed of in this area may have contained minor amounts of asbestos, mercury, beryllium, uranium, thorium and other contaminants, according to the RFI Plan.

The RFI Plan for Spoil Area I includes soil core sampling and chemical analysis along the perimeter of this site.

## 4.4 HAZARDOUS CHEMICAL DISPOSAL AREA-BURN YARD/BONE YARD

Very little quantitative information is available on the nature and quantities of contaminants disposed of in the Hazardous Chemical Disposal Area-Burn Yard/Bone Yard (HCDA-BY/BY). The contaminants have been generically described as including organics (solvents, oils, empty pesticide containers), metal shavings, debris, acids, bases, water reactive compounds and explosive compounds. Specific compounds which were reacted or burned in the area include magnesium chips, picric acid, benzoyl peroxide, ether and beryllium.

Data given in McCauley (1985a) from an investigation carried out by Bechtel National Inc. for several grab samples of sediment collected downstream of the Bone Yard area show elevated levels of mercury (6.7 to 140 $\mu$g/g), uranium (18 to 200 pCi/g), several polynuclear aromatic hydrocarbons and phthalates. Analytical results for groundwater downgradient of the area (ie., monitor wells GW-87 and GW-67) have also indicated the possibility of migration of a number of contaminants from the HCDA-BY/BY, including volatile organic compounds and uranium (HSEAD 1987b).

## 4.5 OIL LANDFARM

### 4.5.1 Disposal of Contaminants

During the total period of operation of the Oil Landfarm between 1973 and October 1982, approximately one million gal of liquid wastes were applied to the plots (HSEAD 1987b). Wastes placed in the Landfarm included:

- Waste oils
- Beryllium-contaminated oils
- Coolants
- Mop waters
- Tanker oils from the Oak Ridge Gaseous Diffusion Plant
- Wastes from cooling towers and the Burial Grounds
- Unidentified miscellaneous liquid wastes.

Because operating instructions (Bailey 1974) called for different types of oils to be applied to different plots, both the composition and volume of liquid waste applied varied from plot to plot. Thus over 50% of the total amount of beryllium-contaminated oil disposed over the lifetime of the

Landfarm was administered to Plot 1/2, with most of the remainder being divided nearly equally between Plots 7/8 and 9/10. Tanker oils were applied most heavily to Plots 3/4 and 5/6; coolants were applied most heavily to Plots 3/4, 5/6, 11/12, 13/14, and 15/16 (Bechtel 1983). In general the East plots received more total liquid waste application than the West, which in turn received more than the North plots.

Summaries have been compiled for the types and amounts of waste oils (Table 4.2) and waste coolants (Table 4.3) disposed of in the plots during the operating period. While waste oils typically consisted of crankcase, hydraulic, gear, vacuum pump, mineral, and machine coolant oils, the totals for 1974 and 1975 included approximately 15,000 gallons of oil skimmed from the surface of the two Oil Retention Ponds located in the Y-12 Plant Burial Ground A. The machine coolants included nonsoluble oils and water-soluble mixtures consisting of approximately 5 percent oil and 95 percent water.

The typical composition of waste oils and coolants generated at the Y-12 Plant is shown in Appendix B. The values are considered to be representative of the oily wastes disposed of in the Oil Landfarm plots. As expected, the waste oils exhibit lower densities and higher carbon contents than the oil/water coolant mixtures. Uranium contents of the oily wastes ranged from approximately 5 to 50 micrograms per gram ($\mu g/g$).

Chemical analyses of oily wastes generated at the Y-12 Plant are presented in Appendix C. These analytical values are considered representative of wastes disposed of in the Oil Landfarm plots. The data indicate that waste oils contained high levels of calcium, iron, sodium, silicon, phosphorous, chlorine, zinc, and lead. Analyses of machine coolants show a similar composition with the exception of barium which is present in the coolants at levels 10 to 50 times higher than in the oils.

Prior to 1979, waste oils and coolants were not specifically analyzed for contaminants before application to the Oil Landfarm. In 1979, analytical results for oil samples collected from the surface of one of the ponds in the Burial Grounds indicated the presence of PCBs. Thereafter, oils were analyzed for uranium, beryllium, thorium, and PCBs. A maximum permissible concentration level of 5 milligrams per liter (mg/L) was established by the Y-12 Plant for PCBs in waste oils to be landfarmed.

Table 4.2. Summary of Waste Oil Disposals at the Y-12 Plant Oil Landfarm[a]

| Calendar Year | Origin | No. of Disposals | Volume (gal) | Active Plots (acres) | Description |
|---|---|---|---|---|---|
| 1973 | Y-12 | 11 | 42,800 | 0.4 | Waste Oil |
| 1974 | Y-12 | 14 | 53,300 | 1.0 | Waste Oil |
| 1975 | Y-12 | 4 | 14,600 | 1.0 | Waste Oil |
| 1976 | Y-12 | 9 | 25,600 | 1.0 | Waste Oil |
| | NR | 5 | 17,700 | 1.0 | No Record |
| 1977 | NR | 5 | 14,000 | 1.4 | No Record |
| 1978 | Y-12 | 12 | 36,000 | 1.7 | Waste Oil |
| | ORGDP | 1 | 1,000 | 1.7 | Mineral Oil |
| 1979 | Y-12 | 4 | 16,500 | 2.6 | Waste Oil |
| | ORGDP | 16 | 63,900 | 2.6 | Waste Oil |
| 1980 | Y-12 | 22 | 72,400 | 2.6 | Waste Oil |
| | Y-12 | 5 | 17,800 | 2.6 | Mineral Oil |
| | ORGDP | 7 | 22,300 | 2.6 | Waste Oil |
| 1981 | - | - | - | 2.6 | No Disposals |
| 1982 | Y-12 | 9 | 32,900 | 2.6 | Waste Oil |
| TOTAL | | 124 | 430,800 | | |

[a]From UCC-ND Report Y/IA-166, "Inventory of Existing Contamination in the Y-12 Plant Bear Creek Valley Oil Landfarm Area," January 31, 1984.

Table 4.3. Summary of Waste Coolant Disposals at the Y-12 Plant Oil Landfarm[a]

| Calendar Year | No. of Disposals | Volume (gal) | Active Plots (acres) | Description |
|---|---|---|---|---|
| 1973 | 12 | 34,800 | 0.9 | Coolants |
| | 8 | 22,500 | 0.9 | Coolants and Mop waters |
| | 2 | 9,700 | 0.9 | Water Contaminated with Nitrate |
| 1974 | 22 | 104,000 | 1.6 | Coolants |
| | 6 | 21,000 | 1.6 | Coolants and Mop waters |
| 1975 | 21 | 97,500 | 2.0 | Coolants |
| 1976 | 25 | 107,000 | 2.0 | Coolants |
| | 3 | 9,400 | 2.0 | Water |
| 1977 | 23 | 114,000 | 1.6 | Coolants |
| 1978 | 15 | 62,600 | 1.4 | Coolants |
| 1979 | - | - | 1.4 | No Disposals |
| 1980 | 1 | 1,000 | 1.4 | Dye Penetrant |
| 1981 | - | - | 1.4 | No Disposals |
| 1982 | - | - | 1.4 | No Disposals |
| TOTAL | 138 | 583,500 | | |

[a]From UCC-ND Report Y/IA-166, "Inventory of Existing Contamination in the Y-12 Plant Bear Creek Valley Oil Landfarm Area," January 31, 1984.

Oils containing greater than 5 mg/L of PCBs were shipped for commercial disposal if uranium concentrations were less than permissible limits established for release to the public. If uranium concentrations were greater than permissible limits established for release to the public, waste oils containing greater than 5 mg/L of PCBs were placed in storage for future incineration at the ORGDP TSCA Incinerator.

In December 1981, the analyses of wastes were expanded to include chlorinated hydrocarbons. A maximum permissible concentration of 3 percent was established for concentrations of chlorinated solvents in the waste oils. Experience that has been gained since 1981 in sampling and analysis of waste oils for chlorinated solvents has shown that waste oils contain concentrations of less than 3 percent chlorinated hydrocarbons.

### 4.5.2 Soil Contaminants

Because of concerns about levels of PCBs which may have been present in the Landfarm due to disposal of contaminated oils, several rounds of sampling for PCBs in Landfarm soils have occurred since 1981. The highest level detected in Landfarm soil during this period was 110 μg/g (Bechtel 1983). A total of 200 samples were collected in 1985 in a randomized block design with the objective of delineating areas containing greater than 25 μg/g. Several portions of plots were identified over this action level; the highest concentration measured was 60.5 μg/g. PCB contamination was principally confined to the upper 6 in. of the soil; PCB concentrations declined by more than 90% between the surface (0-6 in.interval) and the 12-18 in. interval in 10 depth profiles. Highest concentrations were found in the east and west plots (Herbes, in preparation).

Soil samples collected in the 1985 study were also analyzed for uranium. Concentrations of uranium were similarly highest in the east and west plots. The highest mean uranium concentration observed was 204 μg/g (in Plot 7/8). Lowest concentrations were between 13 and 27 μg/g in the north plot group. As was observed for PCBs, uranium concentrations declined rapidly with soil depth.

A total of 48 soil samples were collected and analyzed by the Y-12 Analytical Laboratory for total carbon, PCBs, and a series of metals.

Results are summarized in the Bechtel (1983) report. Maximum levels (in $\mu g/g$) for the metals analyzed were: arsenic (73), barium (340), beryllium (290), cadmium (6), chromium (88), lead (550), mercury (55), selenium (0.4), silver (8), thorium (20), uranium (273). As would be expected from the historical pattern of oil application, contaminant concentrations were uniformly lowest in the north plots. Concentrations of beryllium were highest in plots 1/2 (mean of 4 analyses: 213 $\mu g/g$), 5/6 (112), and 9/10 (75). Beryllium levels in the west plots averaged 32 $\mu g/g$, and in the north plots, 8 $\mu g/g$. With the exception of one sample from plot 1/2, all mercury and lead concentrations were less than 4 $\mu g/g$ and 75 $\mu g/g$, respectively.

Composite samples were obtained in September 1983 from "light" and "dark" areas (differentiated visually) of Plots 1-12, 13-18, and 19-24 (East, West, and North areas, respectively). The 5 samples (no "dark" area was identified in the North plots) were analyzed for volatile organics (VOCs), acid- and base-neutral extractables, ICP-analyzable metals, and pesticides/PCBs. Results are summarized in the Bechtel (1983) report. In general the Plot 1-12 (East) "dark" sample contained highest concentrations of contaminants. Major organic contaminants found, and maximum concentrations (in $\mu g/g$), were: tetrachloroethylene (8.4), trans-1,2-dichloroethylene (2.7), trichloroethylene (0.75), 1,1,1-trichloroethane (0.50), bis(2-ethylhexyl) phthalate (520.), fluoranthene (140.), phenanthrene (13.), phenol (29.), and 2,4-dimethylphenol (31.).

A number of cores from monitoring wells installed around the perimeter of the Landfarm in 1983 by Bechtel were analyzed for the organic contaminants listed above. Principal organic contaminants identified, and the highest levels quantified (in $\mu g/g$), included toluene (1.6), methylene chloride (0.96), tetrachloroethylene (1.1), and trans-1,2-dichloroethylene (0.40). PCBs were found in 3 core segments from well GW-5, located east of the Landfarm, at total concentrations of 1.6 $\mu g/g$ to 2.8 $\mu g/g$ at depths of 0-5 ft (Bechtel 1983).

### 4.5.3 Groundwater Contaminants

Since 1982 a total of 13 groundwater wells which encircle the Oil Landfarm have been sampled for waterborne contaminants. Most of these wells were sampled several times; four are still sampled quarterly as part of the Ground-Water Quality Assessment Plan being conducted for the TDHE (HSEAD 1988b). Of the 13 wells, nine have consistently shown the presence of volatile organic contaminants (VOCs) at total concentrations ranging from 0.01 to 3.1 mg/L. Principal contaminants observed include 1,1-dichloroethane, 1,1,1-trichloroethane, 1,1-dichloroethylene, trans-1,2-dichloroethylene, trichloroethylene, and tetrachloroethylene; chloroethane and vinyl chloride have also been detected at levels below 0.02 mg/L (McCauley 1985e). Of the wells which have shown VOC contamination, five are screened in unconsolidated material at depths of 5 to 21 ft BLS, and four are screened in bedrock (22-200 ft BLS). Of the 13 wells, one well screened in unconsolidated material and three screened in bedrock were sampled but did not show VOC contamination.

During 1986 and 1987, as part of the Ground-Water Quality Assessment Plan groundwater samples from three wells (one was inadvertently omitted from sampling) which border the Landfarm were analyzed for total and dissolved toxic metals and gross radioactivity. Cadmium, chromium, and lead were detected in several samples at levels slightly exceeding drinking-water standards. Levels of arsenic, mercury, lead, selenium, and gross alpha and beta radioactivity did not exceed drinking-water standards on any occasion (HSEAD 1988b).

### 4.5.4 Surface Water and Sediment Analyses

Several water and sediment samples were collected by Bechtel near the confluences of tributaries NT-3 and NT-4 with Bear Creek during 1983 and 1984 (McCauley 1985e). Levels of VOCs, phenols, and beryllium were all below detection limits (0.01, 0.001, and 0.001 mg/L, respectively) in these samples. Both dissolved and particulate PCBs were also below the detection limit (0.0003 mg/L) in single samples collected in 1983.

PCBs were undetectable (<0.05 $\mu$g/g) both in tributary and in Bear Creek sediments. Concentrations of beryllium, heavy metals (cadmium,

chromium, cobalt, copper, lead, nickel, uranium, and mercury), and phenols showed no increases in the tributary sediments above upstream Bear Creek levels (McCauley 1985e).

### 4.5.5 Summary

Based on soil analyses, at least some of the Oil Landfarm plots contain elevated levels of beryllium, several heavy metals, VOCs, and PCBs, and thus potentially could serve as a source for transport of these contaminants into Bear Creek. VOCs have been detected in groundwater from wells bordering the Landfarm; groundwater transport of VOCs and other soluble contaminants into Bear Creek may occur in the future, although VOC levels in both of the tributaries which drain the Landfarm are undetectable at present. Detection of PCBs in soil cores from a boring east of the Landfarm suggests that PCB transport across the surface or through the shallow subsurface has occurred in the past, and may still be occurring. Contaminant levels in water and sediment samples collected from the tributaries which drain the Landfarm are no greater than in Bear Creek, however, which suggests that transport through surface water from the Landfarm is not at present a major source of contaminants to Bear Creek.

## 4.6 SANITARY LANDFILL I

Sanitary Landfill I was designed and permitted for disposal of combustible and decomposable solid waste, including paper, cardboard, plastics, rubber, wood, brush, animal bedding, organic garbage, textile products and asphalt roofing. Although administrative controls were used to exclude the disposal of toxic chemicals and other contaminated materials, it is likely that some of these were disposed of in the landfill. Approximately 105,000 tons of refuse were disposed of at this landfill before it was closed in 1983.

## 4.7 OIL RETENTION PONDS

### 4.7.1 Disposal of Contaminants

During the period from 1959 to 1979 large volumes of solvent-contaminated water and oils were disposed of in Burial Ground-A

(BG-A; Fig. 4.1). Throughout the period of oil disposal, several million gallons of oil and mop waters were disposed of by discharge either directly into oil disposal pits in BG-A North and South, or into standpipes in the burial trenches in BG-A South (Figs. 4.2 and 4.3).

Between 1970 and 1981, volatile solvents were disposed of by pouring into a rock-covered area at the southeastern end of the BG-A South trenches. During this period approximately 100,000 gal of solvents were disposed of in this manner. Table 4.4 summarizes the solvents disposed of during the 12-year period.

Much of the oil disposed of in the BG-A South burial trenches during the 1970's is known to have been contaminated with PCBs (Bailey 1979). In addition, some of the coolants used in the Y-12 Plant during 1963-1971 were reported to contain PCBs, although the means of disposal of these liquids is not known with certainty. PCB- contaminated oils are not known to have been disposed of in Burial Grounds B, C, or D (Fig. 4.1). However, analyses of sediments from Tributary NT-8, which directly drains BG-C and may receive indirect discharges from BG-B and -D (Fig. 4.1), show the presence of PCBs (Sect. 4.8). Data on historical oil disposal patterns may therefore be incomplete.

Although overflow of mop waters from standpipes had occurred previously, oil was first observed seeping from the west ends of trenches A-1 and A-4 into Tributary NT-7 (Fig. 4.2), and from the soil surface above the oil disposal pits, in the 1969-1971 period. At this time oil addition to the BG-A South trenches was discontinued (Bailey 1979). To prevent oil transport down Tributary NT-7 to Bear Creek, Oil Retention Pond 1 (ORP-1; Fig. 4.2), with maximum dimensions of 180 ft (55 m) in length, 110 ft (34 m) in width, and 6 ft (2 m) in depth, was constructed in May 1971. The Pond was equipped with underflow pipes to permit water discharge while retaining floating oils in the impoundment. Simultaneously a drainage ditch was constructed about 60-100 ft (18-30 m) west of and parallel to the Tributary, which rejoined Tributary NT-7 about 50 ft (15 m) south of the Pond, to divert uncontaminated surface runoff around the Pond. A sump was later dug at the western end of one of the trenches east of ORP-1 to collect oil, which was pumped into the Pond; a pipe was also installed

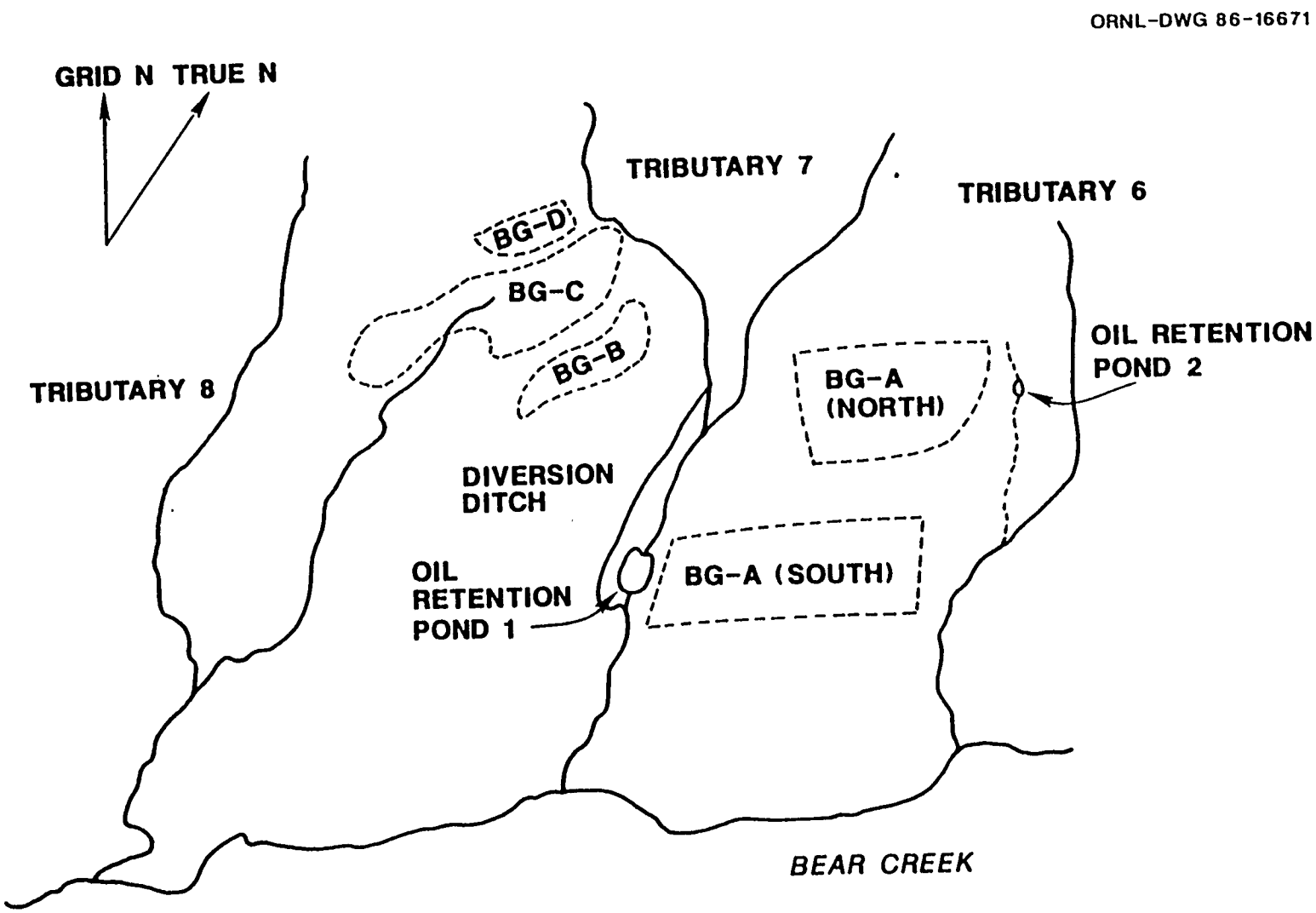


Fig. 4.1. Locations of the Y-12 Plant burial grounds and oil retention ponds with respect to Bear Creek and its tributaries.

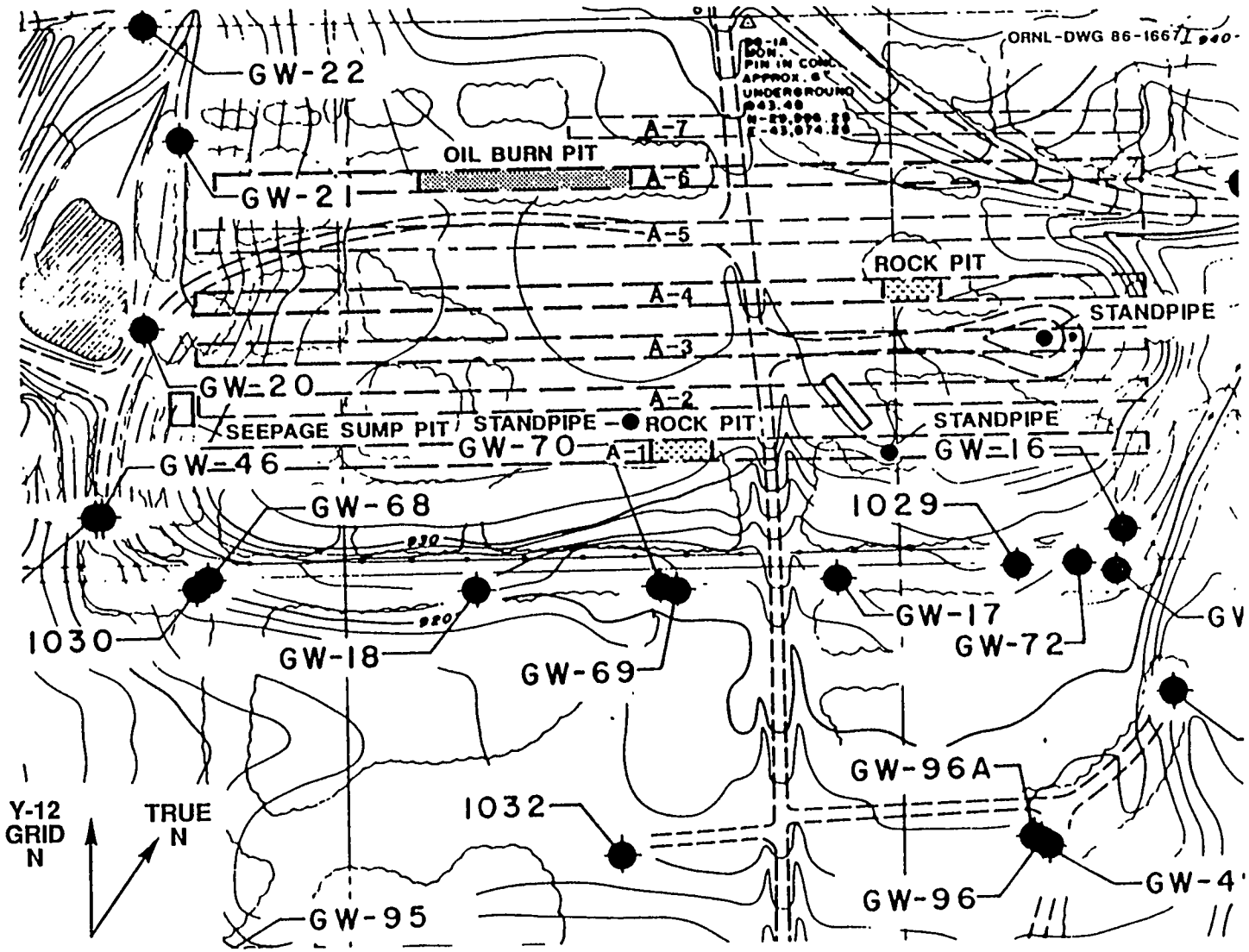


Fig. 4.2. Locations of oil disposal pits and standpipes in Burial Ground A (South). Scale: 1" = 150 ft.

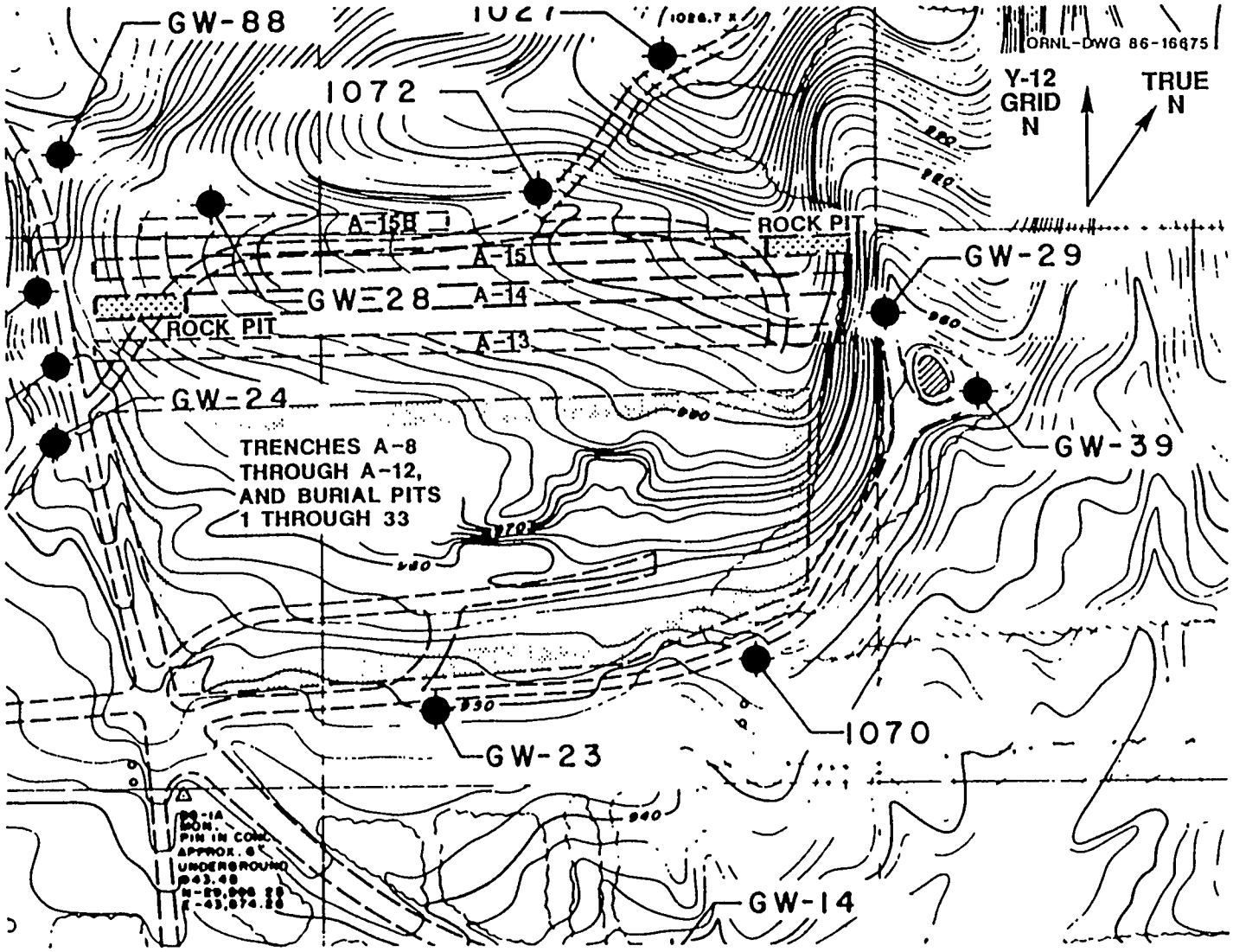


Fig. 4.3. Locations of oil disposal pits and standpipes in Burial Ground A (North). Scale: 1" = 150 ft.

Table 4.4 Solvents discharged into isolation area[a] (in gallons)

| Solvent | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | TOTALS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vythene | 410 | - | 50 | 850 | 1,575 | 210 | - | 555 | 500 | 505 | 1,865 | 1,785 | 8,305 |
| Varsol | 245 | 410 | 1,000 | 720 | 490 | 650 | 615 | 1,000 | 900 | 560 | 810 | 661 | 8,061 |
| Fuel and Water | 450 | 500 | 700 | 110 | 15 | 680 | 1,165 | 2,500 | 400 | 250 | 790 | 205 | 7,765 |
| Perchloroethylene | 100 | - | - | 540 | 180 | 475 | 1,150 | 930 | 1,160 | 710 | 1,000 | 1,390 | 7,635 |
| Freon | 20 | 85 | 520 | - | 265 | 345 | - | - | - | - | 1,390 | 1,470 | 4,095 |
| Alchohol | 25 | 25 | 550 | 490 | 280 | 210 | 20 | 290 | 600 | 200 | 410 | 189 | 3,269 |
| Solvents from Bldg 9208 (Benzene, Toluene, Xylene, Alchohol) | 40 | 265 | 210 | 125 | 50 | 50 | - | 110 | 125 | - | 190 | 5 | 1,295 |
| Trichloroethylene | - | 75 | 50 | - | 220 | - | - | - | 110 | 225 | - | 55 | 73 |
| MEK | - | - | 160 | - | 120 | - | - | - | 75 | 175 | - | - | 53 |
| Miscellaneous | 6,910 | 10,640 | 6,760 | 4,165 | 1,605 | 1,880 | 2,900 | 4,615 | 5,130 | 2,850 | 7,240 | 2,730 | 57,42 |
| Gallons Discharged | 8,200 | 12,000 | 10,000 | 7,000 | 4,800 | 4,500 | 5,850 | 10,000 | 9,000 | 5,600 | 13,695 | 8,470 | 99,11 |

[a]Source: "McCauley, L. L.,Sediment Assessment and Inventory of Existing Contamination and Biological Data of Two Oil Retention Ponds in the Y-12 Plant, Bear Creek Valley Waste Disposal Area," Oak Ridge Y-12 Plant Report Y/IA-165, January 31, 1984.

between the end of a second trench and the Pond to permit direct oil transfer to the Pond (Bailey 1979).

During the mid-1970's oil seepage was observed from the west-facing slope west of trench A-14 (Fig. 4.3) into Tributary NT-7 (Bailey 1979). In 1974 approximately 15,000 gal (57,000 L) of oil were removed from the surface of ORP-1; an additional 5000 gal (19,000 L) were removed in early 1975. In 1979 an additional 18,000 gal (68,000 L) of oil were removed (Battelle 1986).

Oil seepage was observed on a steep slope above Tributary NT-6 at the eastern end of trenches A-14 and A-15 prior to 1972 (Bailey 1979), and in May 1972 a smaller impoundment, Oil Retention Pond 2 (ORP-2; Fig 4.3) was constructed on Tributary NT-6. No significant oil accumulation has been reported on the surface of ORP-2 since 1975 (Battelle 1986).

### 4.7.2 Contaminant Distributions

#### 4.7.2.1 PCBs

During the past six years several hundred soil and sediment samples have been collected from the Oil Retention Ponds and tributaries NT-6 and NT-7 and analyzed to determine contaminant concentrations. The principal contaminant analyzed for has been PCBs, due to the known presence of these contaminants in oil disposed of in the Burial Grounds. These analyses have demonstrated the presence of PCBs at concentrations above 25 $\mu g/g$ throughout the sediments of both Oil Retention Ponds and much of Tributary NT-7.

In 1980 and 1982, series of soil cores were collected along transects from the perimeter of ORP-1 for PCB analysis by the Y-12 Analytical Laboratory. Concentrations of PCBs in 6 surface samples collected between 0 and 12 ft (3.7 m) from the Pond perimeter ranged from 13 to 1448 $\mu g/g$. Several samples collected at a depth of 0.6 m (2 ft) contained 2.8 to 14 $\mu g/g$. Samples collected from the ORP-1 perimeter in July 1985 showed similar concentrations and distribution, while samples collected from ORP-2 showed levels as high as 174 $\mu g/g$ in surface sediment from the perimeter of the Pond, and similarly declining with depth and distance from the Pond. In October 1985 five cores were collected from the bottom of ORP-1 and

subdivided into 6-in. intervals for analysis. Concentrations of PCBs in surface sediments ranged as high as 710 μg/g, but declined to 3 μg/g or less at a depth of 27 in. (Herbes 1988).

Extensive sediment sampling throughout the tributary system conducted between 1985 and 1988 has shown that PCBs are present in concentrations of several hundred μg/g in surface sediments of NT-7 between ORP-1 and the visible area of oil seepage at the west end of burial trench A-14 (Fig. 4.3), but decline below 25 μg/g by a depth of 24 in. PCBs have been found in areas of the NT-7 floodplain south of ORP-1 at concentrations as high as 574 μg/g. Because PCBs partition strongly to particles, elevated concentrations in the NT-7 floodplain appear to be due to sediment transport from upstream areas. Soils and sediments in NT-7 in which PCB levels exceed 25 μg/g are shown in Figs. 4.4, 4.5, and 4.6 (Herbes 1988). Concentrations in NT-7 channel sediments at the confluence with Bear Creek were reported to range from 5.2 to 28.2 μg/g in 1983 and 1984 (McCauley 1984), and 2.1 to 14.1 μg/g in 1986 (Herbes 1988).

A maximum PCB concentration of 33 μg/g was found in sediment of the drainage ditch north of ORP-2. PCBs are present in NT-6 sediments at concentrations between 2.3 and 13.8 μg/g throughout its length between the confluence with the intermittent stream draining ORP-2 and the confluence with Bear Creek. Approximate areas of NT-6 in which sediments exceed 25 μg/g PCBs are shown in Fig. 4.7 (Herbes 1988).

Few analyses of PCBs in water from tributaries and Oil Retention Ponds are available. Samples of water obtained in September 1983 from ORP-1 contained PCBs ranging from 3 to 31 μg/L. Dissolved PCBs in water samples collected from NT-7 at the confluence with Bear Creek contained 2 μg/L in 1983 (McCauley 1984), and less than 1.5 μg/L in December 1987 (Roy F. Weston, Inc., Appendix IX sampling results; Appendix C).

#### 4.7.2.2 Uranium

Because large quantities of uranium were disposed of in the Burial Grounds, the soil and sediment sampling campaigns conducted in NT-6 and NT-7 since 1985 have included total uranium analyses. Concentrations measured in sediments north of the Burial Grounds generally range from 1 to

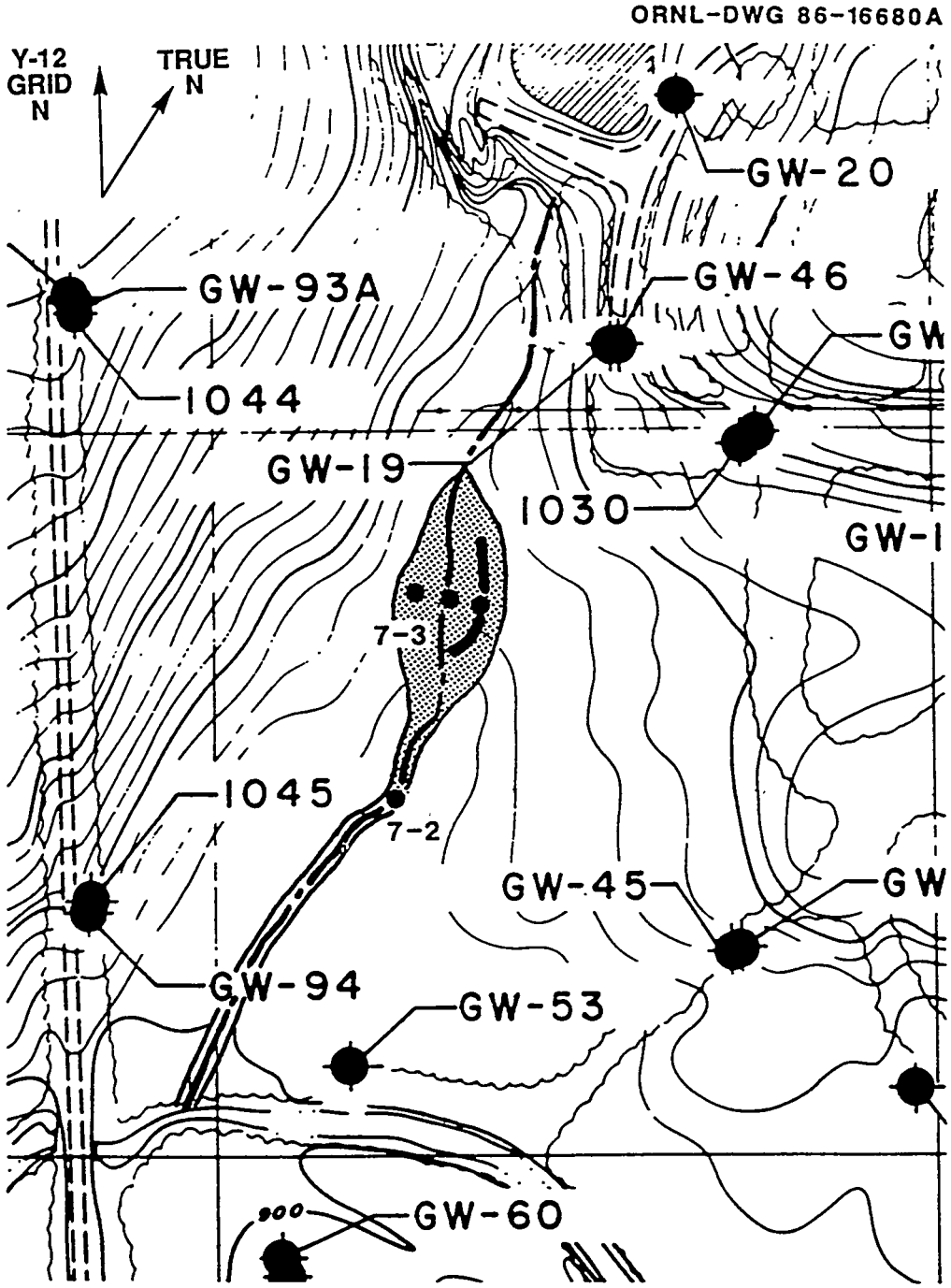


Fig. 4.4. Approximate area (Stippled) south of Oil Retention Pond 1 on tributary NT-7 in which surface (0-8 in.) soil and sediment concentrations of PCBs exceed 25 mg/kg. Heavy solid line indicates location of shallow drainage depression in which PCBs exceed 25 mg/kg to a depth of 24 in. Scale: 1" = 150 ft.

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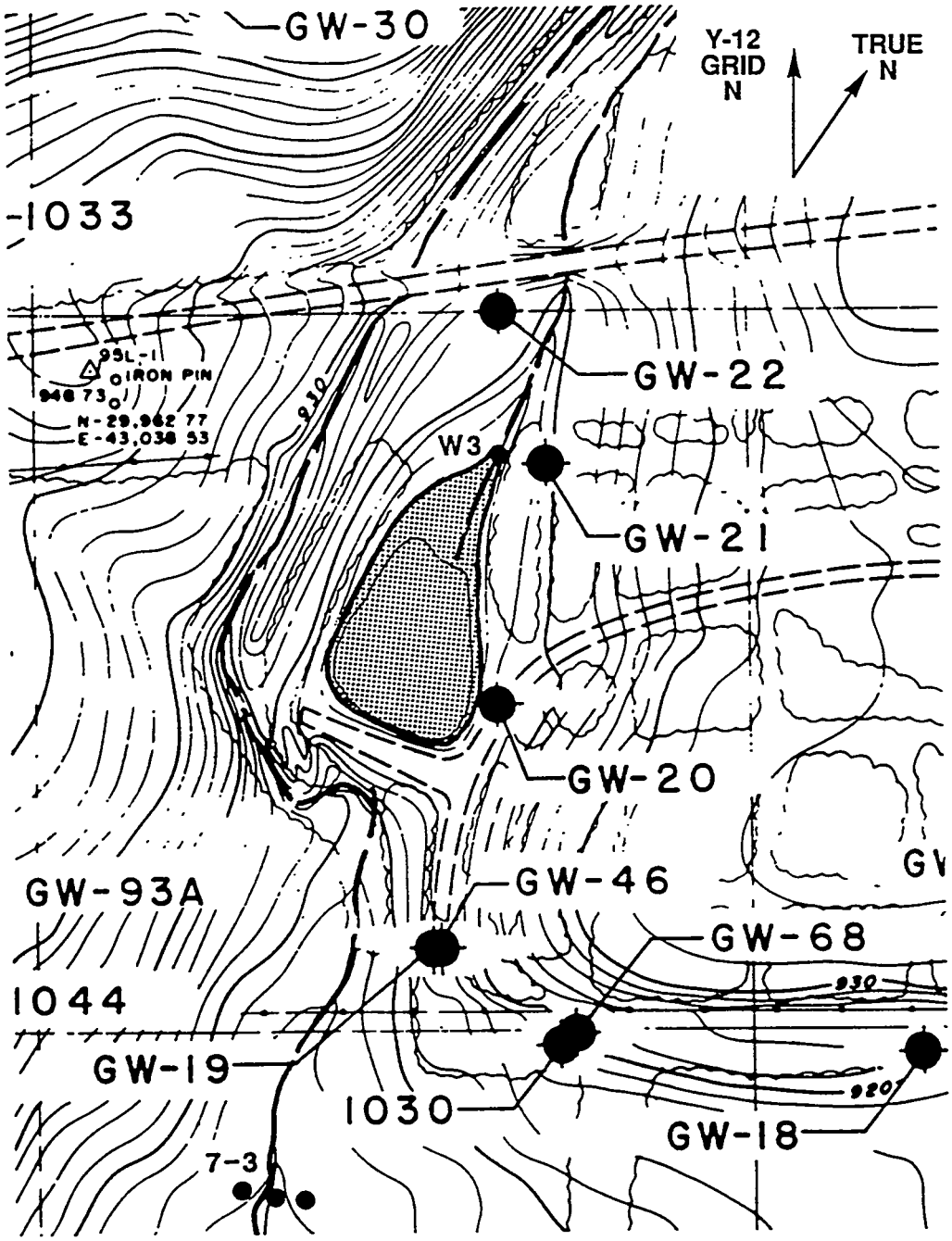


Fig. 4.5. Approximate area (stippled) north of Oil Retention Pond 1 in which surface (0-8 in.) soil and sediment concentrations of PCBs exceed 25 mg/kg. Sediments within the pond exceed this value to a depth of up to 27 in. Scale: 1′ = 150 ft.

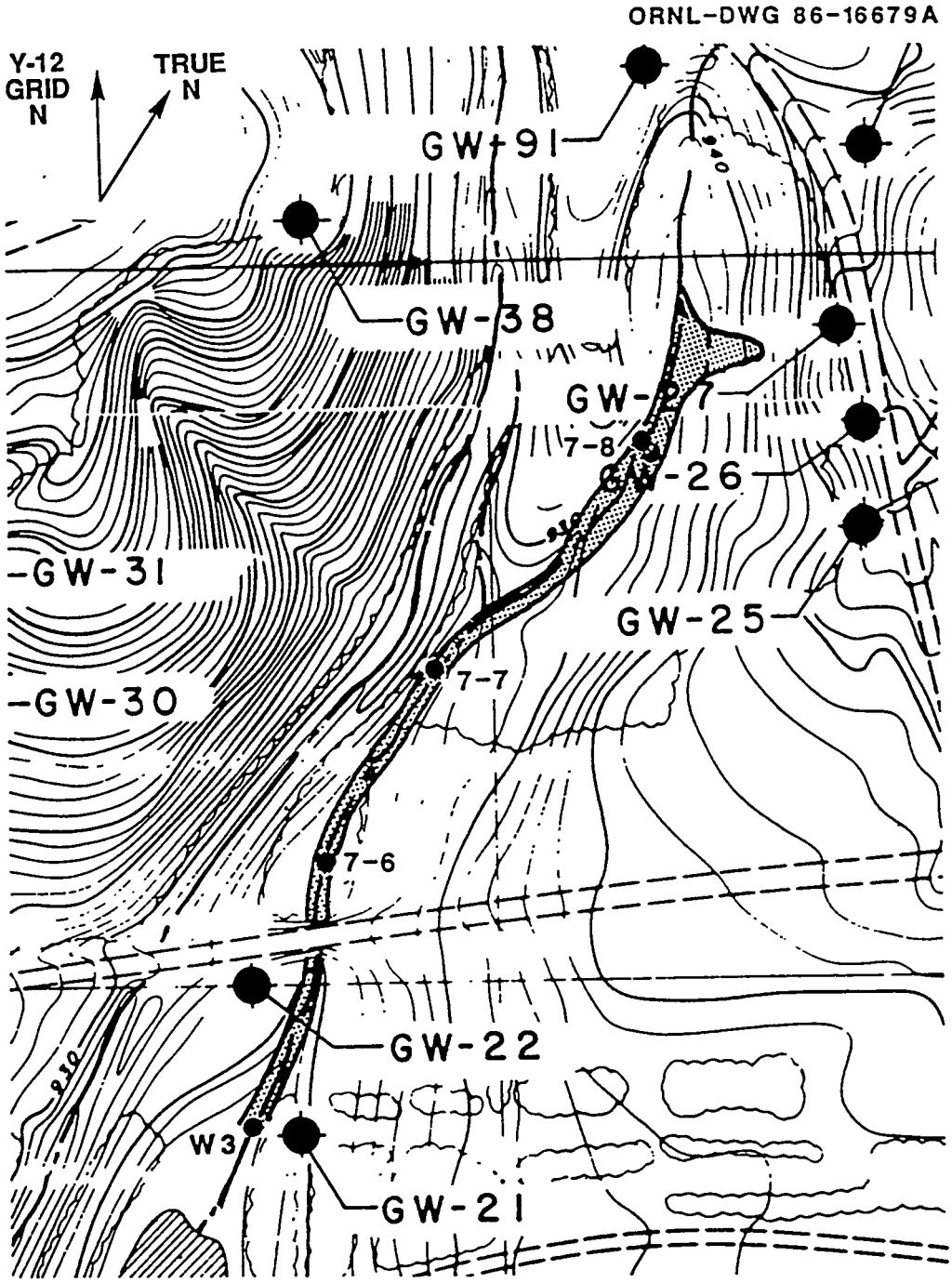


Fig. 4.6. Approximate area (stippled) north of Oil Retention Pond 1 on Tributary NT-7 in which surface (0-8 in) soil and sediment concentrations of PCBs exceed 25 mg/kg. Sediments at certain locations exceed this value to a depth of up to 27 in. Scale: 1" = 150 ft.

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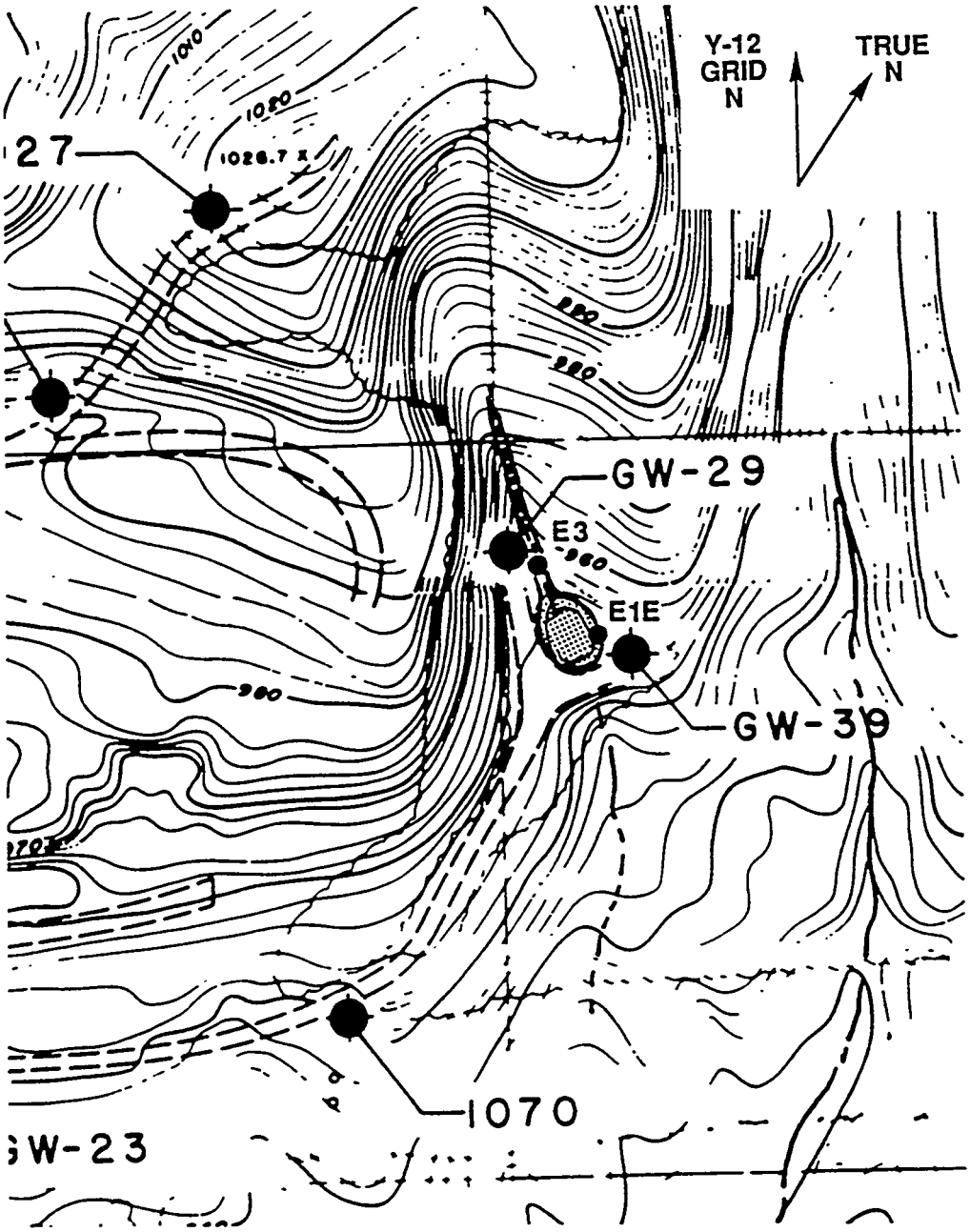



Fig. 4.7. Approximate area (stippled) at and north of Oil Retention Pond 2 on tributary NT-6 in which surface (0-8 in.) soil and sediment exceed 25 mg/kg. Scale: 1" = 150 ft.

10 μg/g. In the lower reaches of both tributaries concentrations range up to 225 μg/g. In contrast to PCBs, which are present at far higher levels in NT-7 sediments than in those of NT-6, uranium levels are similar in the two tributaries: the mean of nine samples collected at three locations from the stream channel and adjacent banks from NT-7 south of ORP-1 was 84 μg/g, while the mean of the same number of samples collected at three sites from NT-6 south of ORP-2 was 98 μg/g (Herbes 1988). Uranium concentrations were not correlated with PCB concentrations.

4.7.2.3 Other Organic and Inorganic Contaminants

Water and sediment samples were collected in 1983 from the Ponds and from several sites in NT-6 and NT-7, and analyzed for volatile organic compounds (VOCs), metals, cyanide, phenols, and a number of conventional water quality parameters. Several VOCs, principally including 1,1-dichloroethane, tetrachloroethylene (PCE), trans-1,2-dichloroethylene, and trichloroethylene (TCE) were found in sediments of ORP- 1, and in both water and sediments of NT-7 downstream from the Pond. However, VOCs were not detected in a water sample collected north of ORP-1, which indicates that the VOC source differs from that of PCBs. The total VOC concentration in the NT-7 sample near the confluence with Bear Creek was 1.6 mg/L (McCauley 1985e). A water sample collected at the same site in 1987 showed a similar VOC profile and similar concentrations (Appendix D). The distribution of VOCs found in NT-7 water and sediment samples is similar to the contaminant distribution found in numerous groundwater monitoring wells located near the burial trenches (Section 4.8), and suggests that subsurface flow is probably responsible for the contaminants detected in the tributary.

Sediment samples collected in September 1983 did not show elevated levels of toxic metals, cyanide, or phenols in ORP-1 or in NT-7 sediments downstream from the Pond when compared to a control site on NT-7 upstream from the Burial Grounds. Sediment concentration ranges (in μg/g) throughout the Pond/NT-7 system were: arsenic (40-140), beryllium (<1-3), cadmium (2-11), chromium (17-48), cobalt (2-20), copper (2-9), lead (30-80), nickel (6-68), silver (<1-2), zinc (21-100), cyanide (0.17-0.24),

and total phenols (0.05-0.21). None of these contaminants were detected in water samples collected in September 1983 from the Pond/NT-7 system, with the exception of cyanide, which was detected north of the confluence with Bear Creek at the analytical detection limit (0.01 mg/L) (McCauley 1985e). A sample collected at this location in December 1987 gave similar results with the exception of nickel, which was detected at a concentration of 0.0619 mg/L (Appendix C).

No semivolatile contaminants were detected from NT-7 at the sampling point north of the confluence with Bear Creek in the December 1987 sampling (Appendix C).

### 4.7.3 Summary

PCBs, uranium, and VOCs are present at elevated levels in sediments from the Oil Retention Ponds and tributaries NT-6 and NT-7. The principal source of PCBs at the present is the visible seep north of ORP-1 on NT-7; PCB contamination is widespread south of this point throughout the tributary and Pond sediments, and have been detected in water samples as well. PCBs are found throughout the sediments of NT-6, although at lower levels. Although VOCs are also present in NT-7 water and sediments south of ORP-1, the source is different because VOCs are not detected between the Pond and the visible seep to the north. Because the VOC profile in NT-7 water and sediments is similar to that of groundwater, elevated VOC concentrations in NT-7 may result from inflow to the stream of subsurface groundwater. Uranium is distributed throughout the sediments of both NT-6 and NT-7 in the reaches which flow past the Burial Grounds. Uranium in these tributary sediments may thus be due to erosion of particles containing uranium from the soils covering the burial trenches and transport into the tributaries.

## 4.8 BURIAL GROUNDS

Since 1955, when the burial grounds were first operated, several types of wastes have been disposed of in the various burial ground areas including the following (not listed in order of generated volume):

Ferrous metals and uranium

Oils and coolants

Salts

Debris

Solvents

Ethylenediamine tetracetic acid (EDTA)

Asbestos

Material contaminated with radioisotopes

Mop water

The actual quantity and identity of materials is uncertain, and other materials may nave been disposed of that are not listed in any inventory. The largest volume of material disposed in the Burial Grounds consists of uranium-contaminated industrial trash (paper, wood, steel, glass and rubble).

An estimated 600,000 gallons of mop waters were disposed of annually in Burial Ground A between 1971 and 1978; the quantities disposed of prior to 1971 were not recorded. Disposal of mop waters in Burial Ground A was terminated in 1979; after that date, these waters were placed in the S-3 Ponds.

Burial Ground A was also used for the disposal of oils and coolants. Prior to 1961, these liquids were placed, along with solid wastes, into unlined trenches. In 1961, a surface tank was installed in Burial Ground A to hold waste oils and coolants; the accumulations were burned, and the liquids which did not burn were drained into adjacent trenches. An estimated 180,000 gallons of oils and coolants were disposed of by this method between 1961 and 1968, when the practice was terminated. In January 1969, a new procedure was adopted, involving pouring of the oils and coolants into standpipes installed in the trenches. By 1976, most of the waste oils and coolants were being disposed of at the Oil Landfarm, and in 1979, oil disposal ceased in the Burial Grounds.

Prior to July 1970, waste solvents were disposed of by burning in an open tank located east of Burial Ground A. Between July 1970 and October 1981, the waste solvents were disposed of by pouring them onto rock piles and into waste-filled trenches in the southeast part of Burial Ground A.

Approximately 100,000 gallons of waste solvents were disposed of in this manner.

Burial Ground B was opened in 1962 for the disposal of depleted uranium metal and oxides. Burial Ground C was opened in 1962 for the disposal of beryllium, beryllium oxides, thorium, and solid waste contaminated with these materials; materials contaminated with enriched uranium were also disposed of in Burial Ground C. Burial Ground D was used after 1968 for the disposal of depleted uranium metals and oxides after Burial Ground B had reached its capacity.

When RCRA Part A permit applications were submitted, trenches and disposal areas in the Burial Grounds that received hazardous waste after November 19 1980, were designated and were given interim status. These trenches are identified in Figures 4.2 and 4.3.

A variety of wastes have been disposed of in the interim status units in the Burial Grounds. They include:

Walk-in Pits: miscellaneous laboratory chemicals

Isolation Area: solvents including alcohol, perchloroethylene, trichloroethylene, freon, and others

Trenches A-7 through A-12: mostly depleted uranium-contaminated solid waste, including wood, metal, paper, glass, debris, and others; smaller quantities of liquids including oils, machine coolants, and solvents

Rock Pits and Standpipes: some solvents and machine coolants

Trenches C-18, C-20 and C-21: various types of solid wastes contaminated with beryllium, beryllium oxide, thorium, and enriched uranium, some contaminated with solvents; small quantities of acid

The Burial Grounds are drained by Tributaries NT-6, -7, and -8. Seepage zones from adjacent burial areas have been observed on all three tributaries (Fig. 4.8); all three may thus serve as sources for contaminant entry into Bear Creek.

Contaminants detected in water and sediments from NT-6 and NT-7 are discussed in Section 4.7. Only a few sediment sample analyses have been reported for NT-8; however, sediments from the Seeps 3 and 4 on NT-8

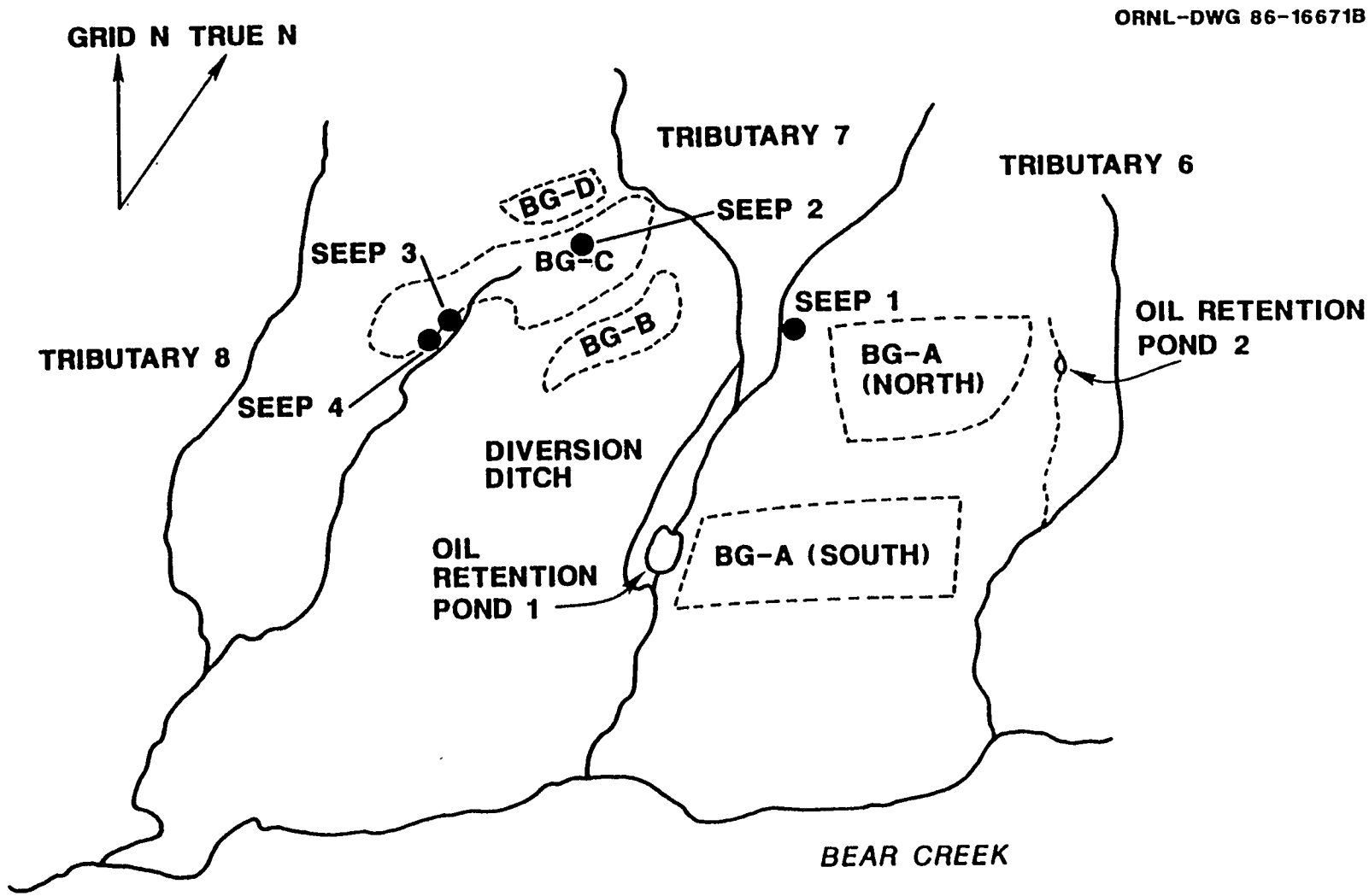



Fig. 4.8. Areas of visible seepage into tributaries NT-6, NT-7, and NT-8 in the vicinity of the Y-12 burial grounds. Scale: 1" = 600 ft.

(Fig. 4.8) have been shown to contain PCBs at concentrations up to 34 $\mu g/g$, and uranium levels up to 283 $\mu g/g$. Sediment samples from Seep 2, which serves as the source of NT-8, did not contain elevated PCBs (<1 $\mu g/g$) but contained uranium at levels up to 1349 $\mu g/g$ (Herbes 1988). Although sediment samples collected in 1983 from NT-7 near the confluence with Bear Creek did not contain detectable PCBs (<0.05 $\mu g/g$), subsequent samples collected in 1986 showed PCB levels up to 58 $\mu g/g$ in sediments deposited in the floodplain near the confluence, with lower levels (<0.1-19 $\mu g/g$) at sites further upstream. Uranium concentrations were also elevated near the confluence with Bear Creek (148-579 $\mu g/g$) relative to concentrations at sites further upstream (<1-315 $\mu g/g$). The results indicate that both PCBs and uranium have been transported from sources in Burial Ground C through NT-8, and have been deposited in the floodplain sediments at the confluence of NT-8 and Bear Creek.

## 4.9 WHITE WING SCRAP YARD

The waste originally stored at the White Wing Scrap Yard was mainly metal, glass, concrete and miscellaneous trash with radioactive contamination. The source and original usage of most of the stored material in the scrap yard has not been documented. Boegly and Moore (1988) have summarized the available information on the nature of contaminants still found at this site after an earlier (1970) cleanup effort. Isotopes reported to occur at elevated levels on the site include Cs-137, Sr-90, Pu-239/240, Am-241, Pu-238, Th-234 and U-235. One memo quoted by Boegly and Moore concluded that the entire area is quite extensively, and in some places intensively, contaminated with radionuclides. Studies by Morrison and Cerling (1987) and Boegly and Moore (1988) of stream water and gravels within, and adjacent to, this scrap yard indicated possible releases of Sr-90 and di-n-butylphthalate from the site. The Environmental Data Package for the White Wing Scrap Yard (Boegly and Moore 1988) concludes that although this SWMU is probably "not a significant source of hazardous constituents....uncertainties concerning the source of elevated levels of Cr, Cd, some organic contaminants, and surface radiation hot spots remain...and further investigations are needed to resolve these concerns."

# 5.0 CHARACTERIZATION OF THE ENVIRONMENTAL SETTING

## 5.1 GEOLOGY AND HYDROGEOLOGY OF THE STUDY AREA

### 5.1.1 General Geology

The DOE Oak Ridge Reservation (ORR), which includes Bear Creek, is located in the Valley and Ridge physiographic province, part of the Appalachian fold and thrust belt. The area is characterized by a succession of northeast-trending ridges and valleys, which formed as a result of differential erosion of the clastic and carbonate lithologies that make up the individual thrust sheets.

The major extent of Bear Creek is located in Bear Creek Valley, which is bounded to the north and south by Pine Ridge and Chestnut Ridge respectively. Maximum relief of the ridges is approximately 200 ft. These ridges and valley are part of the White Oak Mountain (WOM) thrust sheet, which exposes Lower Cambrian to Ordovician rock units in the immediate area. The stratigraphy of the area, from oldest to youngest (and exposed from grid-north to grid-south), includes the Lower Cambrian Rome Formation (exposed on Pine Ridge), the Cambrian Conasauga Group (exposed in Bear Creek Valley), and the Knox Group (exposed on Chestnut Ridge).

The Conasauga Group is further divided into six formations of alternating shale and carbonate-rich lithologies. From oldest to youngest these are: the Pumpkin Valley Shale, the Rutledge Limestone, the Rogersville Shale, the Maryville Limestone, the Nolichucky Shale and the Maynardville Limestone. At the immediate headwaters of Bear Creek south of the S-3 ponds, the creek bed lies in the upper Nolichucky Shale. Within 400 ft to the southwest, the creek crosses the contact of the Nolichucky Shale - Maynardville Limestone and remains in the Maynardville Limestone along much of Bear Creek Valley, flowing roughly parallel to regional geologic strike (N55E).

West of State Route 95 (White Wing Road), Bear Creek cuts north through Bear Creek Valley and Pine Ridge into the relatively gentle topographic depression that separates McKinney Ridge to the southwest from East Fork Ridge to the northeast. This region includes the WOM thrust fault zone, which exposes several slices of the Cambrian Rome Formation,

and the Kingston Thrust Sheet, which exposes slices of the Cambro-Ordovician Knox Group with overlying Ordovician Chickamauga Group strata.

#### 5.1.1.1 Stratigraphy

The strata of greatest interest, with respect to contaminant migration in Bear Creek Valley, include the Maynardville and Nolichucky Formations of the Conasauga Group. For general descriptions of the stratigraphy of other units in the ORR, the reader is referred to Haase et al. (1985) (Conasauga Group and Rome Formation), Lee and Ketelle (1987) (Knox Group), Lee and Ketelle (1988) (Chickamauga Group).

MAYNARDVILLE LIMESTONE (sources: King and Haase 1987; Rothschild et al. 1984; Geraghty & Miller 1987)

In Bear Creek Valley, the Maynardville Formation varies from 418 to 450 ft in thickness and shows a gradational lower contact with the Nolichucky Shale (King and Haase 1987). The Maynardville Limestone is composed of light gray to tan, massive to thinly-bedded limestone with subordinate amounts of dolostone. This formation can be divided into members on the ORR (Haase et al. 1985). The uppermost Chances Branch member consists of medium- to thin-bedded buff and light-gray dolostones, ribbon-bedded dolostones/limestones, and thin-bedded medium-gray limestones. The lower Low Hollow member is principally wavy to even thin-bedded (oo)microsparite, with alternating horizones of dolomite - bearing, ribbon-bedded microsparite and calcarenite. The Low Hollow Member and the lower portion of the Chances Branch Member are oolitic and soft sediment deformation fabrics have been observed (Geraghty & Miller 1987). Both members are locally stylolitic.

Drilling in the Y-12 Plant area (Rothschild et al. 1984, Army Corps of Engineers [1954a,b]) and further west in the Y-12 burial grounds (Bechtel 1984) shows that, in the near subsurface, the Maynardville Limestone is characterized by numerous solution cavities, which generally range in thickness from less than 1 ft to 3 ft although cavities from 8 to 11 ft thick have been noted (Rothschild et al. 1984). The cavities commonly parallel bedding planes. Where Bear Creek lies in the Maynardville Limestone, the position of the channel is controlled by preferential solution along joints and fractures (Geraghty & Miller 1987).

NOLICHUCKY SHALE (sources: King and Haase 1987; Rothschild et al. 1984).

In Bear Creek Valley, the Nolichucky Shale ranges in thickness from 422 to 550 ft (King and Haase 1987). In East Tennessee, the Nolichucky Shale can be divided into three members: the Upper Shale, the Bradley Creek, and the Lower Shale Members (Hasson and Haase 1988) although identification of these members in Bear Creek Valley is not

straightforward. The formation consists of maroon-brown to rare green-gray, massive to very thinly-bedded, locally calcareous mudstones and shales interstratified with thinlybedded, medium gray limestones and calcareous siltstones. The maroon-brown color of the shales is characteristic of the Nolichucky Shale (Haase, King, and Baxter, in prep).The interbedded limestone typically contain limestone-pebble conglomerates and oolite-rich beds similar to those occurring in the underlying Maryville Limestone. Throughout much of the Nolichucky Shale, mudstone/shale and limestone lithologies alternate on a scale of 1 to 3 ft, giving the formation a thickly bedded appearance (Haase, King, and Baxter, in prep).

During drilling at the Y-12 plant, solution cavities, opened fractures and iron precipatate were commonly observed up to downhole depths of 50 ft (Rothschild et al. 1984). Comparison of Maynardville Limestone and Nolichucky Shale descriptions suggest the solution cavity development is not as extensive in the Nolichucky Shale as it is in the Maynardville Limestone.

### 5.1.2 Structural Geology

#### 5.1.2.1 Faults

Pine Ridge, Bear Creek Valley and Chestnut Ridge all are part of the White Oak Mountain (WOM) thrust sheet, which is floored by the WOM thrust fault. The WOM is a regional thrust fault of the Valley and Ridge, which shows at least several km's of displacement. The fault formed during the Permian-Pennsylvanian Alleghanian Orogeny and has not been historically active. At the ORR, the fault trends parallel to regional strike (N55E) and dips steeply (45°) to the southeast (King and Haase 1987). Bedding planes dip values measured in outcrop cluster around 45°, but locally may steepen to vertical as a result of local small scale folding or faulting.

The WOM thrust fault north of Pine Ridge is very complex and is characterized by a sequence of cross-cutting imbricate splay faults that repeatedly stack the Rome Formation. In the vicinity of Bear Creek, this fault superposes the Cambrian Rome Formation over the younger Cambrian Copper Ridge Dolomite member of the Knox Group. In addition, north of the WOM thrust fault, in the underlying Kingston Thrust Sheet, Bear Creek flows over slices of the Knox Group and Chickamauga Group that have been complexely stacked and rotated as a result of footwall deformation associated with displacement along the WOM fault. Because of the complex deformation associated with the WOM thrust fault and the immediately underlying Kingston Sheet, it is anticipated that this region contains

numerous fault-related fracture zones of enhanced permeability.

Bear Creek Valley is characterized by numerous cross-strike streams with a consistent northwestern trend. Such a consistent orientation suggests that the location of these creekbeds is controlled by a geological structural feature, either a minor tear fault or a prominant fracture trend. Both features are possible and in Melton Valley, the White Oak Creek Tear Fault shows a similar north trend. If these structures are faults, they show minor displacement but should have an associated fracture zone.

#### 5.1.2.2 Fractures

Because of the large scale faulting, all geologic units in the ORR are highly fractured. Recent detailed investigations of Conasauga Group core by Lutz and Dreier (1988) show that five fracture sets occur consistently throughout the core. One set is parallel to bedding, but the other four are generally perpendicular to bedding. The parallel bedding fractures are mainly release joints. Recent studies elsewhere in the Appalachians suggest that release joints can form at depths up to a km (Engelder 1985). Assuming a regional strike of N55E, the strikes of the high angle sets are approximately N55E, N75W, N15E, and N20W.

Fracture density varies throughout the cores. The two variables that have the greatest effect on density are lithology and bedding thickness. Density is inversely proportional to bedding thickness. High fracture densities are found in shales and interbedded limestone and shale, whereas limestones exhibit lower densities. Mineralization is almost entirely confined to limestone beds. All fracture sets exhibit vein development; however, the N55E direction is most commonly mineralized.

### 5.1.3 Hydrogeology

The hydrologic regime underlying Bear Creek Valley (BCV) is comprised of two major components:

- Regional flow system
- Local flow system

In general, a groundwater flow system of regional scale is defined by relatively deep circulation that is independent of local topography and small-scale surface water systems. The regional flow system underlying BCV is virtually undefined, primarily because of the limited number of deep wells that are available and have been included in past characterization studies. Currently, the only hint to the depth at which regionally controlled groundwater flow may predominate comes from examination of a few scattered chemical analyses that have been obtained in the deep wells. For example, see the partial analyses presented in Geraghty & Miller (1988a and b) for wells GW-117, -118, -119, -123, and -125. These and more extensive, but as yet unpublished, analyses show that below depths of approximately 500 ft the groundwater appears to become more highly mineralized with sodium, chloride and sulfate than the relatively dilute, shallow groundwaters typical of this region. The nature of any interaction between the compositionally distinguishable shallow and deep groundwaters beneath BCV is unknown at this time, but probably is limited.

The local flow system includes groundwater contained within the unconsolidated weathered residuum and the upper part of the underlying bedrock (see section 5.1.1 for a description of bedrock in BCV). Groundwater flow within this hydrologic system is strongly influenced by topography and surface drainage patterns. Hydrologic investigations reported by Geraghty & Miller (1988a) show that the surface drainage divide that separates East Fork Poplar Creek from Bear Creek near the S-3 Ponds also is a groundwater divide that defines the eastern boundary of the shallow BCV hydrologic system.

Results of numerous studies (e.g., Geraghty & Miller 1988b; Bailey and Lee 1988) within BCV and along its bounding ridges demonstrate that recharge of this flow system occurs along the ridges through infiltration of precipitation. Groundwater flow paths typically are directed away from the bounding ridges and generally follow the topography, converging within the valley in the vicinity of Bear Creek. As an example of the relationship between topography and potentiometric surface, Figure 5.1 presents the configuration of the water table in the Y-12 Burial Grounds which lies on the southern slope of Pine Ridge. The contours generally

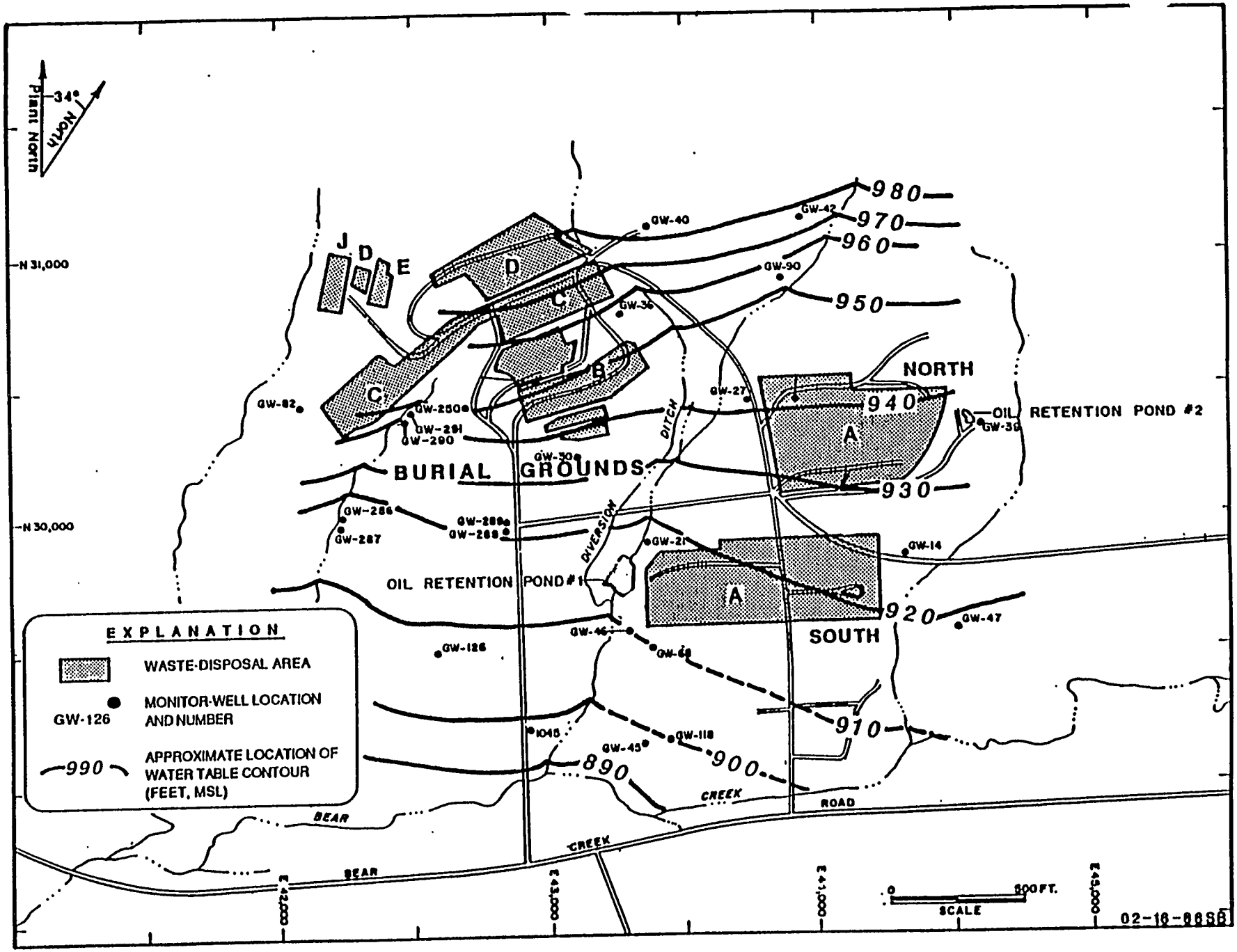



Fig. 5.1. Water table elevation contours at the burial grounds, December 9, 1987 (from Geraghty & Miller 1988b).

indicate southerly and southeasterly directions of groundwater movement northwest of Bear Creek. Figure 5.2 presents a generalized cross section across BCV that illustrates the idealized subsurface flow of groundwater described above. In the zone underlying Bear Creek, the direction of groundwater flow is southwest along the valley axis. These results are consistent with those obtained in other regions of BCV.

Flow within the shallow groundwater system, while dominated by the topography of the drainage system, is also strongly influenced by structural properties of the bedrock. For example, several recent studies have investigated the fractures in bedrock material obtained from coreholes along a transect across BCV near the head of Bear Creek (Lutz and Dreier 1988). These studies demonstrate that several major fracture sets exist, dominated by a strike-parallel set. The results of these studies provide reasonable confirmation for observations from a pumping test performed in this area which showed that hydraulic properties of bedrock are not isotropic (Geraghty & Miller 1987). Rather, hydraulic conductivity values in the strike-parallel direction are at least several times larger than in any other direction. Anisotropy in hydraulic properties means that the direction of groundwater flow will deviate somewhat from that predicted by the potentiometric contours such as presented in Figure 5.1.

In addition to small-scale deformation features such as the fracture sets discussed above, it is probable that large-scale features including fracture zones and faults exist in BCV and influence groundwater flow. The nearly parallel southerly flow direction of most tributaries draining the southern slope of Pine Ridge is one example of the type of surface expression anticipated from parallel fracture zones. At present, the identity of these structural features and their potential for affecting groundwater flow paths, contaminant migration, and the interaction between shallow and deep hydrologic systems is unknown.

In the vicinity of Bear Creek the interaction between the creek and the shallow groundwater system has not been systematically investigated. In many similar drainage basins streams are found to be line sinks with groundwater discharging to the stream bed along its entire length. However, discussions in Sections 7.2.2 and 7.4 demonstrate that over much of its

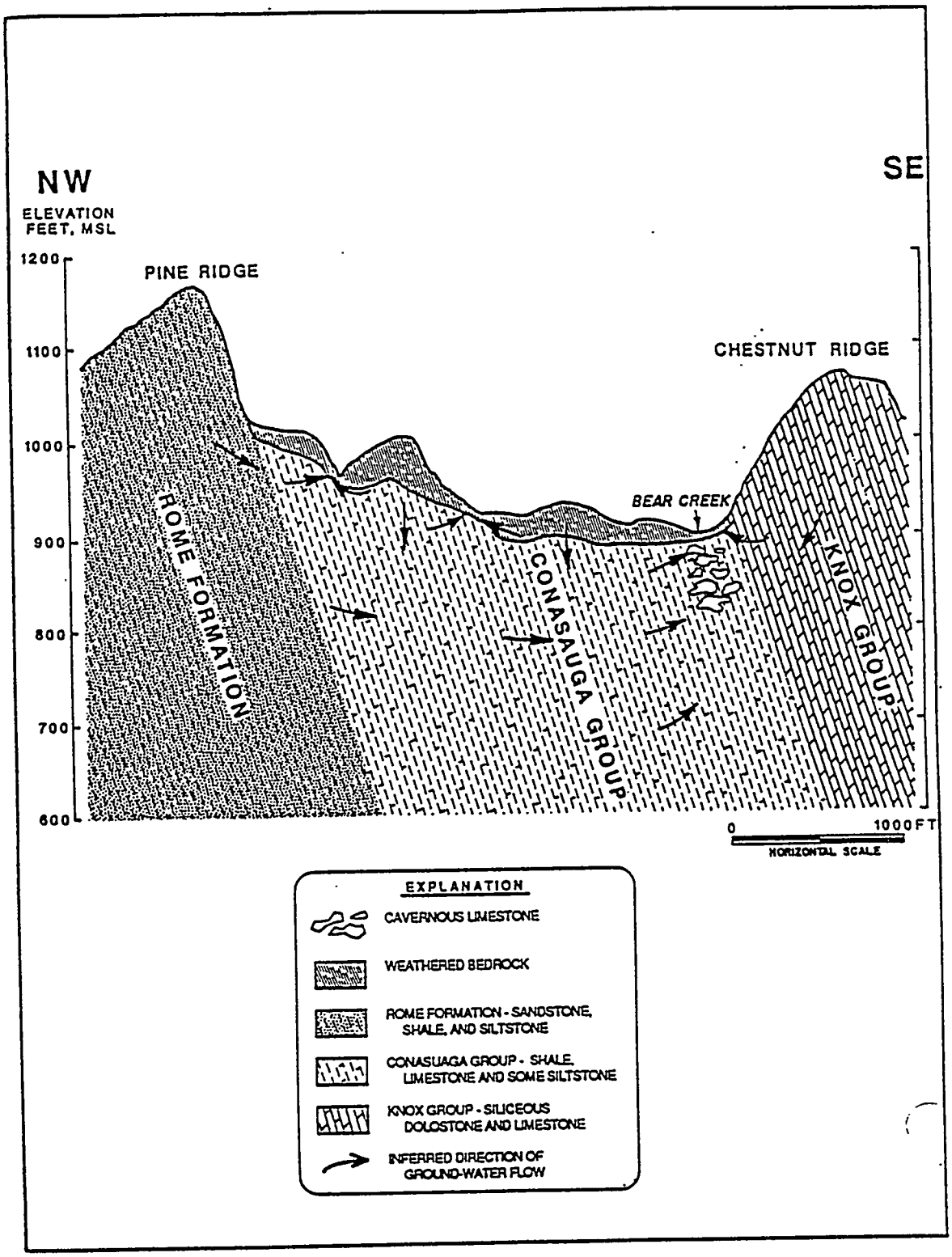



Fig. 5.2. Generalized groundwater flow pattern in Bear Creek Valley (from Geraghty & Miller 1988b).

length Bear Creek is a losing stream. That is, it serves locally as a source of recharge to the shallow groundwater system. It is believed that an extensive network of solution channels within the Maynardville limestone that underlies Bear Creek makes it an efficient drain for the local groundwater system and is the principal cause for the existence of losing reaches along the length of the stream. Section 7.2.2 examines available water level data obtained from monitoring wells along the floodplain of Bear Creek in order to further examine this feature.

## 5.2 SURFACE WATER

### 5.2.1 Surface Water Network

Bear Creek flows westward from its headwaters at the S-3 Ponds for approximately 4-1/2 mi, where it then turns northward to flow into East Fork Poplar Creek. (Fig. 5.3). East Fork Poplar Creek ultimately enters Poplar Creek, which discharges to the Clinch River. The drainage area of Bear Creek at its confluence with East Fork Poplar Creek is 7.4 $mi^2$ (square miles). Altitudes of the land surface in the entire watershed of Bear Creek range from 755 ft msl to about 1,200 ft msl on Pine Ridge and Chestnut Ridge.

Bear Creek is fed by small tributaries originating on the slopes of Pine and Chestnut ridges which border the valleys and by springs emanating mainly from the base of Chestnut Ridge. The trellis type drainage pattern is strongly influenced by the underlying structure.

The headwaters of Bear Creek are characterized by a relatively steep banked channel cut to a depth of about 5 ft or more into the silts and clays of the fill and unconsolidated material. As discussed in Section 3.1 Bear Creek tributaries have been numbered, beginning with NT-1 (North Tributary 1) near the S-3 Ponds. The total area of the Bear Creek watershed above the point where it crosses the Anderson/Roane county line slightly downstream of NT-8 is 1.57 $mi^2$. The area of the watershed at the National Pollutant Discharge Elimination System (NPDES) station at BCK-4.55 is about 4.2 $mi^2$. The area of the flood-of-record floodplain is 164 acres (Fig. 5.4), with an average width of 169 ft. The outline of the flood-of-record floodplain was obtained from maps prepared by the TVA as part of the

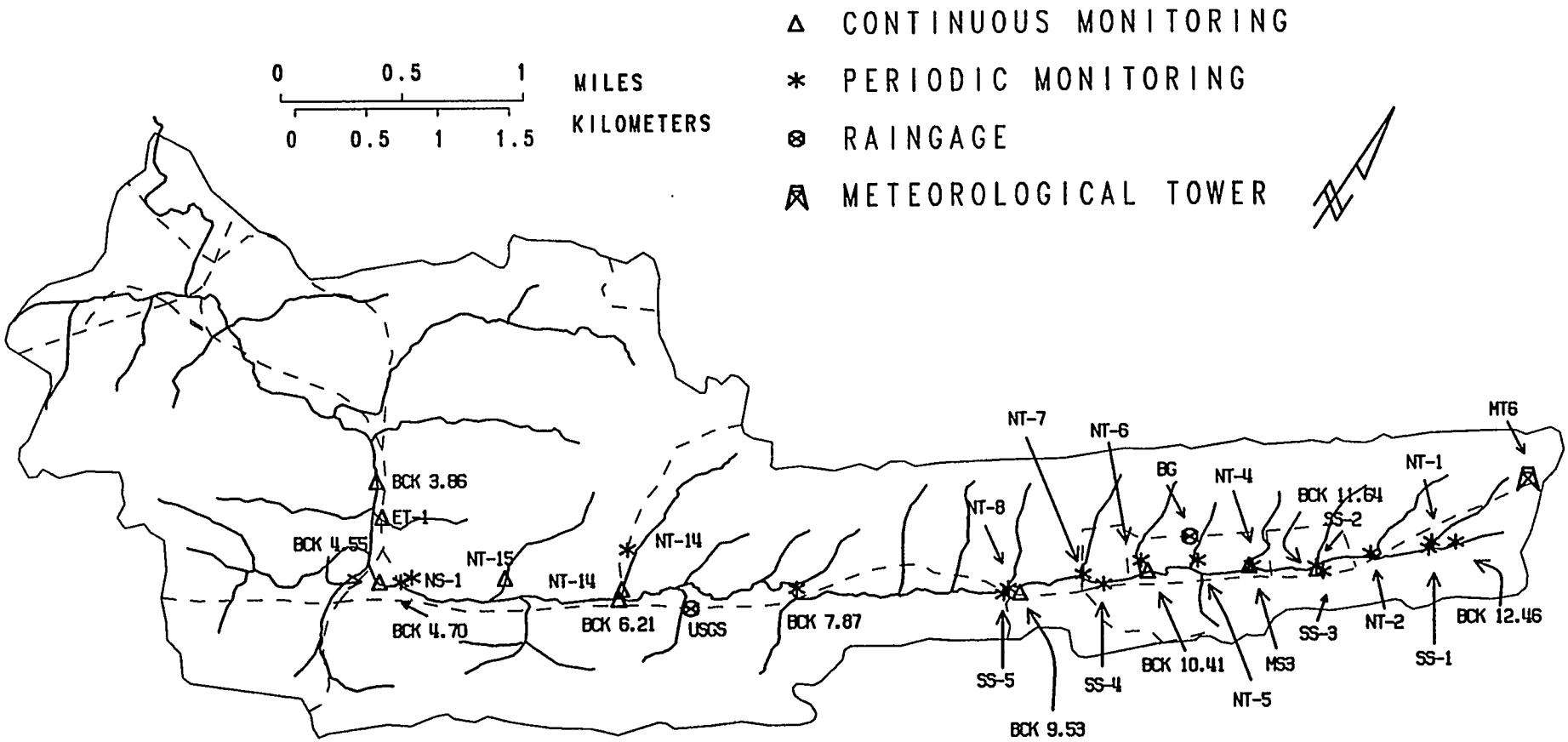



Fig. 5.3. Locations of Bear Creek hydrologic monitoring sites.

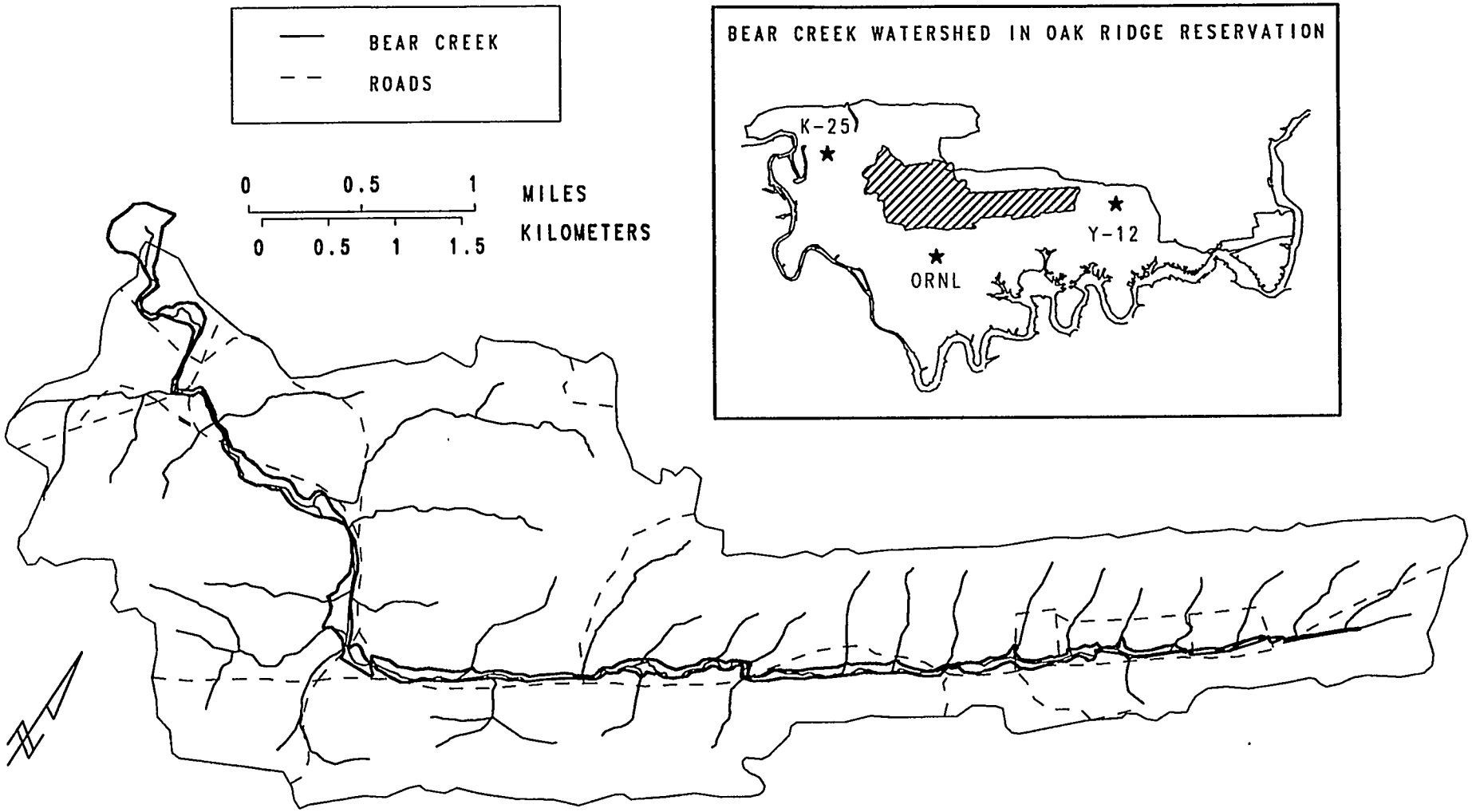



Fig. 5.4. Bear Creek drainage network and flood-of record floodplain (Outline of flood-of-record from TVA maps produced for Oak Ridge Interagency Task Force).

Oak Ridge Interagency Task Force evaluation of contaminants associated with the DOE Oak Ridge facilities.

### 5.2.2 Surface Water Hydrology

The hydrology of Bear Creek and its tributaries reflects the underlying geology of the watershed. Mainstem Bear Creek above the U.S. Geological Survey (USGS) gaging station at BCK 4.55 is characterized by reaches of stream where flow is lost to the solution-cavity system (McCauley 1985a). A major losing reach is located between the burial grounds and oil landfarm near BCK 10.41, and another is located just above BCK 4.70. Periods of zero flow are common in Bear Creek near BCK 10.41 but occur less frequently at BCK 4.70 (Table 5.1). The north tributaries of Bear Creek above the SS-5 spring, especially NT-3, NT-4, NT-5, and NT-6 (Figs. 3.2 and 3.3), drain portions of Pine Ridge; these streams are intermittent and are usually dry during summer and early fall. The south tributaries, on the other hand, originate as springs in the Knox Dolomite of Chestnut Ridge and are perennial streams. There is evidence that springs receive at least some flow from the solution-cavity system, although the precise outlets of the system are unknown (McCauley 1985a). A fluorescein dye tracer study conducted in October 1988 revealed that stream flow which disappeared near BCK 10.41 reappeared within a few days at spring SS-5 (Geraghty & Miller, personal communication).

The characterization of surface water hydrology in Bear Creek watershed is based on weekly or continuous flow measurements at 10 mainstem stations and 15 tributaries. Continuous USGS records of stream flow are available at BCK 4.55 (the NPDES site on lower Bear Creek) since March 1985 and at BCK 6.24 and BCK 3.88 since September and October 1986, respectively. The USGS has also monitored flows on two north tributaries (NT-14 and NT-15) and an east tributary (ET1) since October 1986 (Figs. 3.2 and 3.3). Measurements of stream flow were conducted weekly between March 19 1984, and October 16 1987, by staff in the ORNL Environmental Sciences Division (ESD) at 19 sites, all but three of which were located in Bear Creek watershed at or above the SS-5 spring. Since November 1987,

Table 5.1. Mean, standard deviation (SD), and range of stream flows (L/S) in Bear Creek and selected tributaries (confluence with Bear Creek is given in parentheses), 1985-1987. Flows were measured weekly except at those USGS sites on lower Bear Creek where stream flow is monitored continuously and average daily values are computed. N=45 in 1985, 47 in 1986, and 42 in 1987 except the USGS sites and unless noted otherwise. NA = no data available.

| Site | Drainage area ($km^2$) | 1985 $\bar{X}$ | 1985 SD | 1985 Range | 1986 $\bar{X}$ | 1986 SD | 1986 Range | 1987 $\bar{X}$ | 1987 SD | 1987 Range |
|---|---|---|---|---|---|---|---|---|---|---|
| BCK 12.46 | 0.43 | 0.76 | 0.54 | 0.08-2.6 | 0.71 | 0.85 | 0.06-5.1 | 1.53 | 3.82 | 0.06-20.7 |
| BCK 11.64 | 1.57 | 7.4 | 6.8 | 1.13-26.3 | 7.9 | 12.7 | 0.28-67.7 | 10.2 | 19.5 | 0.0-118.4 |
| BCK 11.17 | 1.91 | 9.1 | 9.1 | 0.3-34.0 | 11.9 | 22.1 | 0.0-124.0 | 18.4 | 59.8 | 0.0-388.0 |
| BCK 10.41 | 2.81 | 9.6 | 12.7 | 0.0-51.5 | 13.3 | 28.3 | 0.0-160.3 | 20.4 | 70.5 | 0.0-456.0 |
| BCK 9.53 | 3.92 | 13.6 | 16.4 | 1.1-63.4 | 16.4 | 36.2 | 0.0-217.5 | 23.2 | 68.5 | 0.0-436.7 |
| BCK 9.41[a] | 4.07[b] | 28.3 | 24.6 | 5.4-95.7 | 29.2 | 51.8 | 0.8-302.4 | 37.4 | 88.6 | 0.8-557.3 |
| BCK 7.87 | 5.96 | 32.3 | 31.7 | 2.8-138.8 | 38.5 | 71.9 | 1.4-431.9 | 47.6 | 123.2 | 1.4-791.0 |
| BCK 6.24[c] | 8.29 | | NA | | | [d] | | 63.8 | 191.4 | 0.3-2,974 |
| BCK 4.70 | NA | 46.2[e] | 45.3 | 3.7-199.4 | 74.2 | 160.6 | 0.0-965.4 | 83.3 | 192.6 | 0.0-1,186 |
| BCK 4.55[c] | 11.03 | 103.9[f] | 159.8 | 12.2-2,237 | 106.0 | 227.6 | 6.5-2,436 | 110.9 | 232.9 | 5.4-2,974 |
| BCK 3.88[c] | 12.95 | | NA | | | [g] | | 119.9 | 351.4 | 6.8-5,579 |
| Tributaries | | | | | | | | | | |
| SS1 (BCK 12.38) | 0.10 | 0.45 | 0.31 | 0.03-1.42 | 0.34 | 0.31 | 0.0-1.70 | 0.42 | 0.57 | 0.0-3.40 |
| SS2 (BCK 11.68) | NA | | NA | | | [h] | | 1.6 | 1.8 | 0.23-6.8 |
| SS3 (BCK 11.67) | 0.23 | 0.76 | 0.68 | 0.17-2.55 | 0.68 | 0.88 | 0.08-3.40 | 1.02 | 1.19 | 0.06-5.10 |
| SS4 (BCK 10.14) | 0.22 | 4.0 | 1.7 | 1.7-9.3 | 3.7 | 2.8 | 0.6-11.9 | 3.7 | 2.8 | 0.4-11.0 |
| SS5 (BCK 9.41) | 0.12 | 11.9 | 6.8 | 4.0-27.5 | 9.9 | 12.2 | 0.8-63.2 | 10.2 | 10.8 | 0.8-45.0 |
| NT14[c,i] (BCK 6.24) | 0.78 | 4.0 | 4.2 | 0.6-18.1 | 5.1 | 11.6 | 0.03-74.2 | 7.6 (5.3)[g] | 19.8 (19.5) | 0.31-124.6 (0.0-311.5) |
| NT15[c] (BCK 5.32) | 0.36 | | NA | | | [g] | | 2.7 | 9.2 | 0.0-141.6 |
| ET1[c] (BCK 4.07) | 0.36 | | NA | | | [g] | | 2.2 | 6.9 | 0.0-102.0 |

[a]Tabular values based on summation of flows at BCK 9.53, NT8, and SS5 (Fig. 3-2).

[b]BCK 9.42 (McMaster 1967).

[c]USGS station; tabular data are based on average daily values.

[d]N=98 in 1986 and N-365 in 1987.

[e]N=40 in 1985 because monitoring initiated on February 21, 1985.

[f]N=306 in 1985 because monitoring initiated on March 1, 1985. N=365 in 1986 and N=360 in 1987.

[g]N=92 in 1986 and N=360 in 1987.

[h]N=6 in 1986.

[i]USGS data in parentheses.

monitoring has been conducted monthly. The flow measuring techniques utilized in the ESD program are described in McCauley (1985a, Sec. 6.2.1).

Flow data collected on Bear Creek and selected tributaries from 1985 through 1987 by both USGS and ESD personnel are summarized in Table 5.1. Because the ESD program was primarily a hydrologic characterization of Bear Creek during low-flow periods, the increase in the mean annual discharge observed from 1985 to 1987 at all mainstem sites except BCK 12.46 is probably spurious. High flows could not be accurately measured and peak flows could have been missed by the weekly sampling frequency. Moreover, the maximum flow measured at ESD site BCK 4.70 was only 40% of that observed at USGS site BCK 4.55 in 1986 and 1987 and <10% in 1985. Although two large springs (SS-7 and SS-8) enter Bear Creek between these two sites, their contribution to the flow at BCK 4.55 would not significantly increase the annual maximum flow. The decrease in the annual minimum flow observed between 1985 and 1987 was most likely real, reflecting the effects of an extended drought.

### 5.2.3 Drought Effects

The environmental evaluation of Bear Creek described in this report coincided with a period of extended drought, which is described below in terms of its effect on both precipitation pattern and stream flows.

#### 5.2.3.1 Precipitation Patterns

Precipitation is measured by the National Oceanic and Atmospheric Administration (NOAA) at the Atmospheric Turbulence and Diffusion Laboratory (ATDL) in Oak Ridge. Records are available since 1973 at this site and since May 1947 at previous locations in Oak Ridge. Precipitation is also measured by ESD staff at seven sites on the Oak Ridge Reservation, including a site in the Bear Creek Burial Grounds where precipitation has been measured since August 1984. The site is located between tributaries NT-5 and NT-6 and approximately 150 m north of Bear Creek near BCK 10.6. The Oak Ridge station is approximately 5.6 km northeast of the Bear Creek station.

Annual precipitation at the ATDL site was below normal (1951-1980 record period) in four of the past five years (1983-1987) but was less than 75% of normal in 1986 and 1987 (Table 5.2) and was at or above normal in only three months of each year (Fig. 5.5). Of particular significance was the below normal rainfall that occurred from November through April in each of the past four years (Table 5.2). During this period, evapotranspiration is minimal and the groundwater recharge rate is usually high. Low precipitation, however, can result in low recharge of the aquifer, thus resulting in lower-than-normal stream flows. The effect on flow from consecutive years of low groundwater recharge can be cumulative.

Rainfall during the other six months of the year (May through October) was above normal in 1984 and 1985 and 76% and 79% of normal in 1986 and 1987, respectively (Table 5.2). As much as 80% of the precipitation that falls during July to September is lost to evapotranspiration (McMaster 1967), so stream flow is usually low. At this time, streams are at base flow, and the contribution from groundwater to surface flow is maximum. The annual minimum flow decreased from 1985 relative to 1987 at most sites on Bear Creek watershed (Table 5.1), and the occurrence of zero flow increased in both frequency and area over this same period (Fig. 5.6 and Table 5.3). Annual rainfall measured at the rain gage near BCK 10.6 decreased by 11.1% from 1986 TO 1987, whereas rainfall at the ATDL meteorological station in Oak Ridge increased by 3.8% over this same period. The trend toward increasing severity of the drought through time was due to both low rainfall in late summer and fall and to the cumulative effect of low groundwater recharge rates in 1984-1985 and 1985-1986. The effects of the drought on stream flow in Bear Creek are discussed in greater detail below.

#### 5.2.3.2 Bear Creek Hydrograph

The 3-year hydrograph for lower Bear Creek at the NPDES monitoring station (BCK 4.55) was dominated by extensive periods of low flow in both 1986 and 1987 (Fig. 5.7). In both years, the mean annual flow at BCK 4.55 (Table 5.1) was approximately 50% of that estimated by McMaster (1967) for the period 1936-1960. From late July through October of the 2 years, mean

Table 5.2. Comparison of precipitation (mm) for two periods of the year with contrasting evapotranspiration rates and groundwater recharge rates, 1983-1988. Data were recorded at the NOAA meteorological station in Oak Ridge. Normal precipitation is based on the 1951-1980 record period. Source: NOAA (1988).

| | Annual | | November-April[a] | | May-October | |
|---|---|---|---|---|---|---|
| | Total | % of normal | Total | % of normal | Total | % of normal |
| 1983 | 1210.82 | 87.0 | 765.30 | 98.4 | 502.16 | 81.9 |
| 1984 | 1435.61 | 103.2 | 719.07 | 92.4 | 864.88 | 141.0 |
| 1985 | 1181.61[b] | 85.0 | 466.36 | 60.0 | 723.38 | 118.0 |
| 1986 | 986.28[b] | 70.9 | 440.43 | 56.6 | 484.64 | 79.0 |
| 1987 | 1023.87[b] | 73.6 | 642.89 | 82.7 | 469.15 | 76.5 |
| 1988 | - | - | 549.40 | 70.6 | - | - |
| Normal | 1390.90 | - | 777.74 | - | 613.16 | - |

[a]From November of preceding year to April of year listed.

[b]Total annual precipitation recorded at a rain gage in the Bear Creek Valley burial grounds was 1,030 mm in 1985 (excluding January 1-17); 1,003 mm in 1986; and 89 mm in 1987. The gage was installed in August 1984 and is located approximately 150 m north of BCK 10.6 (Fig. 5.3).

Table 5.3. Frequency and duration of zero flow periods in Bear Creek, 1984-1987. NS = not sampled.

| Site | Proportion of sampling dates with zero flow[a] | | | | No. of consecutive sampling dates of zero flow | | | |
|---|---|---|---|---|---|---|---|---|
| | 1984 | 1985 | 1986 | 1987[b] | 1984 | 1985 | 1986 | 1987[b] |
| BCK 12.46 | 0[c] | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| BCK 11.64 | 0 | 0 | 0 | 4.0 | 0 | 0 | 0 | 1 |
| BCK 11.17 | 6.7 | 0 | 19.2 | 36.0 | 3 | 0 | 5 | 6 |
| BCK 10.41 | 4.2 | 38.5 | 76.9 | 68.0 | 7 | 2 | 6[d] | 14 |
| BCK 9.53 | 8.3 | 0 | 15.4 | 44.0 | 2 | 0 | 1 | 9 |
| BCK 9.41 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| BCK 7.87 | 0[c] | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| BCK 4.70 | NS | 0 | 15.4 | 28.0 | NS | 0 | 3 | 6 |

[a]May through October only; N=24 (1984), N=26 (1985), N=27 (1986) and N=25 (1987).

[b]Actual values may be higher because no measurements were taken during October 17-31 when precipitation was low (total for that month was only 24% of normal).

[c]No flow measurements were taken prior to July 26, 1984.

[d]July 17-August 22 and again from September 5-October 9.

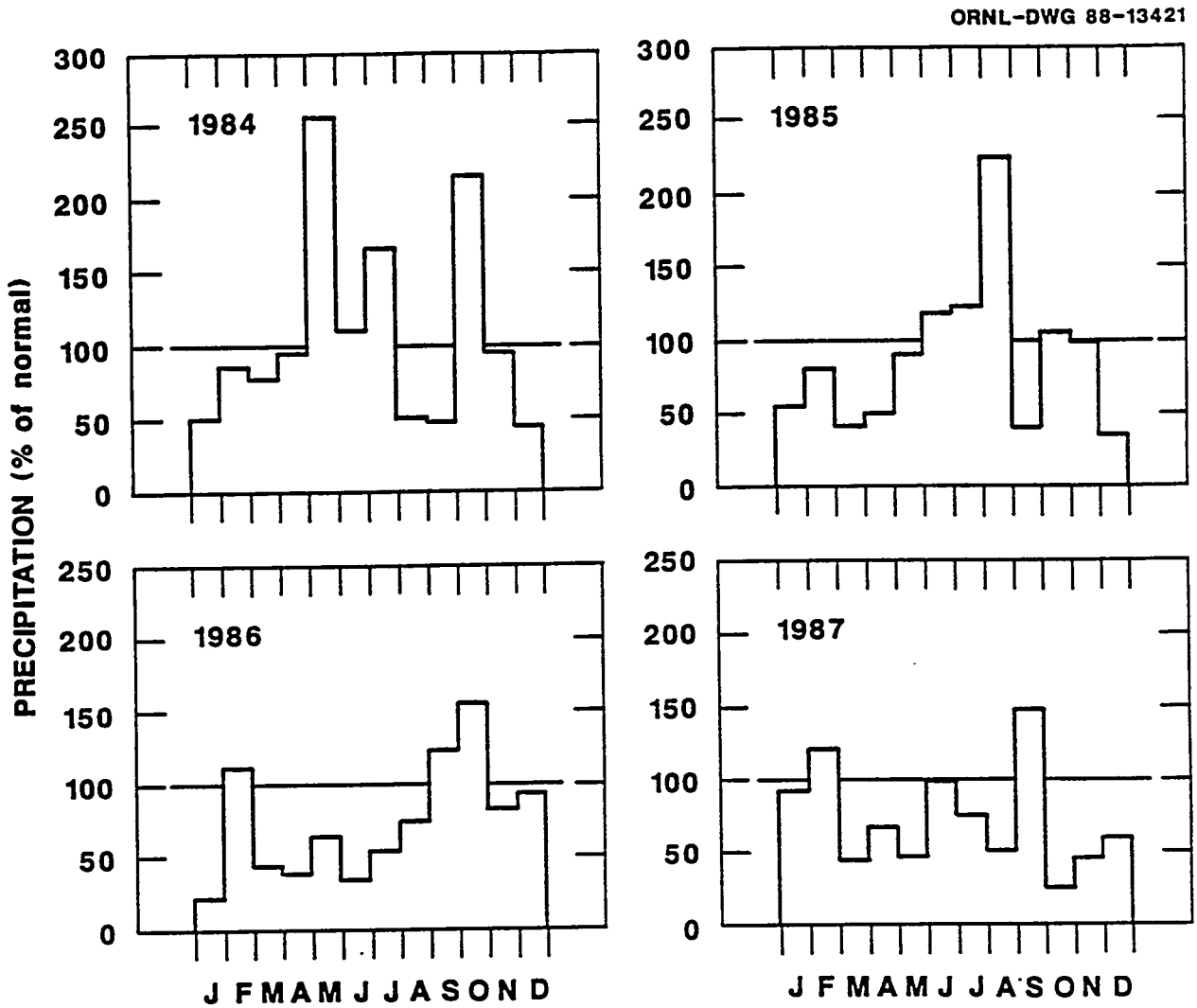



Fig. 5.5. Monthly precipitation, as percent of normal (1951-1980 record period), at the NOAA Meteorological Station in Oak Ridge, 1984-1987. The station is located approximately 3.5 km northeast of the headwaters of Bear Creek. Source: NOAA (1988).

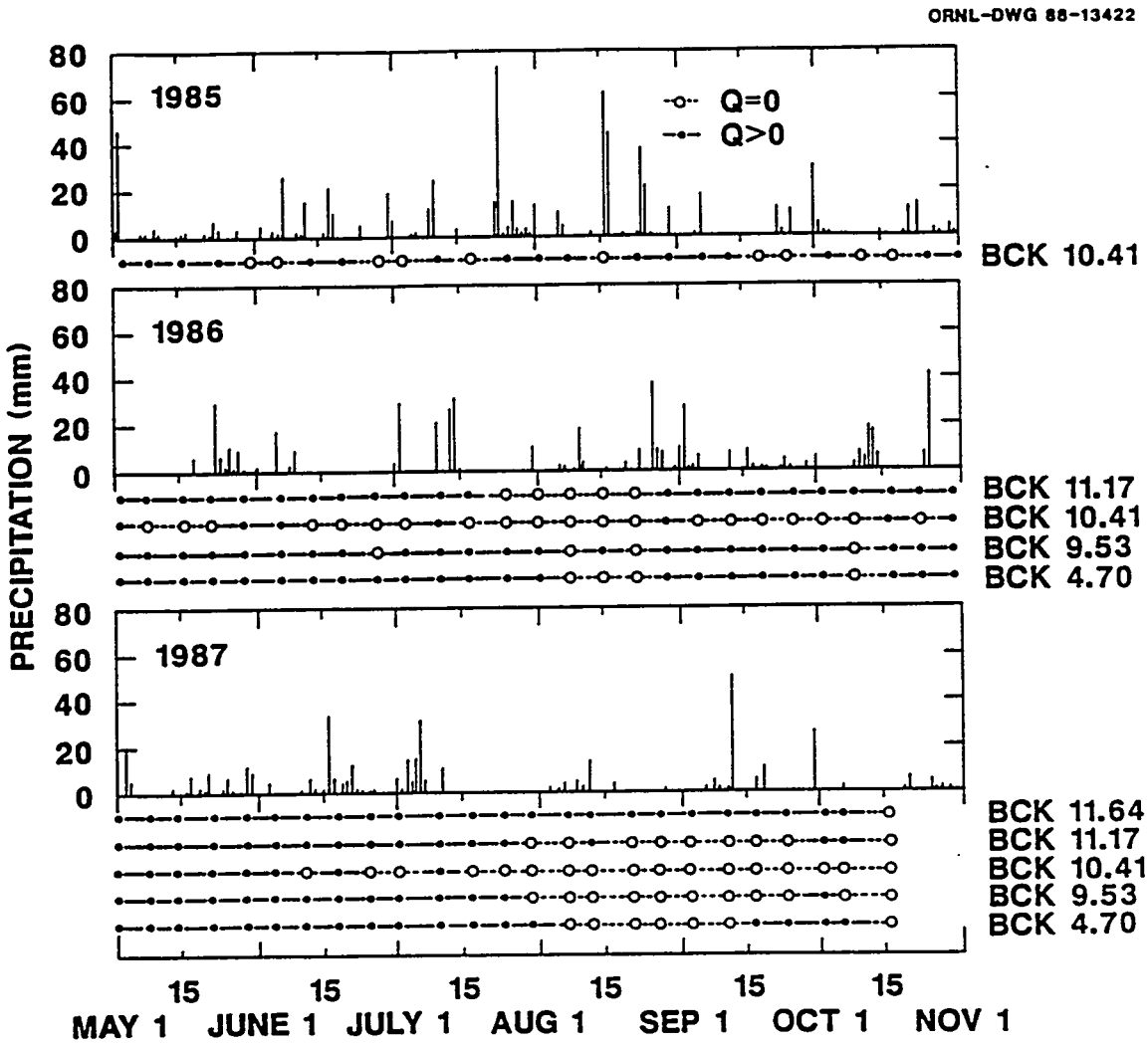



Fig. 5.6. Comparison of total daily precipitation and the frequency of occurrence of zero flow in mainstem Bear Creek, 1985-1987. Sampling dates are indicated by open circles (zero flow) and closed circles (flow > 0.02 L/s). Precipitation was measured at a rain gage located near BCK 10.6 in the Bear Creek Valley burial grounds. Total precipitation for the period May through October is given in Table 2-9, footnote "b".

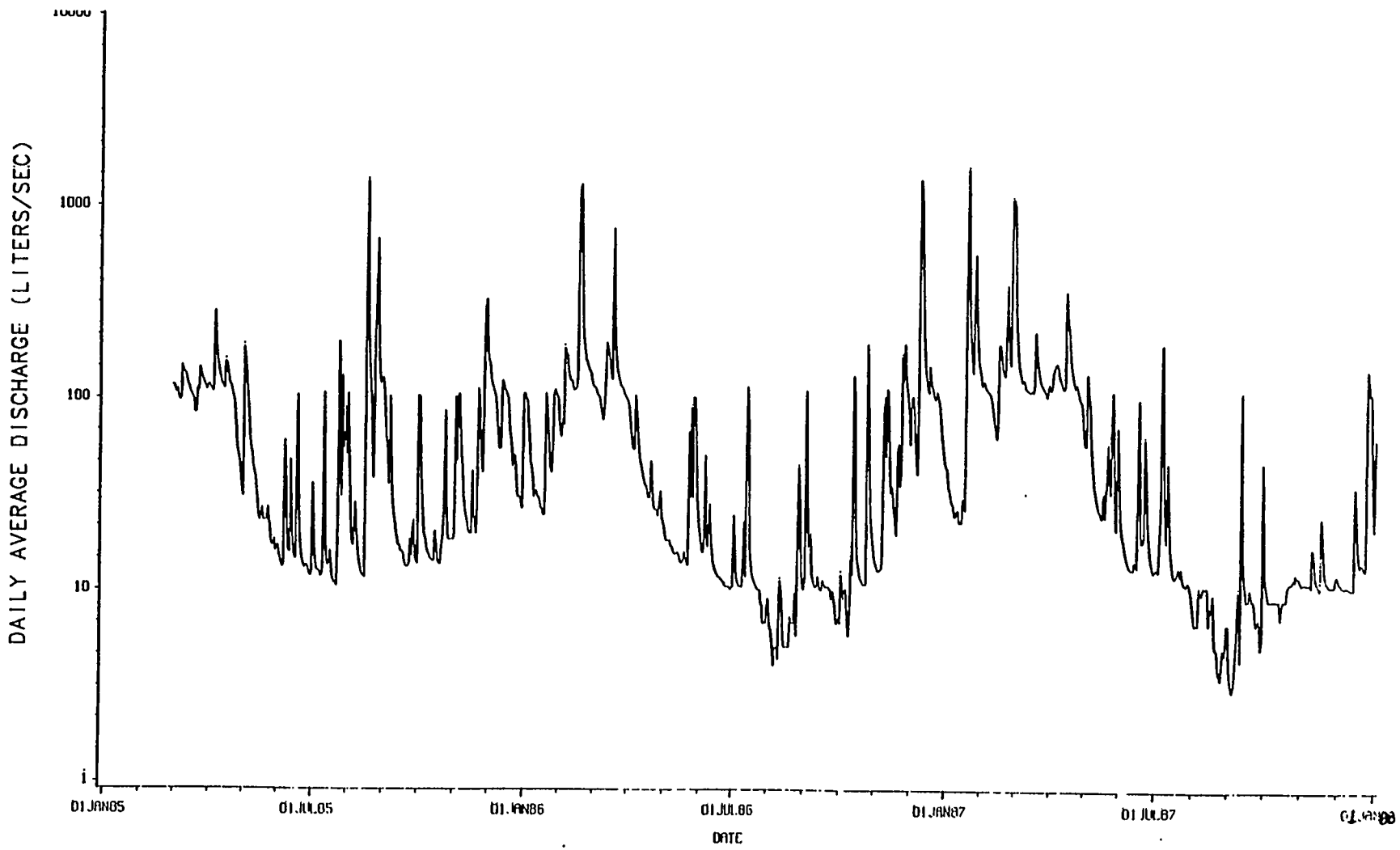



Fig. 5.7. Mean daily stream flow in Bear Creek at USGS gaging station 03538270 at BCK 4.55, March 1985-December 1987. The mean flow during this period was 107.1 L/s. Source: Lowery et al. (1986, 1987) and USGS provisional data (L. D. Voorhees, ORNL, personal communication.

daily flow was consistently below 10 L/s and contrasted sharply with 1985 when stream flow never fell below 10 L/s (Fig. 5.7). Minimum flows were always more than double the 7Q10 (i.e., the lowest mean discharge for seven consecutive days with a recurrence interval of 10 years) of 2.8 L/s, but in 1986 and 1987 flows were less than the estimated 7Q2 of 8.5 L/s for this site (McMaster 1967).

The occurrence of minimum flows at BCK 4.55 in excess of the 7Q10 during a period of severe drought can probably be attributed to the location of the site just below two large springs (SS-7 and SS-8), as shown in Fig. 3.3. Upstream at BCK 9.53, which is located just above the SS-5 spring, the minimum flow was zero in both 1986 and 1987 compared to the estimated 7Q10 and 7Q2 for that site of 0.85 and 0.57 L/s, respectively (McMaster 1967). Because the flow rates of springs are less variable than those of other tributaries (Table 5.1), reaches of Bear Creek immediately below these springs are less impacted by extended periods of drought than other reaches not in proximity to upstream springs, such as BCK 4.70 and BCK 10.41 (Table 5.1, Fig. 5.6).

Because of below normal precipitation, especially during the period from November to April (Fig. 5.6), the Bear Creek hydrograph exhibited infrequent periods of high flow. There were eight major storms (i.e., greater than 5 cm of precipitation in a 24-h period) during 1985-1987, but only one had a recurrence interval greater than 1.5 yrs. The maximum 24-h rainfall during this period occurred on August 16-17 1985, when 10.9 cm of rain was recorded at the ATDL station in Oak Ridge (NOAA 1985 1986 1987). A storm of this magnitude has a recurrence interval of 3 years (Sheppard 1974). Runoff from the August 1985 storm resulted in a peak flow (2240 L/s) in Bear Creek that was similar in magnitude to those observed in the winter and early spring, when runoff is usually high due to minimal evapotranspiration. This peak in flow was more than an order of magnitude greater than the peak flows that occurred during the summer and fall of 1986 and 1987 (Table 5-1 and Fig. 5.7).

### 5.2.4 Importance of Springs

The numerous springs that originate on the north slope of Chestnut Ridge are a dominant feature of the hydrograph of upper Bear Creek, especially during drought periods. At such times, most of the flow in the mainstem Bear Creek is contributed by springs. The best example of the importance of these springs occurred in the fall of 1987, a time of low precipitation (e.g., rainfall was 24% and 47% of normal in October and November, respectively; see Fig. 5.4) that followed a period of extended drought (Sect. 5.2.3). Four of the five flow monitoring stations on the mainstem Bear Creek above the SS-5 spring were dry (Table 5.1 and Fig. 5.4). The only flow in this reach of stream during this period was immediately below the SS-2, SS-3, and SS-4 springs and in the headwaters (BCK 12.46) below the S-3 ponds.

The springs in upper Bear Creek differ greatly in flow rate (Table 5.1). Flow rates are highest in the SS-5 spring at BCK 9.41 and lowest in the SS-1 spring at BCK 12.38 where flow was intermittent between late August and mid-October 1987. Several springs also occur downstream of the SS-5 spring, and two of the largest (SS-7 and SS-8) are located less than 100 m above the USGS/NPDES monitoring station at BCK 4.55. Although flow at this site was never zero (Tables 5.1 and Fig. 5.5), a section of stream at BCK 4.70 immediately above the SS-7 and SS-8 springs was periodically dry in both 1986 and 1987 (Fig. 5.4). Thus, springs in this limited section of Bear Creek, like those in the 3-km reach above the SS-5 spring, provide a significant portion of the flow in Bear Creek during periods of low rainfall.

### 5.2.5 Thermal Characteristics

Continuous monitoring of water temperatures was initiated in September 1985 at the SS-5 spring and three sites in Bear Creek located just above, immediately below, and 1.5 km below the spring. In April 1987, two additional sites, BCK 11.98 and Grassy Creek, a reference stream, were added to the monitoring program.

In addition to their importance in stabilizing flows, springs also influence the thermal regime of Bear Creek, especially the upper reaches

where springs are numerous and flows are intermittent in summer and early fall. The thermal characteristics at a given site are dependent, in part, upon the proximity of springs. Mean temperatures at BCK 9.40 just below the SS-5 spring were approximately 2-3°C warmer in the winter and 4-8°C cooler in the summer compared to BCK 9.91 above the spring (Fig. 5.8). The temperature differential between the two sites was greater in the summer than winter due to the seasonal difference in flow and smaller effect of the spring on mainstem flows in winter. Although BCK 9.91 is located less than 250 m below the SS-4 spring, the flow rate of this spring is only one-third that of the SS-5 spring (Table 5.1). The thermal regime at BCK 9.91 is nearly identical to that at BCK 7.87 located approximately 1.5 km below the SS-5 spring (Fig. 5.8). These comparisons indicate that the moderating effect of springs on mean temperatures in Bear Creek is highly localized.

The effect of springs on temperature extremes, however, was more pronounced and extended over greater distances. The maximum temperature at BCK 9.91 was 24.9°C, which was similar to that at BCK 9.40 (23.4°C) but 6.7°C below the maximum observed at BCK 7.87. Temperatures as high as 38°C were recorded at BCK 11.98 during a period of near-zero flow in July and August 1987. This site is not significantly influenced by springs; the nearest upstream spring is SS-1, which was dry in late August 1987. Minimum winter temperatures were higher at BCK 9.91 than BCK 7.87 and, like the trend in maximum temperatures, indicate a greater moderating effect on temperature at BCK 9.91, the site nearest a spring.

Springs have their greatest influence on stream temperatures during periods of low rainfall in summer and fall. Both the mean and maximum temperature in August 1987 exceeded those in June and July at BCK 9.91 and BCK 7.87. At BCK 9.40, however, August temperatures were actually lower than those observed in the two previous months. Rainfall for August 1987 totaled only 3.2 cm in the Bear Creek Burial Grounds (51% of normal at the Oak Ridge site), and no precipitation occurred on 22 consecutive days prior to August 2. Thus, the importance of springs in moderating the effects of elevated stream temperatures caused by decreased stream flow during a drought is directly related to the severity of the drought.

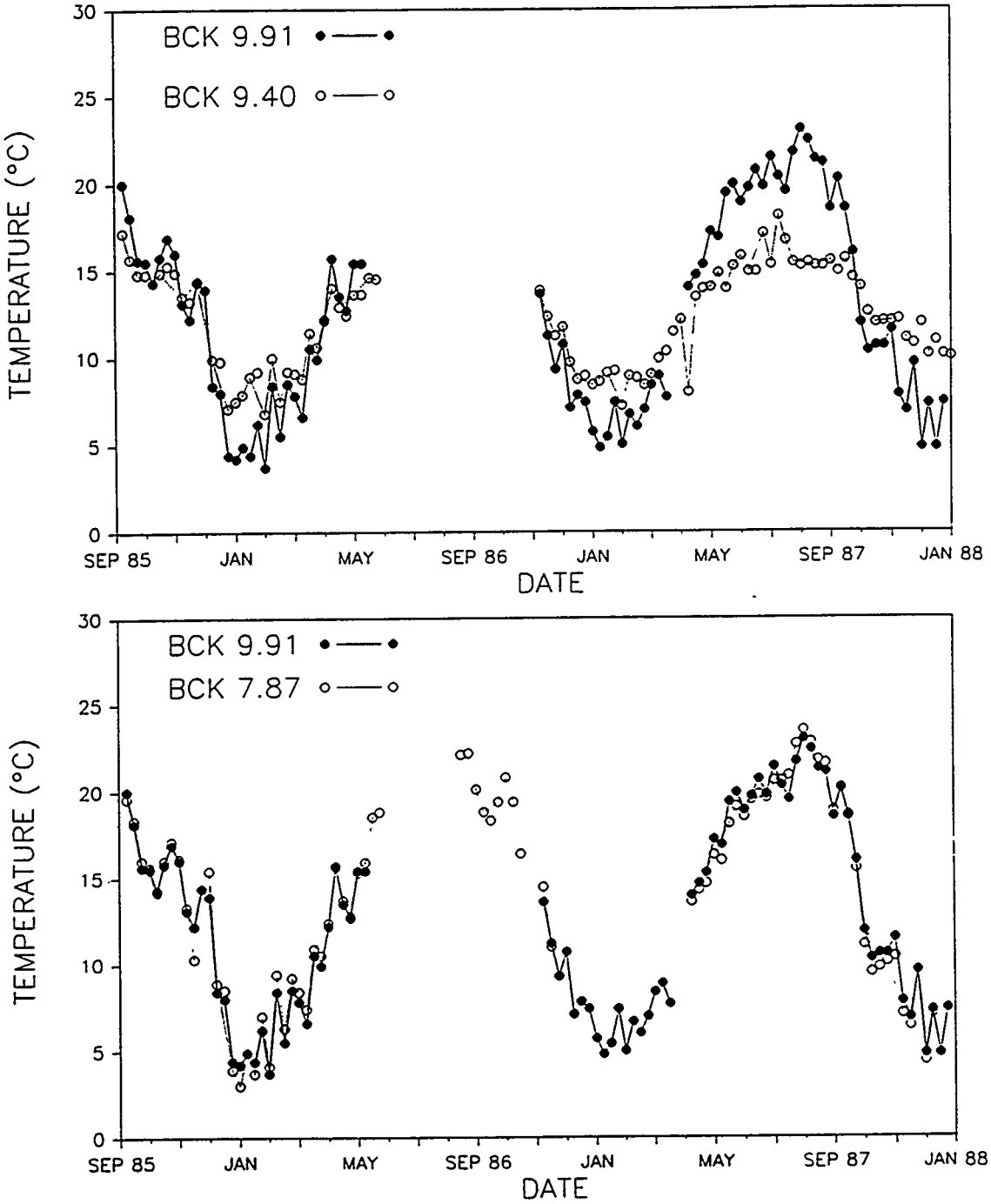



Fig. 5.8. Mean weekly temperatures in Bear Creek above the SS5 spring (BCK-9.91), immediately below the SS5 spring (BCK-9.40), and 1.54 km downstream (BCK-7.87). Prior to April 1987, data were collected at 2-h intervals using a Ryan-Peabody thermograph (Model J-90). After April 1987, a Ryan Tempmentor digital thermograph was used to obtain data at 20-min intervals (April-June 1987) and 1-h intervals (after June 1987).

## 5.3 AIR

A detailed discussion of air is provided in Section 4.5 of the RFI Plan-General Document, Volume I (Welch 1987a). One of the two meteorological observation towers situated in Bear Creek Valley is located at the extreme eastern margin of the Bear Creek watershed (Fig. 5.9). In addition, two air quality monitoring stations are located within, or near the margin of, the Bear Creek watershed (Fig. 5.9). One of these stations, Local Air Monitoring Station No. 8, is operated by the Y-12 Plant and is located at the eastern margin of the watershed. Parameters monitored at this site include total suspended particulates, sulfur dioxide, mercury, uranium, beryllium and fluoride. The other air quality monitoring station, Perimeter Air Monitoring Station No. 45, is located adjacent to Bear Creek near BCK-11.17. Parameters monitored at this site include gross alpha, gross beta, iodine, gross gamma and noble gas. Air filters from this site are also composited quarterly and analyzed for radionuclides (cobalt-60, cesium-137, plutonium-238, plutonium-239, thorium-228, thorium-230, thorium-232, strontium-89+90, uranium-234, uranium-235, uranium-238).

## 5.4 SOIL/SEDIMENT

### 5.4.1 General Soil Description

The Bear Creek watershed is overlain primarily by residual soils and, to a much lesser extent, by alluvial soils. Soils have been derived from rocks of the Knox Group, Conasauga Group and Rome Group. These are typically silt loams with variable amounts of clay and chert or shale depending on the parent rock type and slope position. Section 4.2.1 of the RFI Plan-General Document, Volume I (Welch 1987a) discusses each of the soil types found in Bear Creek Valley. Lietzke et al. (1988) also thoroughly describes soils which occur at the Low-Level Waste Disposal Development and Demonstration Program site adjacent to Bear Creek near the junction of S.R. 95 and Bear Creek Road.

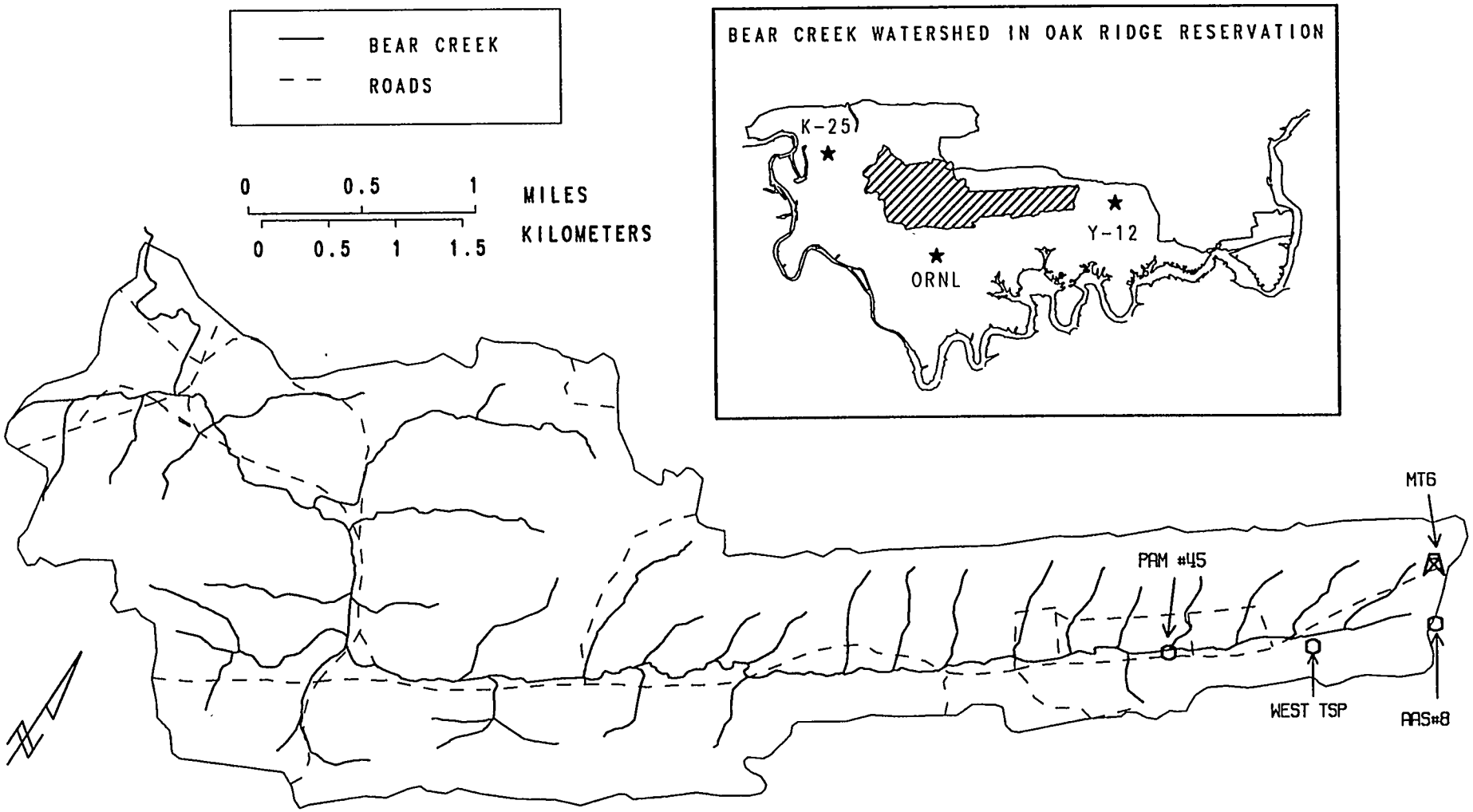



Fig. 5.9. Location of meteorological tower (MT6) and air monitoring stations in Bear Creek Watershed.

### 5.4.2 General Sediment Description

The substrate materials of Bear Creek vary considerably among several general types, including rock ledges, sand/gravel bars, indurated cohesive clay, flocculant precipitates/clays and mixtures of these types. In most areas the creek is stable to degradational with respect to net sediment accumulation. The supply of sediment from upland areas and the floodplain is small with respect to the ability of stream flow to export sediment from the watershed. Due to a high percentage of forest cover and stabilization of bank deposits by riparian vegetation, peak stream flows are generally insufficient to produce significant soil erosion. Thus the most voluminous sediment deposits tend to be fairly coarse-grained, the finer material having been winnowed and exported out of the watershed. Between high flow events fine-grained sediment deposits do accumulate in low energy environments (pools, leeward of obstacles, inside of bends) in the creek. These deposits are typically classified as silty sands or sandy silts, with small and variable amounts of gravel and clay. Figure 5.10 exhibits sediment size distributions for several locations on Bear Creek. These distributions were measured on samples collected for chemical analysis and thus may be somewhat biased in favor of fine particles.

Although no mineralogical investigations have been conducted on Bear Creek sediment, such investigations carried out on streams flowing over rocks and soils derived from the Knox, Conasauga and Rome Groups have reported the occurrence of illite, quartz, and feldspar with minor amounts of hematite and hydrous manganese oxides. Common clay minerals include kaolinite, mica, vermiculite, hydroxy-interlayered vermiculite and gibbsite. White to yellowish-white precipitates occur in the upper reaches (above BCK 11.83) and are presumed to be amorphous aluminum hydroxide resulting from the neutralization of acidic groundwater which originates from the plume of the S-3 Ponds (Turner and Kamp 1984).

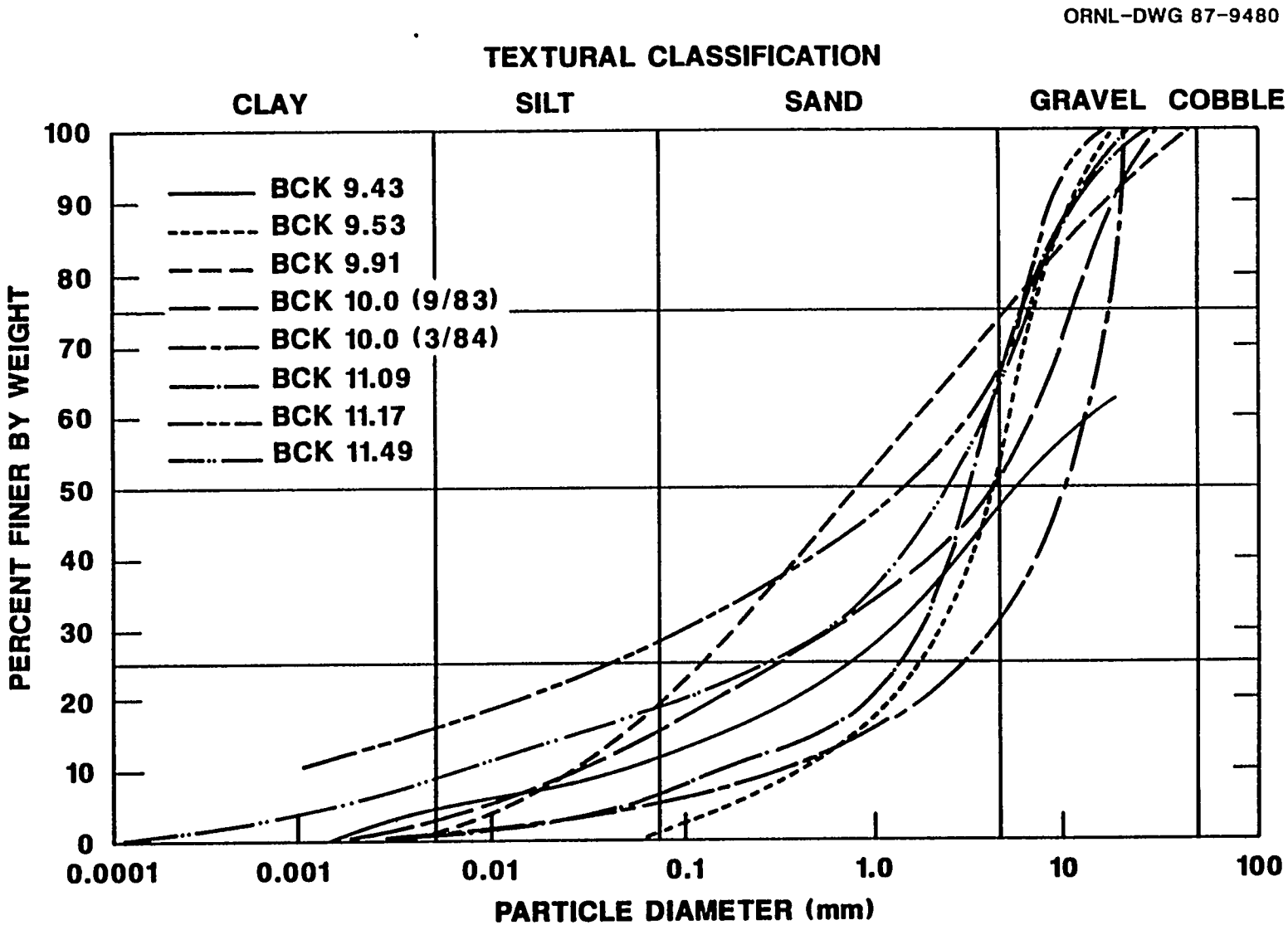



Fig. 5.10. Particle size distribution of sediment samples collected in Bear Creek for chemical analysis.

# 6.0 IDENTIFICATION OF POTENTIAL MIGRATION PATHWAYS AND POTENTIAL RECEPTORS

The migration of contaminants in Bear Creek as a result of releases from the SWMUs located in the watershed has been demonstrated to occur via two primary pathways: (1) surface water transport and (2) subsurface transport (see Section 7.0). The atmospheric transport of contaminants is considered to be inconsequential and will not be addressed in this RFI Plan. Important factors in the transport of materials via surface water and subsurface pathways are discussed in Section 5.1 of the RFI Plan-General Document, Volume I (Welch 1987a).

## 6.1.1 Surface Water Transport

Surface water transport of contaminants from several of the SWMUs in the Bear Creek watershed is strongly suspected or documented. For example, seepage of oils from trenches in the Burial Grounds prompted the eventual construction of Oil Retention Ponds 1 and 2 to intercept these contaminants. However, there is evidence (Herbes 1988) of extensive contamination of the floodplain of Tributary 7 downstream of the Oil Retention Pond 1 and of the Bear Creek floodplain further downstream indicating considerable surface water transport of contaminants prior to pond construction. Sediment samples from other tributaries to Bear Creek also indicate surface water transport of contaminants. The flow of surface water over and through areas of contaminated floodplain soils and sediments provides a potential for further transportation and redeposition of material within Bear Creek, as well as direct solubilization of contaminants retained in soils and sediments from historical releases. Section 8 of this RFI Plan addresses strategies for delineating the contribution of surface water system to the contamination of Bear Creek.

## 6.1.2 Subsurface Transport

Groundwater and soil/sediment are media of concern when addressing subsurface transport in the Bear Creek floodplain. Results of previous investigations (see Section 7.0) indicate that the primary contaminants, PCBs and uranium, are associated with the floodplain soils and sediments in

the streambed and, as such, represent a potential source of continuing release to both groundwater and surface water systems associated with Bear Creek. As discussed in Section 5.1.3, the potential for groundwater recharge along losing reaches of Bear Creek, and the reemergence of the creek further downstream, enhance the potential for leaching of contaminants such as uranium and PCBs from floodplain soils and sediments. Unlike point sources of discharges to Bear Creek, the discharge of contaminants via groundwater recharge cannot be easily identified. In addition, the potential exists for contaminants to enter over a large reach of the creek. Sections 9 and 10 of this RFI Plan address strategies for delineating the contribution of contaminated soil/sediment deposits to the contamination of Bear Creek, but do not specifically address the issue of the recharge of groundwater by Bear Creek in the losing reaches. As discussed in Section 2.1.1 the issue of groundwater recharge in losing reaches of Bear Creek is being addressed as part of SWMU closures and assessment monitoring.

### 6.1.3 Air

Airborne contamination from Bear Creek and its floodplain is believed to be minimal. Disturbance of contaminated sections of the floodplain without application of effective dust suppression measures could lead to airborne contamination.

## 6.2 POTENTIAL RECEPTORS

Radionuclides and chemical pollutants that are introduced into the biosphere are subject to the same biogeochemical processes that normally cycle elements within and among ecosystems. Pollutant concentrations in the soil can be incorporated into plants by uptake through the root system. Pollutants released into the atmosphere can be incorporated into plant systems by foliar deposition and absorption. When this occurs, the pollutant may then pass directly to humans or to grazing animals as superficial or metabolically absorbed contamination. Radionuclide and chemical pollutants in surface water can be adsorbed to or incorporated into periphyton (attached algae) or other material that comprise the base

level of the food chain. These pollutants can then pass rather quickly through higher levels of the food chain, often accumulating in tissues of organisms occupying these levels. Potential receptors (human populations, aquatic and terrestrial flora and fauna, and threatened and endangered species) are discussed in Section 5.2 of the RFI Plan-General Document, Volume I (Welch 1987a).

### 6.2.1 Human Population

Because Bear Creek watershed occupies a section of the Oak Ridge Reservation that is entirely uninhabited and largely restricted from public access, the potential for direct human exposure to the contaminants in the creek and its floodplain is minimal. However, downstream surface water bodies (Poplar Creek, Clinch River, Watts Bar Lake) are used for domestic and industrial supplies, fishing, recreation and irrigation.

Given the presence of floodplain deposits in Bear Creek contaminated with PCBs, the potential for current or future redistribution of these deposits into downstream waters and bioaccumulation into components of the food chain is of special concern.

### 6.2.2 Terrestrial Flora and Fauna and Aquatic Biota

The pollutants in Bear Creek and its floodplain can either be absorbed to or assimilated into vegetation and subsequently accumulate through different levels of the food chain. Investigations addressing contaminant levels in various biota are reviewed in Section 7.7 of this RFI Plan. As a part of the Y-12 Plant Bear Creek Ecological Characterization, extensive studies were conducted along Bear Creek. Results are summarized in a recent progress report (Southworth 1988).

Bear Creek contains little aquatic life in its uppermost reaches (BCK 11.8-12.4), where toxic inputs of contaminated groundwater from the S-3 ponds site have a major impact. The diversity and standing crop of fish and benthic invertebrates increase relatively steadily with distance below BCK 12.36. The intermittent reach from BCK 11.81 to BCK 9.41 contains only four species of fish (mountain redbelly dace, blacknose dace, creek chub, and stoneroller), but this is not atypical of small, unimpacted

streams in this region. Below BCK 9.41, streamflow is stabilized by inputs from the large SS-5 spring, and several additional fish species occur. The benthic fauna is relatively diverse and abundant in this reach, but pollution intolerant species (mayflies in particular, stoneflies and caddisflies to a lesser extent) are missing or rare. The aquatic fauna at the lowermost ecological monitoring site on Bear Creek (BCK 3.25) shows little evidence of adverse water quality.

Bear Creek does not contain any rare or endangered species, but it does sustain a robust population of mountain redbelly dace (*Phoxinus oreas)*, a species deemed in need of special management by the state of Tennessee. It is against the law to alter this species' habitat without permission from the state.

The aquatic fauna of most of Bear Creek consists of small minnows that would not be taken as food by humans. The lower reaches of the stream (BCK 3.25-BCK 0.00), however, contain larger fish (primarily rockbass and redbreast sunfish) that are species commonly sought by sport fishermen. This reach of stream, and the reaches of East Fork Poplar Creek and Poplar Creek downstream from the mouth of Bear Creek, are closed to public access, but the fish populations of these waters do have the potential to act as a pathway for human exposure to bioaccumulable contaminants. The Clinch River/Watts Bar Reservoir below the mouth of Poplar Creek is the waterway nearest Bear Creek that contains a large, diverse population of fish that is commonly exploited by sport fishermen. Watts Bar Reservoir also supports a limited commercial fishery for rough fish (catfish, carp, and buffalo). While the flow of Bear Creek is greatly diluted by the flow of the Clinch River, inputs of large amounts of bioaccumulable contaminants, such as mercury or PCBs, to this system via Bear Creek would have the potential to adversely impact a large resource and substantial human population.

# 7.0 EXISTING MONITORING DATA

## 7.1 INTRODUCTION

A substantial amount of environmental monitoring data exist for the Bear Creek watershed. Besides monitoring activities such as NPDES monitoring at BCK 4.55 which is conducted by Y-12 Plant staff, the Y-12 Plant contracted for monitoring work to Bechtel National Inc. in 1983-84 and to Roy Weston Inc. in 1985-86. In addition ORNL has performed monitoring for Y-12 as part of the Ecological Characterization of Bear Creek Program and for special studies. K-25 (Oak Ridge Gaseous Diffusion Plant) also performed soil and groundwater sampling and analysis for the Y-12 Plant. The U. S. Geological Survey has installed groundwater wells and stream monitoring stations in the Bear Creek watershed, and conducted water quality sampling and analysis at these and other sites in the watershed. Environmental staff from the Tennessee Valley Authority (TVA) sampled and analyzed water, sediment, and aquatic biota from Bear Creek in 1984 as part of an evaluation of contaminant releases from the Oak Ridge DOE facilities.

Although the bulk of the environmental monitoring data have been collected since 1982, some limited historical data are available. This section will summarize and evaluate environmental monitoring data relevant to developing the RFI Plan. Most of the data presented have been published, but some were obtained from unpublished portions of the large data base maintained by H & R Technical Associates (Mercier 1988) and from files of the authors of this RFI Plan. Most of the unpublished data have been included in the Appendices to this RFI Plan.

In discussing water, sediment and soil data in subsequent sections, references will be made to health and environmental assessment criteria. These include regulatory as well as guidance and advisory type criteria. For example, Maximum Contaminant Levels (MCLs) promulgated under the Safe Drinking Water Act represent one type of assessment criteria for use when evaluating monitoring data for surface water and groundwater. Concentrations of contaminants which are acutely or chronically toxic to aquatic life are another type of assessment criteria. Background concentrations of contaminants in an area of study represent yet another

type of criteria. To prepare this RFI Plan, information on a variety of assessment criteria were assembled for the purpose of determining whether a given contaminant in a given medium needed further investigation. The same health and environmental assessment criteria may be used in the risk assessment for Bear Creek which is planned as a separate activity. Initially a comprehensive list of contaminants was prepared which represented all contaminants which have been reported to have been disposed of in Bear Creek watershed or which have been found in water, soil or sediment in Bear Creek watershed at levels equal to or greater than analytical detection limits. This list was then compared with lists of health and environmental criteria given in the DRAFT (12/87) RCRA Facility Investigation Guidance, Volume I (USEPA 1987) and in various other documents. Contaminants which appeared on both lists (occurrence and criteria) were designated "potential contaminants of concern" for Bear Creek. The health and environmental criteria for the potential contaminants of concern for Bear Creek are summarized in Appendix F, and Appendix G summarizes local background concentrations of a variety of contaminants in surface water and sediment. These background data were collected at site NT-2 upstream of all waste facilities and at two sites, GCK-1.4 and GCK-2.4, in the Grassy Creek watershed, which represents the westward continuation of Bear Creek Valley after Bear Creek turns north through Pine Ridge.

Assessment criteria for contaminants in soil and sediment are almost non-existent, although they may be calculated from allowable doses or intakes given assumptions about pathways and absorption. Criteria for PCBs, uranium, and mercury have been proposed. Under the Toxic Substances Control Act (TSCA) PCB Spill Cleanup Policy (40 CRF Part 761), a level of 25 $\mu$g/g has been proposed for sites with restricted access, such as industrial complexes and remote rural areas. The TDHE has also adopted this level as a cleanup level for waste facilities in Bear Creek watershed. The proposed (DOE and NRC) guidance "policy" for uranium in soil is in the range of 30-35 pCi/g for sites with unrestricted access. The Y-12 Plant uses 30 pCi/g for internal control of depleted uranium in soil. Lastly, TDHE proposed a soil guidance value for mercury in soil of 12 $\mu$g/g (Bashor and Turri 1983).

### 7.1.1 Y-12 Plant Monitoring

Y-12 Plant staff have performed compliance and special monitoring at several sites in the Bear Creek watershed. The Bear Creek site at BCK-4.55 has been monitored for stream discharge and selected constituents under an NPDES permit since 1971. Some contaminants not on the NPDES permit have also been analyzed at this site as part of the radiological and PCB monitoring plans for the Y-12 Plant. NPDES monitoring of the effluent from the two Oil Retention Ponds in the Burial Grounds has also been conducted. In response to requirements of the Memorandum of Understanding (MOU) signed on May 26 1983 by DOE, EPA and TDHE, Y-12 Plant staff began weekly monitoring of a site in Upper Bear Creek (BCK-12.46) for a variety of water quality parameters in July 1983. When the "lagoons" located in Upper Bear Creek were excavated in the summer of 1988, Y-12 staff performed the characterization of both the material removed from the two lagoons, and that left behind in the two lagoons. Although others have performed most of the recent groundwater level and quality monitoring, Y-12 Plant staff have conducted some of this work. Y-12 Plant staff operate the local ambient air monitoring station (No. 8) at the eastern margin of the Bear Creek watershed, while others (ORNL) operate the perimeter air monitoring station near BCK-11.09.

Aside from some special studies with limited sampling, the Y-12 Plant staff has not routinely performed any soil or sediment monitoring in Bear Creek watershed. Instead, this responsibility has been delegated to contractors and staff from K-25 and ORNL.

### 7.1.2 ORNL Monitoring

Staff, mainly from the Environmental Sciences Division (ESD), but also from the Health and Safety Research Division (HSRD) and Energy Division, from ORNL have performed a variety of environmental monitoring tasks and special investigations on behalf of the Y-12 Plant. ESD staff established and monitored 19 hydrologic monitoring sites on Bear Creek beginning in 1985. ESD staff collected sediment and/or floodplain soil samples in Bear Creek in 1982 (Van Winkle et al. 1983) and 1985 (Turner unpublished) as part of the preliminary evaluation of the nature of contaminants in Bear

Creek and East Fork Poplar Creek. Subsequently, ESD staff provided field oversight to the sampling of Bear Creek in 1985 and 1986 by Roy F. Weston, Inc. This included submission of aliquots of Weston collected samples for analysis of PCBs, metals and uranium to the ORNL Analytical Chemistry Division. ESD staff have also conducted the Bear Creek Ecological Characterization (Southworth et al. 1988).

### 7.1.3 U. S. Geological Survey Monitoring

The U. S. Geological Survey (USGS) has conducted hydrologic monitoring of Bear Creek for several years. McMaster (1967) summarized some of the earliest data for monitoring sites in Bear Creek. Beginning in 1984 the USGS conducted several comprehensive surveys of stream discharge, specific-conductance and selected water quality parameters in Bear Creek watershed. Results of these survey have been published as Open File Reports of the USGS (Evaldi 1984; Pulliam 1985a,1985b; Evaldi 1986) and in the Water Resources Data for Tennessee series of annual reports (1984-1987). Appendix E tabulates the water quality data for Bear Creek. In addition to surface water investigations, the USGS has also installed a series of groundwater monitoring wells in Bear Creek watershed as part of a regional investigation of groundwater. Bailey and Wittington (1988) recently described the USGS drilling effort. Limited chemical analyses for wells in Bear Creek valley have been published in Water Resources Data for Tennessee (Lowery 1987).

### 7.1.4 TVA Monitoring

The Tennesee Valley Authority conducted limited environmental sampling and analysis in Bear Creek in 1984 as part of the Oak Ridge Interagency Task Force evaluation of offsite contamination associated with the DOE facilities near Oak Ridge. The majority of the TVA analyses were related to East Fork Poplar Creek and mercury. However, 56 water samples, 15 sediment samples and 26 aquatic biota samples were collected in Bear Creek. The TVA results are summarized in TVA (1986) and in Appendix E of this RFI Plan.

### 7.1.5 Contractor Monitoring

Two large consulting companies (Bechtel National, Inc. and Roy F. Weston, Inc.) have undertaken extensive sampling and chemical analyses in Bear Creek for the purpose of characterizing the nature and extent of contamination from waste disposal activities in the watershed. One additional contractor (Geraghty & Miller) has performed extensive evaluation of all extant data for Bear Creek watershed.

Bechtel National, Inc. installed numerous groundwater monitoring wells and conducted chemical monitoring of groundwater, surface water, soil and sediment during the period 1983-84. Investigative and analytical methods employed by Bechtel are given in McCauley (1985f). Complete analytical results of the chemical monitoring are tabulated in McCauley (1985e), with analytical/quality control data given in McCauley (1985d).

Roy F. Weston, Inc. conducted extensive monitoring of surface water, groundwater and sediment in Bear Creek watershed in the period 1985-87. Sampling and analytical methods employed by Weston are described in (Kimbrough 1987) and have conformed closely with EPA approved methods. The complete results of the Weston monitoring have not been published in a comprehensive volume but are available in the large computer data base maintained by H & R Technical Associates (Mercier 1988). Limited results are published in topical reports (e.g., Southworth et al. 1988; Geraghty & Miller 1987).

Geraghty & Miller, Inc. have prepared numerous reports characterizing groundwater, surface water, soil and sediment in Bear Creek watershed. Geraghty & Miller have also specified the locations and construction details for a number of monitoring wells in Bear Creek watershed and conducted special groundwater investigations.

### 7.1.6 Quality Evaluation of Extant Monitoring Data

Sampling and analytical methods for many environmental contaminants have been evolving rapidly over the past decade. Application of more rigorous sampling and analytical Quality Assurance and Quality Control (QA/QC) protocols has also increased during this period. Both Bechtel National Inc. and Roy F. Weston Inc. generated extensive QA/QC data which

accompany the environmental data in the large H&R Technical Associates computer data base (Mercier 1988). These data include results for trip blanks, field blanks, equipment rinsate blanks, process blanks, field duplicates, blind splits, matrix spikes and standard reference materials. All analytical QA/QC data for the Bechtel National Inc. sampling campaigns have been tabulated in a report (McCauley 1985d). The analytical QA/QC data for the Roy F. Weston Inc. sampling campaigns have not been published but are contained in the H&R Technical Associates computer data base. A thorough evaluation of both QA/QC data sets is currently in progress and will be published in 1989. Preliminary evaluation of these data has not indicated QA/QC failures that would seriously curtail the use of the environmental monitoring data generated by these contractors in determining the full nature and extent of contaminant releases to Bear Creek.

Monitoring data generated by the Y-12 Plant, ORNL and K-25 have also been generally collected under rigorous QA/QC protocols since about 1983. Field sampling and laboratory analytical procedures have been documented and controlled by written methods such as contained in " Martin Marietta Energy Systems Environmental Analysis Manual" (MMES 1986) and "Methods and Procedures Utilized in Environmental Management Activities at Oak Ridge National Laboratory" (ORNL 1984) as well as the methods given in "Test Methods for Evaluating Solid Waste" (USEPA 1986a) and "Methods for Chemical Analysis of Water and Wastes" (USEPA 1983a). Each analytical laboratory and field sampling group has also been subjected to both internal and external audits. Annual environmental surveillance reports (e.g., ORNL 1986, MMES 1987, MMES 1988) have included summaries of QA/QC activities, including results of audits, interlaboratory comparisons, analyses of standard reference materials and other performance checks. The summaries reflect a high quality effort and success in maintaining analytical performance at state-of-the-art levels.

As discussed subsequently, an important conclusion from the evaluation of the quality of environmental monitoring data for Bear Creek is the concordance of results among the various sampling and analytical groups who have performed monitoring in Bear Creek. Both the nature and concentrations of contaminants of concern have been very similar regardless

of which group performed the sampling and analyses. For example, uranium concentrations in Bear Creek surface water are reported consistently by Bechtel National Inc., Roy F. Weston Inc., the USGS, the Y-12 Plant and ORNL to occur at levels up to about 1.0 mg/L in the headwaters and to decrease to about 0.05 mg/L downstream.

The discussion above should not be taken to imply that no sampling or analytical problems have occurred during the extensive previous monitoring of Bear Creek and its floodplain. The formal and informal QA/QC protocols used by each investigative group have detected problems which were either corrected or the data flagged as suspicious. The following illustrate some examples of detected QA/QC problems:

1. Certain metals (especially As, Se, Sb, Pb, Ni, Cd) reported by Bechtel National Inc. and Roy F. Weston Inc. based on analysis by inductively coupled plasma emission spectroscopy (ICP) exhibit a positive bias compared with analysis by atomic absorption spectroscopy (AAS). The AAS values are believed to be more accurate based on analysis of standard reference materials and of samples from areas known not to be contaminated. However, results from both types of analyses have been preserved in the data bases.

2. Some groundwater samples collected by Bechtel National, Inc. contained excessive amounts of sediment (up to 100 g/L) and were digested 'as received' for metal analyses. This procedure solubilized metals in the sediment and yielded unreasonably high metal concentrations for a number of wells sampled initially by Bechtel. Subsequent samples from many of these wells contained much less sediment and more reasonable metal concentrations.

3. Filtration of groundwater and surface water samples for metals analysis should yield lower concentrations in the filtered aliquot compared with the unfiltered aliquot unless the metal occurs mainly in dissolved form (in which case filtered and unfiltered should be nearly identical). Data reported by Roy F. Weston often shows dissolved

metal concentrations exceeding total metal concentration. As this condition is impossible, the result suggests contamination of the dissolved sample during filtration, loss of metal from the 'total' sample (e.g., by sorption to container in unpreserved sample) or analytical imprecision.

4. Uranium concentrations in Bear Creek surface waters reported for the January and May 1986 sampling campaigns by Roy F. Weston are anomalously low compared with other extant data (Y-12 monitoring) for the same period and are believed to be in error due to the suspected absence of proper sample preservation.

5. Split samples of fish tissue analyzed by the EPA laboratory in Athens, Georgia revealed PCB concentrations which were 1.4 times higher than in samples analyzed by the TVA as part of the Oak Ridge Interagency Task Force evaluation of contaminants associated with the DOE facilities in Oak Ridge. Thus, TVA urged caution in comparing their results for PCB in fish (including those collected in Bear Creek) with the FDA Action Level.

### 7.1.7 Low Level Waste Disposal Development and Demonstration Program

Environmental characterization of a site located in the western portion of Bear Creek Valley is being conducted as part of the Low Level Waste Disposal Development and Demonstration (LLWDDD) Program. The site is located where Bear Creek turns north and flows through Pine Ridge. It is bounded by Bear Creek on the south and west, by Gum Hollow Road to the east, and by Pine Ridge to the north. The site is under consideration as the location of a future low level waste disposal facility that would serve the three DOE plants on the Oak Ridge Reservation. The new facility will utilize advanced technology for the isolation of radioactive wastes. These technologies are presently being developed, with some presently being demonstrated at field scale. If approved and selected, this site would be developed, with beneficial occupancy planned for 1991.

The data collected under this initiative are presented and summarized in a data package (LLWDDD 1988) that will be given to the subcontractor (not yet identified) that will generate the Environmental Impact Statement for the future LLW disposal facilities.

Characterization is being coordinated by staff in the Energy Division, ORNL. As part of this activity, the USGS is collecting stream flow discharge at 5 sites on Bear Creek and its tributaries starting October 1 1986. In addition, the USGS has been collecting data at the NPDES monitoring site located at BCK4.55 since March 1 1985.

Staff from the Environmental Monitoring and Compliance Division (EMCD) has conducted quarterly sampling of surface water at these 6 sites starting December 1987. Data for three quarters are reported in LLWDDD (1988).

Golder Associates, under subcontract to Energy Division, is conducting geohydrologic characterization activities at the site. In Appendix G, Part 1, of LLWDDD (1988) drilling and well construction logs of 45 piezometers are presented. A total of 4 shallow (<100 ft) and 9 bedrock (>100 ft) wells have been constructed on the Bear Creek floodplain. Three of these wells (GW443, GW467, GW468) are sampled for water quality quarterly, starting December 1987, with results for 3 quarters summarized in LLWDDD (1988).

## 7.2 GROUNDWATER DATA

Over 400 wells have been installed in Bear Creek watershed. Most of these have been installed since 1983. As shown in Figure 7.1, these wells have been installed in two general locations, upper Bear Creek in the vicinity of the waste disposal facilities and near the intersection of Bear Creek Road and S. R. 95. The latter area has been extensively drilled as part of the evaluation of the site for the Low Level Waste Disposal Development and Demonstration Program (LLWDDD 1988). All but two of the monitoring wells in this area were constructed of PVC and intended primarily as piezometers.

As discussed in Section 2.1.1, the scope of the BEAR Creek RFI is limited to technical issues pertaining directly to the mainstem of Bear Creek and its flood-of-record floodplain. The potential for migration of

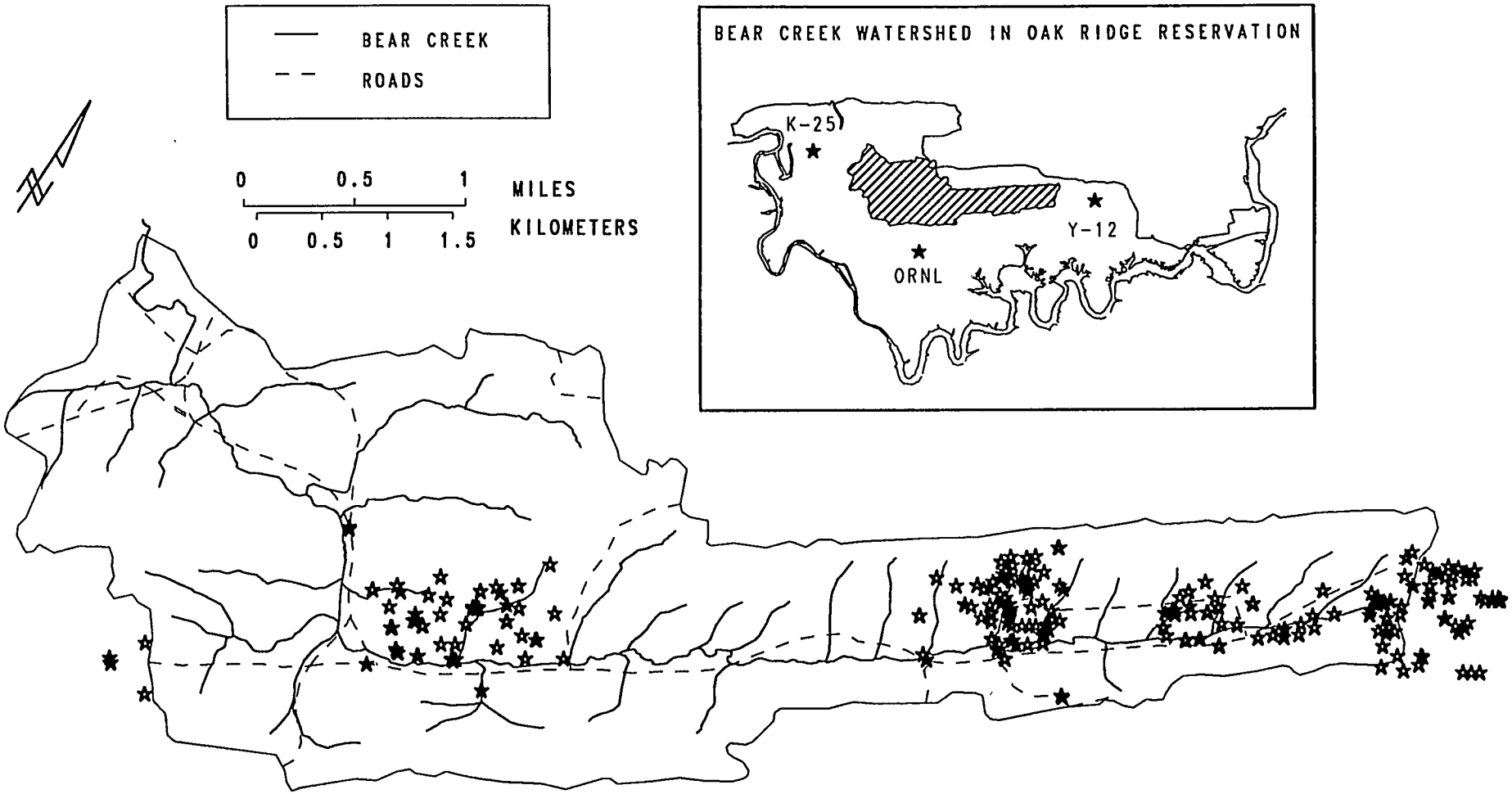



Fig. 7.1. Location of groundwater monitoring wells in Bear Creek Watershed. Some sites have multiple wells (nests).

contaminants contained in floodplain deposits is the only technical issue to be addressed by the RFI. The issues of recharge of groundwater by Bear Creek along the losing reaches and groundwater migration of contaminants from the individual SWMUs is being addressed by the post-closure monitoring plans for these facilities and is not addressed in the RFI Plan.

For the purpose of developing the RFI Plan, only monitoring data for wells located within the flood-of-record floodplain and nearby areas were reviewed. The available water level and water quality data for this subset of wells in the Bear Creek watershed is summarized and evaluated in this section.

### 7.2.1 Existing Well Locations and Descriptions

Table 7.1 summarizes information on location and construction of the subset of wells utilized to develop a shallow groundwater monitoring plan for this RFI. Figure 7.2 illustrates the location of these wells with respect to Bear Creek. Not all wells near the creek were included in this subset. For example, several wells which were finished in deep (>100 ft) bedrock zones were excluded because the possibility of exchange of groundwater with the creek is remote for the deeper bedrock zones.

### 7.2.2 Water Level Monitoring

Of the hundreds of monitoring wells existing within Bear Creek Valley (BCV), 35 lie in the floodplain of Bear Creek within approximately 100 ft of the creek and are screened either in unconsolidated material or weathered bedrock (Figure 7.2). Consequently, water level and hydrochemical data for these wells are assumed to constitute the most appropriate data base from which conclusions about the interaction between Bear Creek and the shallow groundwater flow system can be evaluated. Table 7.1 summarizes location and completion information for these wells.

Comparison of water levels within these monitoring wells with the elevation of the stream bed in the adjacent creek provides insight into the dynamics of the stream-groundwater system interaction. For many streams, water levels in nearby shallow monitoring wells lie above that of the stream indicating that the stream is a site of discharge for the shallow

Table 7.1. Summary Information for Shallow Monitoring Wells Within the Floodplain of Bear Creek

| Well No. | Northing | Easting | Elevation (ft) | Total Depth (ft) | Open/Packed Interval (ft) | Aquifer (Bedrock Fm) | Casing Matrial | Screen Material | RCRA Quality |
|---|---|---|---|---|---|---|---|---|---|
| 1003 | 29939 | 51595 | 1000.86 | 48 | 28-48* | WB(∈nl) | PVC/#40 | PVC/sl | No |
| 1005 | 29578 | 51064 | 986.00 | 24 | 8-18* | U | PVC/#40 | PVC/sl | No |
| 1008 | 29933 | 52128 | 1004.52 | 20 | 7.3-20 | U | Unknown | Unknown | No |
| GW-50 | 29078 | 44097 | 912.2 | 15 | 6-14 | U | SS#304 | SS/SW/.01 | Yes |
| GW-51 | 29056 | 43740 | 906.6 | 11.2 | 2-11 | U | SS#304 | SS/SW/.01 | Yes |
| GW-52 | 29052 | 43478 | 903.4 | 19.5 | 4-19.5 | U | SS#304 | SS/SW/.01 | Yes |
| GW-53 | 29066 | 43086 | 900.5 | 39.7 | 11.4-32.8 | U/WB(∈mn) | SS#304 | SS/SW/.01 | Yes |
| GW-54 | 28823 | 42180 | 890.0 | 40 | 31.1-37.2 | WB(∈mn) | SS#304 | SS/SW/.01 | Yes |
| GW-55 | 28811 | 41283 | 889.6 | 20.6 | 15.5-20 | WB(∈mn) | SS#304 | SS/SW/.01 | Yes |
| GW-56 | 28708 | 41382 | 886.8 | 55.2 | 49.1-55.2 | WB(∈mn) | SS#304 | SS/SW/.01 | Yes |
| GS-57 | 28699 | 41379 | 887.1 | 25 | 17.5-22.8 | WB(∈mn) | SS#304 | SS/SW/.01 | Yes |
| GW-58 | 28714 | 43211 | 910.0 | 45.2 | 38.8-45 | WB(∈mn) | SS#304 | SS/SW/.01 | Yes |
| GW-59 | 28702 | 43215 | 910.0 | 27 | 195.-24.7 | WB(∈mn) | SS#304 | SS/SW/.01 | Yes |
| GW-60 | 28927 | 43053 | 900.8 | 50 | 38-49.8 | WB(∈mn) | SS#304 | SS/SW/.01 | Yes |
| GW-61 | 28916 | 43049 | 901.0 | 25 | 17.5-24.6 | WB(∈mn) | SS#304 | SS/SW/.01 | Yes |
| GW-62 | 29005 | 48258 | 959.8 | 56.7 | 45.1-51.4 | WB(∈mn) | SS#304 | SS/SW/.01 | Yes |
| GW-63 | 29016 | 48257 | 959.0 | 35 | 27.7-32.7 | WB(∈mn) | SS#304 | SS/SW/.01 | Yes |
| GW-64 | 29195 | 49169 | 979.3 | 57 | 46.8-52.7 | WB(∈mn) | SS#304 | SS/SW/.01 | Yes |
| GW-65 | 29185 | 49167 | 979.7 | 35 | 29-34 | WB(∈mn) | SS#304 | SS/SW/.01 | Yes |
| GW-66 | 29153 | 48677 | 957.3 | 55.8 | 50-54.9 | WB(∈mn) | SS#304 | SS/SW/.01 | Yes |
| GW-67 | 29504 | 48697 | 957.1 | 16.5 | 7.6-17.2 | WB(∈mn) | SS#304 | SS/SW/.01 | Yes |
| GW-100 | 29759 | 50957 | 984.6 | 20.7 | 3.8-20.7 | U/WB(∈mn) | SS#304 | SS/SW/.01 | Yes |
| GW-103 | 30058 | 52291 | 1008.2 | 25 | 17.8-25 | U/WB(∈mn) | SS#304 | SS/SW/.01 | Yes |
| GW-127 | 29850 | 51828 | 1003.67 | 24 | 14-24 | U/WB(∈mn/∈nl) | SS#304 | SS/SW/.01 | Yes |
| GW-209 | 31775 | 27699 | 792.96 | 48.1 | 42-48.1 | U | PVC/#40 | PVC/SS/01 | No |
| GW-226 | 29155 | 47422 | 940.56 | 55 | 45-55 | WB(∈mn) | Black Steel | Open | No |
| GW-227 | 29172 | 47802 | 943.91 | 40 | 45-55 | WB(∈mn) | Black Steel | Open | No |
| GW-229 | 29256 | 47016 | 945.71 | 55 | 30-40 | WB(∈mn) | Black Steel | Open | No |
| GW-236 | 29712 | 50453 | 980.39 | 18.5 | 10-18.5 | WB(∈mn) | PVC/#40 | PVC/SW/.01 | No |
| GW-276 | 29925 | 52557 | 998.70 | 18.5 | 11.3-18.5 | U | SS#304 | SS/SW/.01 | Yes |
| GW-277 | 29937 | 52564 | 999.05 | 77.41 | 62.2-77.41 | WB(∈nl) | SS#304 | SS/SW/.01 | Yes |
| GS-422 | 28849 | 28855 | 807.42 | 7.6 | 3.9-7.6 | U | PVC | PVC | No |
| GW-424 | 28773 | 29299 | 814.33 | 4.4 | 3.4-4.4 | U | PVC | PVC | No |
| GS-428 | 28678 | 30217 | 815.97 | 14.0 | 10-14 | U | PVC | PVC | No |
| GW-464 | 28688 | 30111 | 815.80 | 27.5 | 10-22.5 | U | PVC | PVC | No |

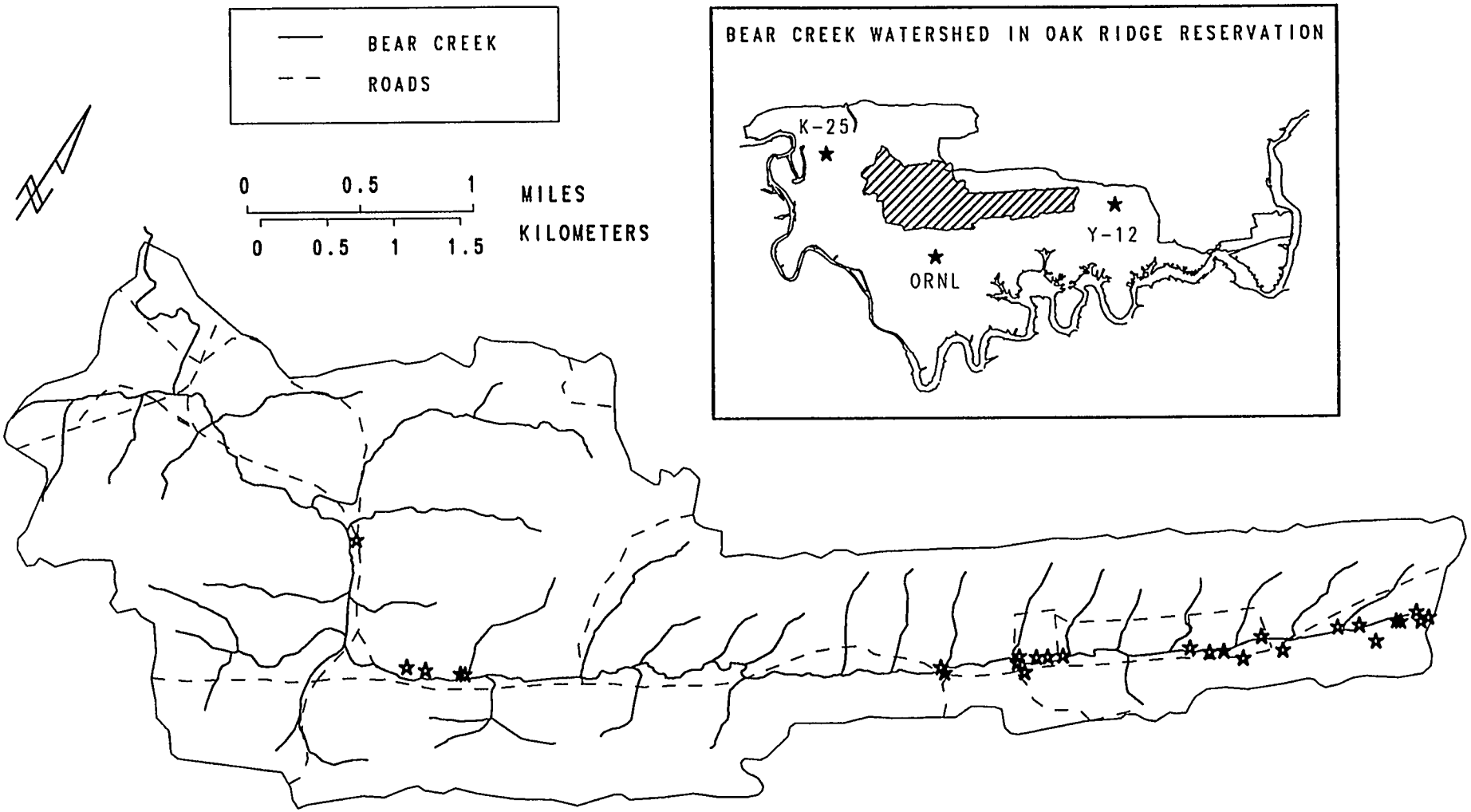



Fig. 7.2. Location of groundwater monitoring wells for which level and quality data were evaluated for this RFI Plan.

groundwater system (i.e., a gaining stream). If the monitoring well water levels are less than that of the stream, the stream is a source of recharge to the groundwater system (i.e., a losing stream). For some streams, certain reaches may be gaining while others are losing. Furthermore, seasonal fluctuations in the water table can lead to periodic changes in the nature of stream-groundwater interaction such that a specific reach can be gaining during wet seasons and losing during dry periods.

Figure 7.3 shows a map of Bear Creek and its tributaries with the location of the shallow floodplain monitoring wells considered in this discussion. The signs in parentheses next to each well number indicates whether water level data from that well is suggestive of Bear Creek being locally gaining (+) or losing (-). The water level data used in this analysis nominally consists of weekly measurements collected over a period of six months to several years. Except where noted, there is no indication of significant seasonal changes in the gaining or losing hydrologic properties of the stream.

Analysis of these water level data suggest that for a distance of approximately one mi downstream from its headwaters, Bear Creek is a site of groundwater discharge. From the vicinity of the Oil Landfarm westward to the Burial Grounds, Bear Creek appears to be a losing stream. Monitoring wells in the floodplain of Bear Creek near the western end of BCV where the stream turns northward to cross Pine Ridge appear to yield equivocal results. There is no clear cut tendency for the stream to be consistently gaining or losing along this reach. Further downstream, at the site of monitoring well GW-209 near Pine Ridge, evidence points to a gaining reach for Bear Creek. In summary, the preponderance of monitoring well water level data point to gaining reaches near the headwaters and western sections of Bear Creek, with the remainder of stream probably constituting a losing reach. This analysis agrees with that presented for surface water hydrology presented in Section 5.2.

Further insight into the hydrologic interaction between Bear Creek and the shallow groundwater flow system can be obtained from evaluation of hydrogeologic cross sections oriented normal to the axis of BCV. Figure 7.4 shows the location of cross sections AA′ and BB′ at the Oil

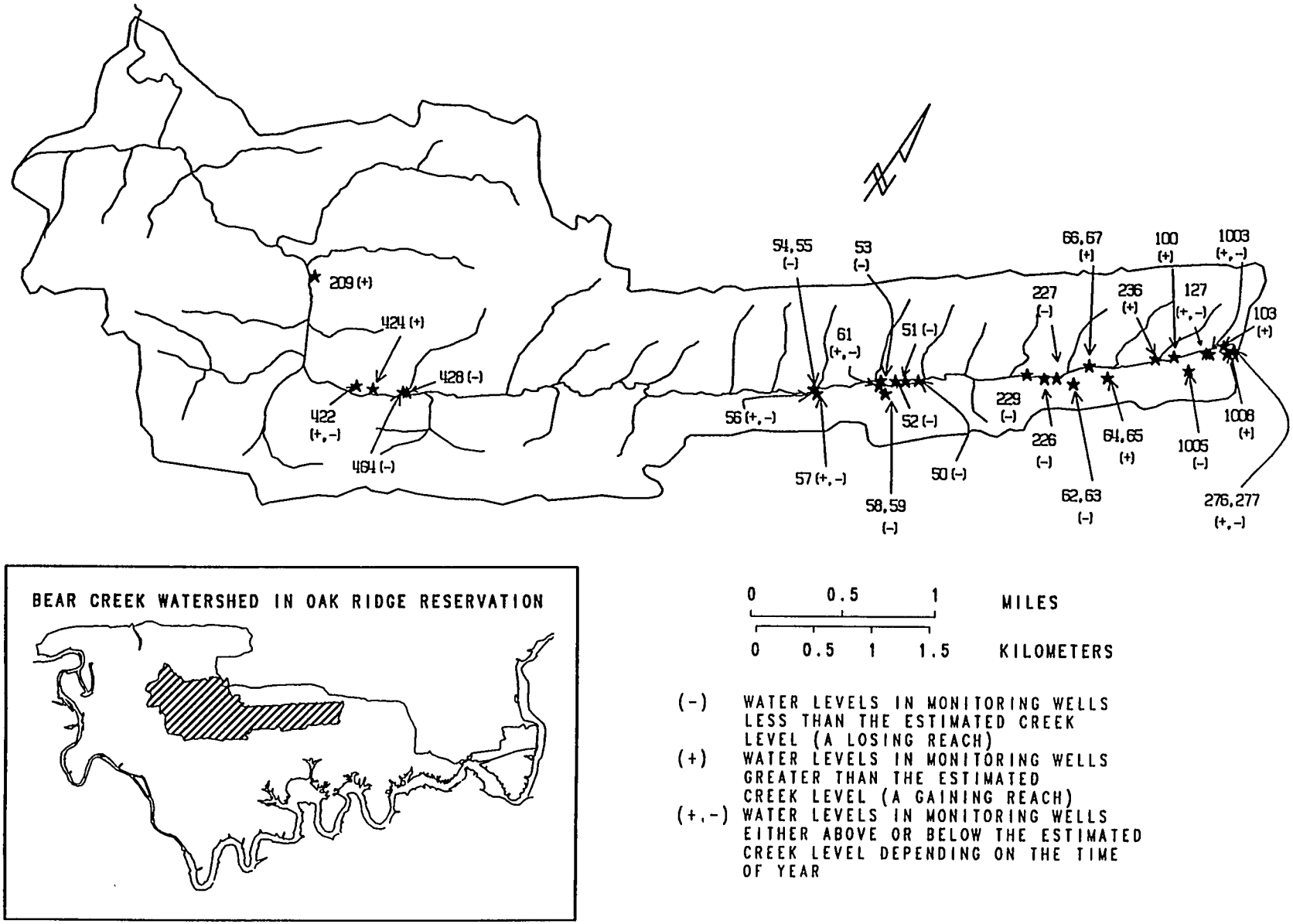
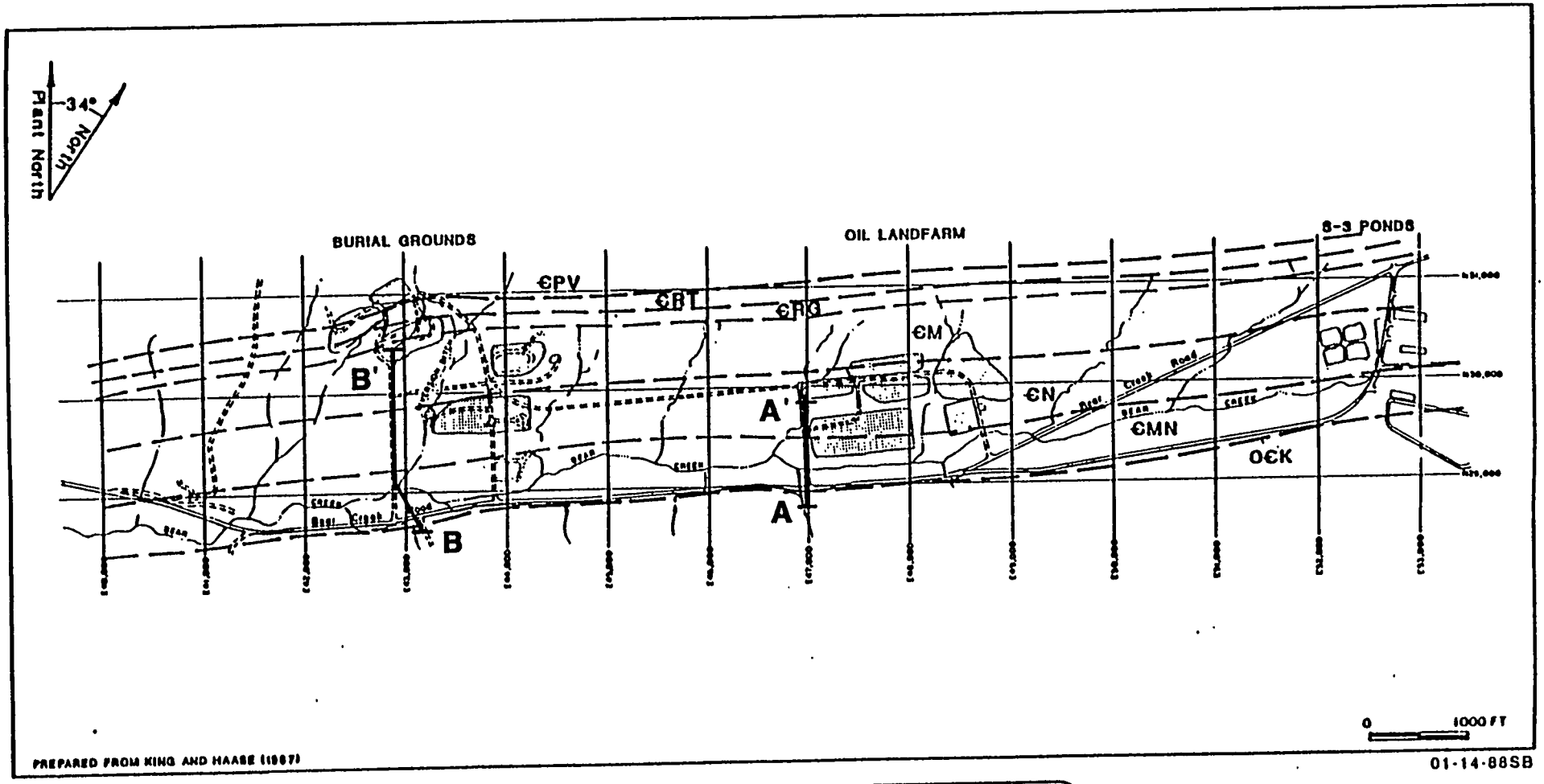



Fig. 7.3. Map showing location of shallow monitoring wells along Bear Creek with information on water levels. A "+" means that water levels are greater than the estimated water level in Bear Creek (i.e., a gaining reach). A "-" signifies a losing reach.




**EXPLANATION**

| | | | |
|---|---|---|---|
| | WASTE-DISPOSAL AREA | €pv | PUMPKIN VALLEY |
| | DIRT AND GRAVEL ROAD | €rl | RUTLEDGE |
| | APPROXIMATE FORMATION CONTACT | €rg | ROGERSVILLE |
| | | €m | MARYVILLE |
| | | €n | NOLICHUCKY |
| | | €mn | MAYNARDVILLE |
| | | O€k | KNOX |

Fig. 7.4. Locations of cross sections in Bear Creek Valley.

Landfarm and Burial Ground sites, respectively. These cross sections are presented in Figure 7.5. The configuration of the water table is shown for two times of measurement. The upper line represents a "wet" period while the lower line is the water table during a "dry" period. Note that both the wet and dry water tables at the Oil Landfarm support the interpretation of Bear Creek as a locally losing stream. In contrast, for the Burial Grounds cross section there is the suggestion that groundwater may discharge to the stream bed due to flow from the north. However, south of Bear Creek evidence points to flow going out of the stream to the groundwater system. This observation may be anomalous in that most of the other monitoring wells in this vicinity support the interpretation of Bear Creek as a losing stream in this reach.

The cross sections demonstrate that Bear Creek is underlain by the Maynardville Formation. This formation is a limestone with some dolomitic zones. From drillers records it is known to contain abundant solution channels. Interpretations of Geraghty & Miller (1988a) suggest that this feature of the Maynardville makes it a local sink for groundwater. Consequently, Bear Creek, which flows over the Maynardville for much of its length, likely loses a component of its flow to this formation, accounting for the relationships observed in Figure 7.3.

### 7.2.3 Sampling Results

From the discussions presented in Section 7.2.2 it is apparent that groundwater discharge to the headwaters reach of Bear Creek is an important part of the water balance for the stream in this region. Geraghty & Miller (1988a) have demonstrated that shallow groundwater in this region contains significant contaminants whose source is the S-3 Ponds. Of the range of constituents found in the S-3 Ponds, the nitrate ion is the most mobile component and should be transported conservatively in both surface and subsurface environments. Consequently, it constitutes an important tracer with which to monitor contaminant migration from the source region.

Geraghty & Miller (1987) report that discharge of contaminated groundwater to the headwaters reach of Bear Creek has resulted in observed nitrate concentrations ranging between 443 and 1950 mg/L nitrate-N for

ORNL DWG 88-15455A

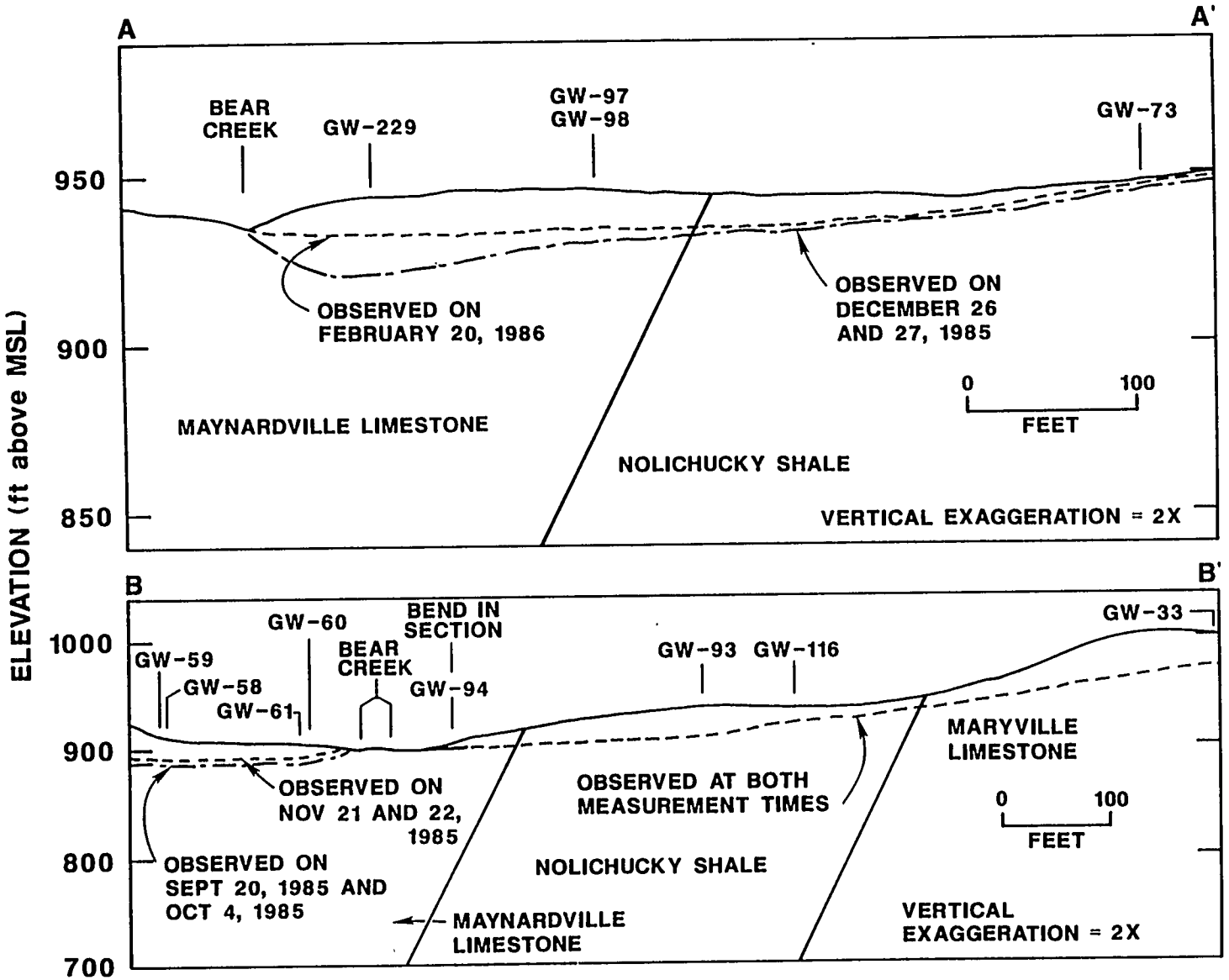



Fig. 7.5. Cross sections A-A′ and B-B′ showing the water table configuration during "wet" and "dry" periods. See Fig. 7.4 for location of cross sections.

samples collected between 1984 and 1986 at a stream sampling station approximately 2000 ft downstream from the S-3 ponds. By examining the distribution of nitrate in shallow groundwaters underlying the Bear Creek floodplain it is possible that the interaction between the creek and the groundwater flow system can be deciphered. If it can be shown that nitrate contamination of shallow groundwater along the major losing reach of the creek between BCK 11.17 and BCK 9.53 is related to recharge of the groundwater system with stream water, then an important tool will be available for assessing the impact of contaminants transported by Bear Creek on the composition of shallow groundwaters in the vicinity of the stream. Recent dye tracer studies revealed that water from losing reaches of Bear Creek above BCK 10.41 reappears in spring SS-5 (Geraghty & Miller, personal communication).

Figure 7.6 shows the location of shallow monitoring wells in the floodplain of Bear Creek for which groundwater nitrate analyses (see Appendix H) are available. The parentheses associated with each well number gives a qualitative assessment of the nitrate concentrations observed in the respective wells. In addition, nitrate concentrations observed for surface water samples collected from several Bear Creek monitoring stations are given. It is clear that groundwater samples collected from shallow wells along Bear Creek near the S-3 Ponds contain high concentrations of nitrate, a fact that is consistent with this being a site of discharge of contaminated groundwater. Furthermore, there is a general tendency for the nitrate concentrations in both surface water from Bear Creek and groundwater underlying the floodplain to decrease in the downstream direction. However, in the vicinity of the burial grounds, several wells yield anomalously high nitrate concentrations. The cause of this anomaly is unknown, but a local source of nitrate cannot be ruled out.

From an examination of the overall distribution of nitrate in surface waters and groundwaters along Bear Creek it is not possible to distinguish whether the source of the contamination is from infiltration through the stream bed, subsurface migration from the S-3 Ponds, transport from other waste sites, or a combination of these factors. Consequently, this evaluation technique does not lead to definitive results.

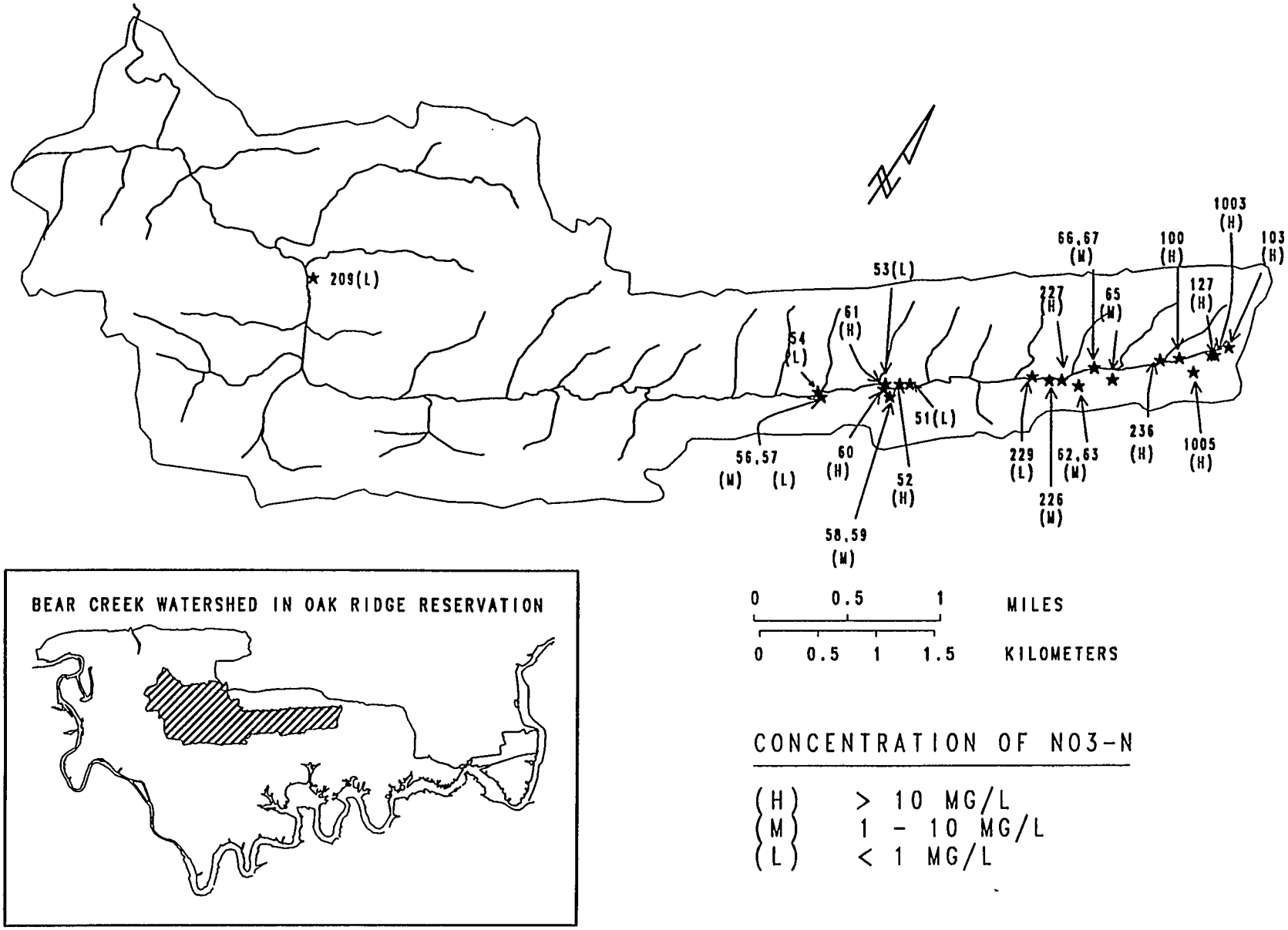



Fig. 7.6. Location of shallow monitoring wells along Bear Creek with information on nitrate-nitrogen concentrations. See legend for explanation of concentration ranges.

### 7.2.4 Conclusions and Recommendations

The issue of contamination of shallow groundwater by recharge in the losing reaches of Bear Creek is expected to be resolved by on-going investigations (eg., ACL demonstrations) associated with post-closure of the upstream SWMUs, and thus inclusion of this issue in the RFI would be redundant. In addition, the most obvious solution (corrective measure) to the problem of contaminated surface water recharging groundwater would be to focus corrective measures on eliminating or reducing the source(s) of contaminants in surface water. This is precisely the aim of the closures underway at the S-3 Ponds, Oil Land Farm and Burial Grounds. As the migration of contaminants from these areas is reduced or eliminated, the quality of Bear Creek surface water is expected to improve rapidly. At that time shallow groundwater in the cavernous Maynardville Formation near Bear Creek may continue to discharge residual contaminants into the creek via the springs (eg., SS-4 and SS-5) and diffuse seepage until this reservoir is flushed. Based on the preliminary results of recent dye tracer studies, the flushing time for the shallow aquifer near Bear Creek may be relatively short. If so, mobile residual contaminants in the shallow aquifer will not continue to sustain surface water concentrations of contaminants for very long after the quality of upstream surface water improves. The possible exception to this hypothetical recovery scenario concerns the less mobile contaminants, such as uranium, which may continue to leach from contaminated creek sediments and floodplain soils over an extended period of time. Thus, the RFI should focus on investigating the potential migration of the less mobile contaminants from contaminated floodplain soils.

## 7.3 SOIL/SEDIMENT DATA

### 7.3.1 Floodplain Soil Sampling Results

Floodplain soils in Bear Creek have been sampled and analyzed for selected contaminants on several occasions since 1983 (Fig. 7.7). As discussed below, only one investigation (unpublished; see Appendix I of this RFI Plan) has examined the depth distribution of contaminants in the

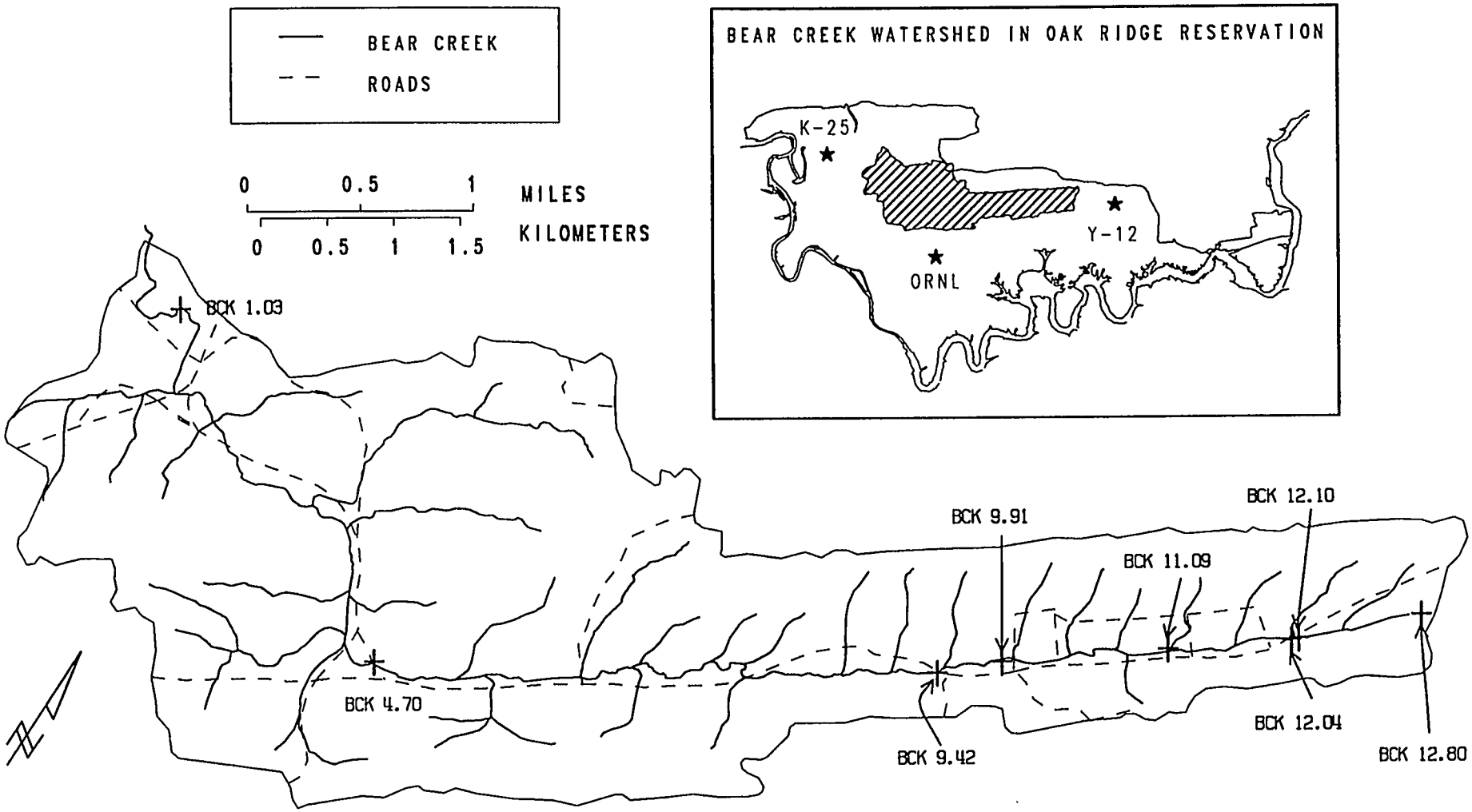



Fig. 7.7. Locations of Bear Creek floodplain soil sampling sites.

floodplain. The latter effort was intended mainly as a preliminary screening exercise for PCBs and uranium. The other available data are derived from isolated sampling and partial analyses which were part of larger studies. Floodplain soils in NT-7, including a part of the flood-of-record floodplain of Bear Creek, have been intensively characterized with respect to PCBs and a few other contaminants (Herbes 1988).

Hoffman et al. (1984) give analytical data (Table 7.2) for a single soil sample collected October 14 1983, near BCK-4.68. The sample was a composite of 12 cores which were 15 to 20 cm long from the backswamp area on the southside of the creek at this location. The sample was collected by R. R. Turner of ORNL as part of a contaminant screening study. A memo report (Turner 1983) fully documents the sampling methodology. The sample was analyzed by a Tennesee Valley Authority laboratory for priority pollutants. The ORNL Low Level Radiochemical Laboratory performed the radiological analyses.

The results for metals and cyanide indicate essentially background concentrations. Likewise, the radionuclides also occur at background levels, with the exception of the uranium isotopes which are slightly elevated but do not exceed the criteria (30 pCi/g) suggested by the Nuclear Regulatory Commission (NRC) and DOE for uranium in soil with unrestricted access. Except for the organic compounds shown in Table 7.2, which occurred at very low concentrations, no other organic compounds were reported at or above analytical detection limits. However, it should be noted that the analytical detection limits given by the laboratory were high for some compounds with respect to current (1988) detection limits. For example, the values for PCBs were given as < 5.00 $\mu$g/g, whereas current detection limits are 0.01 $\mu$g/g or better in a soil matrix. The presence of methylene chloride in this sample is suspect and may be due to the use of this solvent as a final rinse of the sample containers in the cleaning process (Turner 1983). The use of methylene chloride for sample container cleaning was erroneously specified by the analytical laboratory.

In April 1985 five locations (BCK-1.30, BCK-4.70, BCK-9.91, BCK-11.09 and BCK-12.10) were selected for further screening of contaminants in the Bear Creek Floodplain. Two or three soil cores up to 27 inches in length

Table 7.2. Results of floodplain soil analyses for site BCK-4.68 sampled in October 1983. Data from Hoffman et al. (1984)

| | BCK 4.68 (BC-FP-1)[a] |
|---|---|
| Metals and Cyanide (μg/g) | |
| Antimony | <0.20 |
| Arsenic | 5.8 |
| Beryllium | 0.60 |
| Cadmium | 2.5 |
| Chromium | 16 |
| Copper | 9 |
| Lead | 25 |
| Mercury | 0.25 |
| Nickel | <5.0 |
| Selenium | 0.44 |
| Silver | <1.0 |
| Thallium | <5.0 |
| Zinc | 44 |
| Cyanide | 0.70 |
| Radionuclides (pCi/g)[b] | |
| Strontium-90 | 0.18 ± 0.20 |
| Technetium-99 | 0.86 ± 1.0 |
| Thorium-228 | 0.59 ± 0.05 |
| Thorium-230 | 0.27 ± 0.03 |
| Thorium-232 | 0.46 ± 0.06 |
| Uranium-234 | 4.6 ± 0.78 |
| Uranium-235 | 0.81 ± 0.14 |
| Uranium-238 | 8.1 ± 1.03 |
| Plutonium-238 | <0.001 |
| Plutonium-239 | 0.008 ± 0.003 |
| Netpunium-237 | <0.03 |
| Cesium-137 | 0.59 ± 0.11 |
| Organics (μg/g)[c] | |
| Bis (2-ethylehexyl) phthalate | 1.40 |
| Fluoranthene | 0.81 |
| Methylene chloride | 0.02 |
| Phenols (total) | 2.30 |
| Pyrene | 0.52 |

[a]Station identifier used by Hoffman et al. (1984).

[b]Values converted from reported units of Bq/kg by multiplying by 0.027.

[c]Only compounds which were reported at or above detection limits are included.

were collected at each site using a vibracorer. Each core was extruded from the aluminum core barrel and cut into intervals ranging from 3 inches to 8 inches. Where a levee or berm was present, one core was taken on the levee on each side of the creek. The third core came from a backswamp area typically a scour route. Core sections were subsampled for volatile compounds (PCE and TCE only) immediately and then the balance of the material air-dried (22-24°C) and homogenized by crushing in a mortar and pestle. The ORNL Analytical Chemistry Division performed all the chemical analyses except the gamma spectrometry which was performed in the ESD Low Level Counting Facility.

Tables 7.3 and 7.4 summarize the analytical data for all April 1985 results combined and for surface (0 to 3 inches) soil only. The combined summary indicates that PCBs in some samples were elevated above the TSCA PCB Spill Cleanup criterium (25 $\mu$g/g) for soil on the bank of a stream (Note: TDHE has agreed to the 25 $\mu$g/g cleanup level for Bear Creek watershed). Likewise the combined summary indicates that some samples exceeded the NRC/DOE guideline of 30-35 pCi/g for uranium in soil with unrestricted access. Certain metals, including especially cadmium, also slightly exceeded maximum expected natural background concentrations. In most cases the highest concentrations of contaminants were in the surface soils (Table 7.4). However, the highest PCB concentration was in subsurface soil (Core B only) at BCK-4.70 (Figure 7.8). Uranium was also usually highest in the surficial floodplain soil but also showed a large subsurface peak at BCK-4.70 (Core B only).

Based on the finding of elevated PCBs in floodplain soils near BCK-4.70, a second sampling was conducted in October 1986 to better define the areal and depth distribution of PCBs and uranium at this site. The followup sampling involved coring two cross sections centered near the location of Core B from the April 1985 sampling (Figure 7.9). The complete results are given in Table 7.5 and summarized graphically in Figure 7.3. The results confirmed the presence of a narrow, lens-shaped deposit with elevated levels of PCBs and uranium along the southern bank of Bear Creek immediately upstream of the large culvert under Bear Creek Road. The constriction of the channel at the road crossing, plus the presence of

Table 7.3. Statistical Summary of Contaminant Levels at the Five Floodplain Soil Sampling Localities Sampled April, 1985. Data are for all depth intervals combined. Units are μg/g, dry weight, except as noted. (DL = detection limit)

| | N | # Times < DL | Mean | Maximum | Minimum |
|---|---|---|---|---|---|
| Σ Alpha (pCi/g) | 62 | 0 | 22.0 | 103. | 2.4 |
| Σ Beta (pCi/g) | 62 | 0 | 22.5 | 119. | 6.5 |
| $^{137}$Cs (pCi/g) | 63 | 23 | 0.35 | 2.3 | 0.01 |
| $^{40}$K (pCi/g) | 63 | 0 | 11.0 | 18.2 | 4.9 |
| $^{235}$U (pCi/g) | 63 | 51 | 0.27 | 2.8 | 0.07 |
| $^{238}$U (pCi/g) | 63 | 36 | 9.9 | 93. | 0.80 |
| Σ Uranium | 62 | 0 | 28. | 241. | 0.51 |
| TCE | 61 | 52 | 0.03 | 0.45 | 0.01 |
| PCE | 61 | 54 | 0.01 | 0.06 | 0.01 |
| PCBs | 48 | 0 | 3.87 | 132. | 0.02 |
| Ag | 63 | 63 | 1.49 | 1.70 | 1.10 |
| Al | 63 | 0 | 16540. | 39000. | 10000. |
| As | 63 | 63 | 4.1 | 4.8 | 2.5 |
| Ba | 63 | 0 | 120. | 270. | 59. |
| Be | 63 | 0 | 0.96 | 2.2 | 0.66 |
| Ca | 63 | 0 | 1735. | 14000. | 670. |
| Cd | 63 | 1 | 2.4 | 12. | 0.12 |
| Co | 63 | 0 | 16.6 | 37. | 9.8 |
| Cr | 63 | 0 | 24. | 73. | 13. |
| Cu | 63 | 0 | 13.0 | 51. | 4. |
| Fe | 63 | 0 | 17338. | 39000. | 1300. |
| Ga | 63 | 63 | 10. | 12. | 7. |
| Hf | 50 | 0 | 8. | 15. | 3.6 |
| Li | 63 | 1 | 19.8 | 58. | 5.0 |
| Mg | 62 | 0 | 1402. | 4100. | 600. |
| Mn | 63 | 0 | 988. | 2100. | 220. |
| Mo | 62 | 61 | 0.57 | 2.10 | 0.32 |
| Na | 62 | 0 | 74. | 180. | 33. |
| Ni | 62 | 0 | 21. | 63. | 10. |
| P | 63 | 0 | 273. | 490. | 140. |
| Pb | 62 | 0 | 29. | 90. | 15. |
| Sb | 62 | 48 | 8.1 | 17. | 4.8 |
| Se | 63 | 55 | 9.8 | 33. | 5. |
| Sr | 62 | 0 | 6.4 | 18. | 3.7 |
| Ti | 62 | 0 | 65. | 100. | 41. |
| V | 62 | 0 | 23. | 48. | 13. |
| Zn | 63 | 0 | 39. | 130. | 20. |
| Zr | 63 | 1 | 4.3 | 10. | 1.1 |

Table 7.4. Statistical Summary of Contaminant Levels in Floodplain Surface Soils at Five Sites in Bear Creek Sampled April, 1985. Units are $\mu g/g$, dry weight, except as noted. (DL = detection limit)

| | N | # Times < DL | Mean | Maximum | Minimum |
|---|---|---|---|---|---|
| Σ Alpha (pCi/g) | 14 | 0 | 39.7 | 103. | 9.4 |
| Σ Beta (pCi/g) | 14 | 0 | 37.2 | 116. | 19.7 |
| $^{137}Cs$ (pCi/g) | 14 | 0 | 1.04 | 2.30 | 0.14 |
| $^{40}K$ (pCi/g) | 14 | 0 | 11.95 | 18.10 | 5.20 |
| $^{235}U$ (pCi/g) | 14 | 8 | 0.55 | 2.80 | 0.07 |
| $^{238}U$ (pCi/g) | 14 | 3 | 23.2 | 92.7 | 1.5 |
| Σ Uranium | 14 | 0 | 73.4 | 241.0 | 11.0 |
| TCE | 14 | 11 | 0.02 | 0.19 | 0.01 |
| PCE | 14 | 13 | 0.01 | 0.03 | 0.01 |
| PCBs | 14 | 0 | 1.59 | 11.30 | 0.02 |
| Ag | 14 | 14 | 1.50 | 1.70 | 1.10 |
| Al | 14 | 0 | 18286. | 39000. | 12000. |
| As | 14 | 14 | 4.04 | 4.85 | 2.50 |
| Ba | 14 | 0 | 120.36 | 150.00 | 95.00 |
| Be | 14 | 0 | 1.05 | 2.20 | 0.69 |
| Ca | 14 | 0 | 3721. | 14000. | 1300. |
| Cd | 14 | 0 | 3.96 | 12.00 | 0.90 |
| Co | 14 | 0 | 17.3 | 37.0 | 13.0 |
| Cr | 14 | 0 | 22.9 | 36.0 | 16.0 |
| Cu | 14 | 0 | 21.7 | 51.0 | 9.4 |
| Fe | 14 | 0 | 17214. | 35000. | 11000. |
| Ga | 14 | 14 | 10.4 | 12.0 | 7.5 |
| Hf | 11 | 0 | 8.2 | 11.0 | 5.8 |
| Li | 14 | 0 | 28.4 | 58.0 | 16.0 |
| Mg | 14 | 0 | 1685. | 4100. | 890. |
| Mn | 14 | 0 | 929. | 1900. | 610. |
| Mo | 14 | 13 | 0.64 | 2.10 | 0.32 |
| Na | 14 | 0 | 80. | 180. | 35. |
| Ni | 14 | 0 | 30. | 63. | 18. |
| P | 14 | 0 | 362. | 490. | 220. |
| Pb | 14 | 0 | 41. | 90. | 15. |
| Sb | 14 | 11 | 8.3 | 17.0 | 4.8 |
| Se | 14 | 13 | 8.8 | 19.0 | 5.0 |
| Sr | 14 | 0 | 9.6 | 18.0 | 5.9 |
| Ti | 14 | 0 | 63. | 90. | 44. |
| V | 14 | 0 | 23. | 41. | 16. |
| Zn | 14 | 0 | 62. | 130. | 31. |
| Zr | 14 | 0 | 5.0 | 6.9 | 3.4 |
| Depth | 14 | 0 | 1.50 | 1.50 | 1.50 |

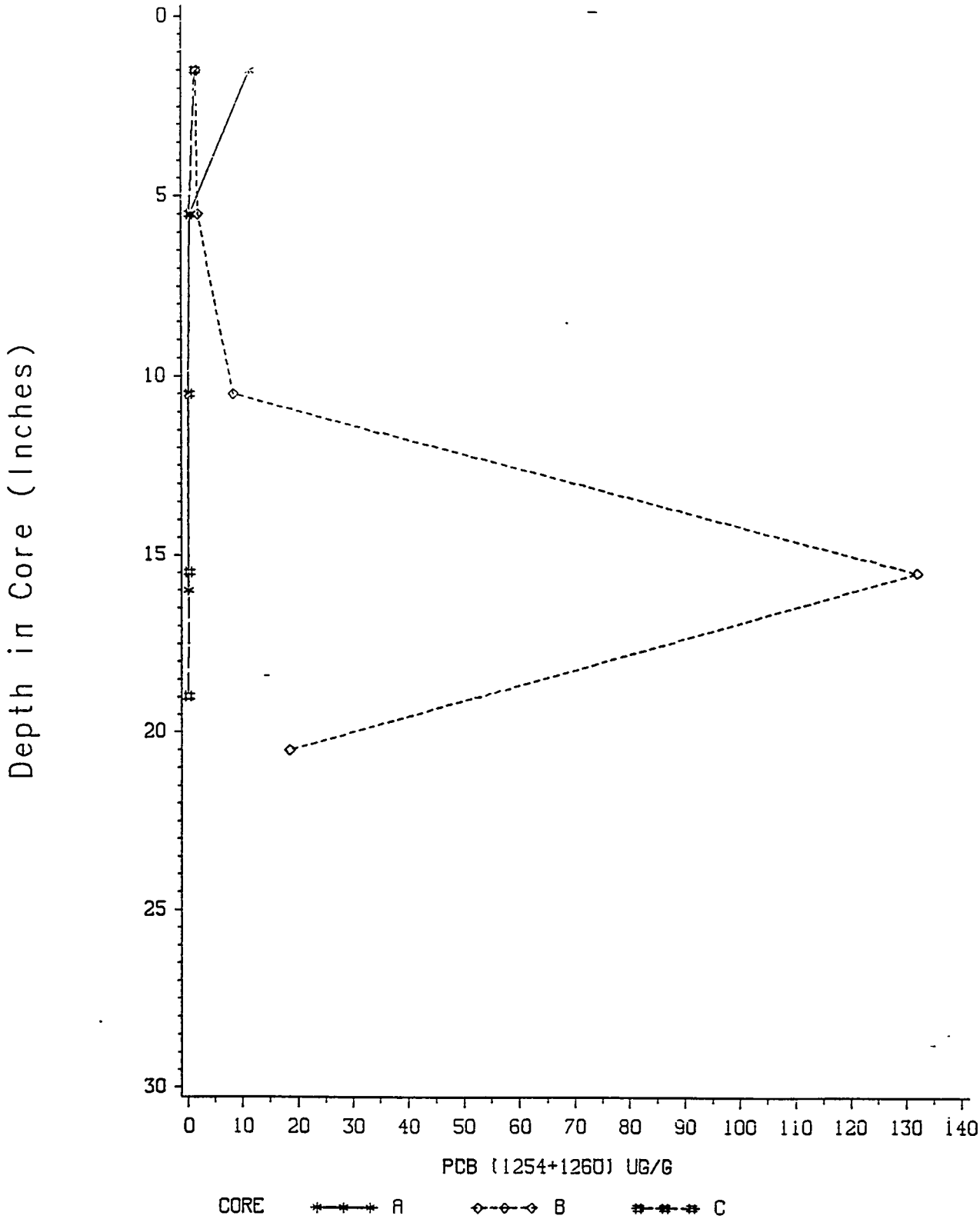



Fig. 7.8. Depth distribution of PCBs in floodplain soil at BCK-4.70.

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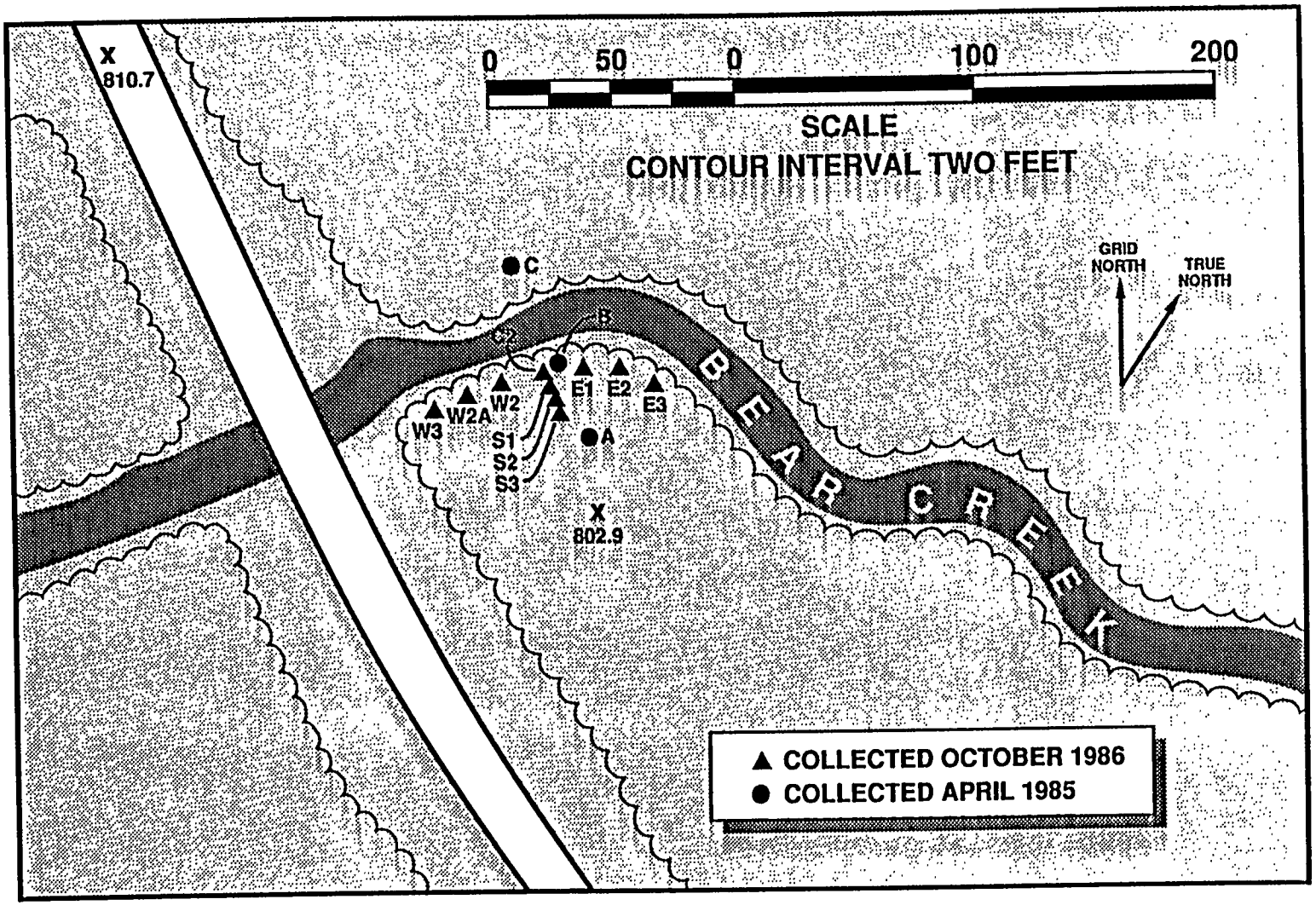


Fig. 7.9. Locations of floodplain soil coring sites at BCK-4.70.

Table 7.5 PCB and Uranium Data for Bear Creek Floodplain Soils Collected October 10, 1986

| Location | Core | Top | Bottom | Total U µg/g | PCB-1254 µg/g |
|---|---|---|---|---|---|
| BCK-4.70 | C2 | 0 | 6 | 56.0 | 1.5 |
| BCK-4.70 | C2 | 6 | 12 | 100.0 | 2.4 |
| BCK-4.70 | C2 | 12 | 18 | 140.0 | 3.4 |
| BCK-4.70 | C2 | 18 | 24 | 202.0 | 13.0 |
| BCK-4.70 | E1 | 0 | 6 | 47.0 | 2.2 |
| BCK-4.70 | E1 | 6 | 12 | 77.0 | 11.1 |
| BCK-4.70 | E1 | 12 | 18 | 23.0 | 1.0 |
| BCK-4.70 | E1 | 18 | 24 | 7.0 | 0.1 |
| BCK-4.70 | E2 | 0 | 6 | 57.0 | 2.8 |
| BCK-4.70 | E2 | 6 | 12 | 33.0 | 2.2 |
| BCK-4.70 | E2 | 12 | 18 | 14.0 | 0.6 |
| BCK-4.70 | E2 | 18 | 24 | 9.0 | 0.4 |
| BCK-4.70 | E3 | 0 | 6 | 26.0 | 1.2 |
| BCK-4.70 | E3 | 6 | 12 | 6.0 | <0.1 |
| BCK-4.70 | E3 | 12 | 18 | 7.0 | 0.2 |
| BCK-4.70 | E3 | 18 | 24 | 3.1 | <0.1 |
| BCK-4.70 | S1 | 0 | 6 | 60.0 | 1.8 |
| BCK-4.70 | S1 | 6 | 12 | 74.0 | 8.0 |
| BCK-4.70 | S1 | 12 | 18 | 10.0 | 0.4 |
| BCK-4.70 | S1 | 18 | 24 | 5.0 | <0.1 |
| BCK-4.70 | S2 | 0 | 6 | 79.0 | 2.9 |
| BCK-4.70 | S2 | 6 | 12 | 23.0 | 1.0 |
| BCK-4.70 | S2 | 12 | 18 | 21.0 | 0.8 |
| BCK-4.70 | S2 | 18 | 24 | 11.0 | 0.4 |
| BCK-4.70 | S3 | 0 | 6 | 48.0 | 1.8 |
| BCK-4.70 | S3 | 6 | 12 | 5.0 | <0.1 |
| BCK-4.70 | S3 | 12 | 18 | 4.0 | <0.1 |
| BCK-4.70 | S3 | 18 | 24 | 5.0 | <0.1 |
| BCK-4.70 | W1 | 0 | 6 | 56.0 | 1.4 |
| BCK-4.70 | W1 | 6 | 12 | 130.0 | 31.7 |
| BCK-4.70 | W1 | 12 | 18 | 100.0 | 105.0 |
| BCK-4.70 | W1 | 18 | 24 | 40.0 | 7.9 |
| BCK-4.70 | W2 | 0 | 6 | 135.0 | 2.2 |
| BCK-4.70 | W2 | 6 | 12 | 225.0 | 5.8 |
| BCK-4.70 | W2 | 12 | 18 | 299.0 | 45.1 |
| BCK-4.70 | W2 | 18 | 24 | 69.0 | 5.4 |
| BCK-4.70 | W2A | 0 | 6 | 83.0 | 2.1 |
| BCK-4.70 | W2A | 6 | 12 | 171.0 | 11.1 |
| BCK-4.70 | W2A | 12 | 18 | 186.0 | 83.0 |
| BCK-4.70 | W2A | 18 | 24 | 43.0 | 8.5 |
| BCK-4.70 | W3 | 0 | 6 | 257.0 | 4.7 |
| BCK-4.70 | W3 | 6 | 12 | 126.0 | 15.9 |
| BCK-4.70 | W3 | 12 | 18 | 27.0 | 1.9 |
| BCK-4.70 | W3 | 18 | 24 | 22.0 | 2.7 |

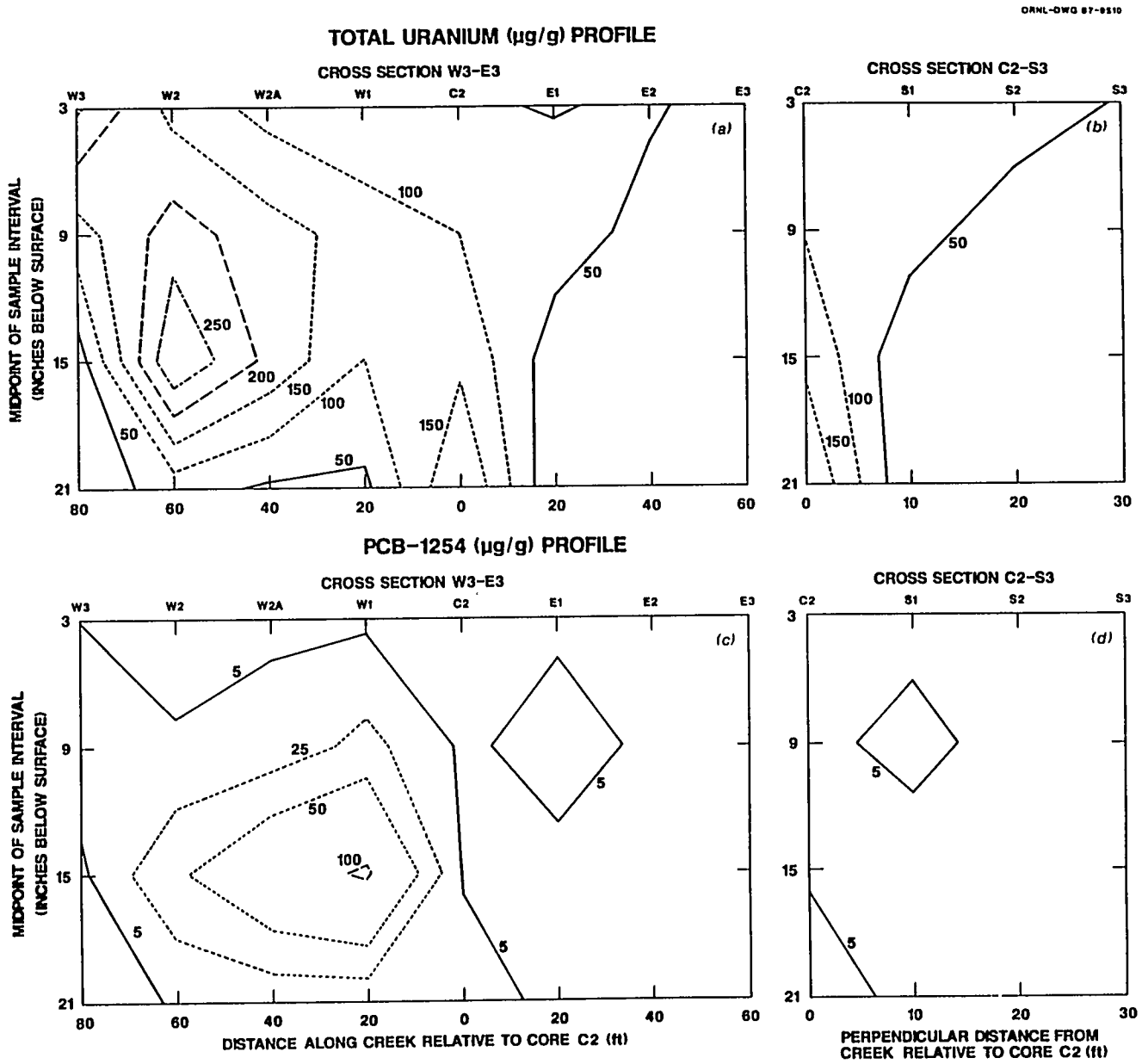


Fig. 7.10. Vertical cross section of PCB and uranium concentrations in soil at BCK-4.70.

large stilling pond (for hydrologic monitoring) at BCK-4.55 likely create flood backwater in this area, with the consequent deposition of the suspended load of Bear Creek.

Floodplain soils were also sampled at BCK-9.42 in November 1985 prior to repair of the bridge over Bear Creek at this location (see Appendix J for complete results.

### 7.3.2 Sediment Sampling Results

Bear Creek sediment deposits have been sampled extensively (Fig. 7.11) and analyzed for a wide variety of contaminants. The contractors, Bechtel National Inc. and Roy Weston Inc., have collected and analyzed most of the samples. Collection, handling and analyses were generally in accordance with methods given in SW-846 (USEPA 1986a). As discussed pereviously (Section 7.1.6) extensive quality assurance/quality control activity accompanied these sampling and analytical campaigns.

#### 7.3.2.1 Organic contaminants

Bear Creek sediments contain low levels of volatile organic compounds (VOCs), oil residues, and polychlorinated biphenyls (Table 7.6). The distribution of volatile organic compounds at the sediment sampling sites closely parallels their distribution in water samples. The highest levels are noted in the region around the burial grounds, with tributary NT-7 having the highest concentrations (1932 $\mu$g/kg summed VOCs). The concentrations of VOCs were highly variable among sampling dates, but the highest levels in Bear Creek on a given date always occurred at BCK 9.91, just downstream from tributary NT-7. The maximum concentration observed in sediments from this site was 650 $\mu$g/kg summed VOCs. Only barely detectable traces of VOCs were found in sediments farther downstream. The predominant compounds found in contaminated sediments at this site were trans 1,2 dichloroethene, tetrachloroethene, and trichloroethene. These same compounds predominated in water samples at this site. These low molecular weight halogenated hydrocarbons have relatively low affinities for sorption to sediments (Callahan et al 1979). Measured concentrations in sediments roughly approximated aqueous concentrations at the same site. Thus,

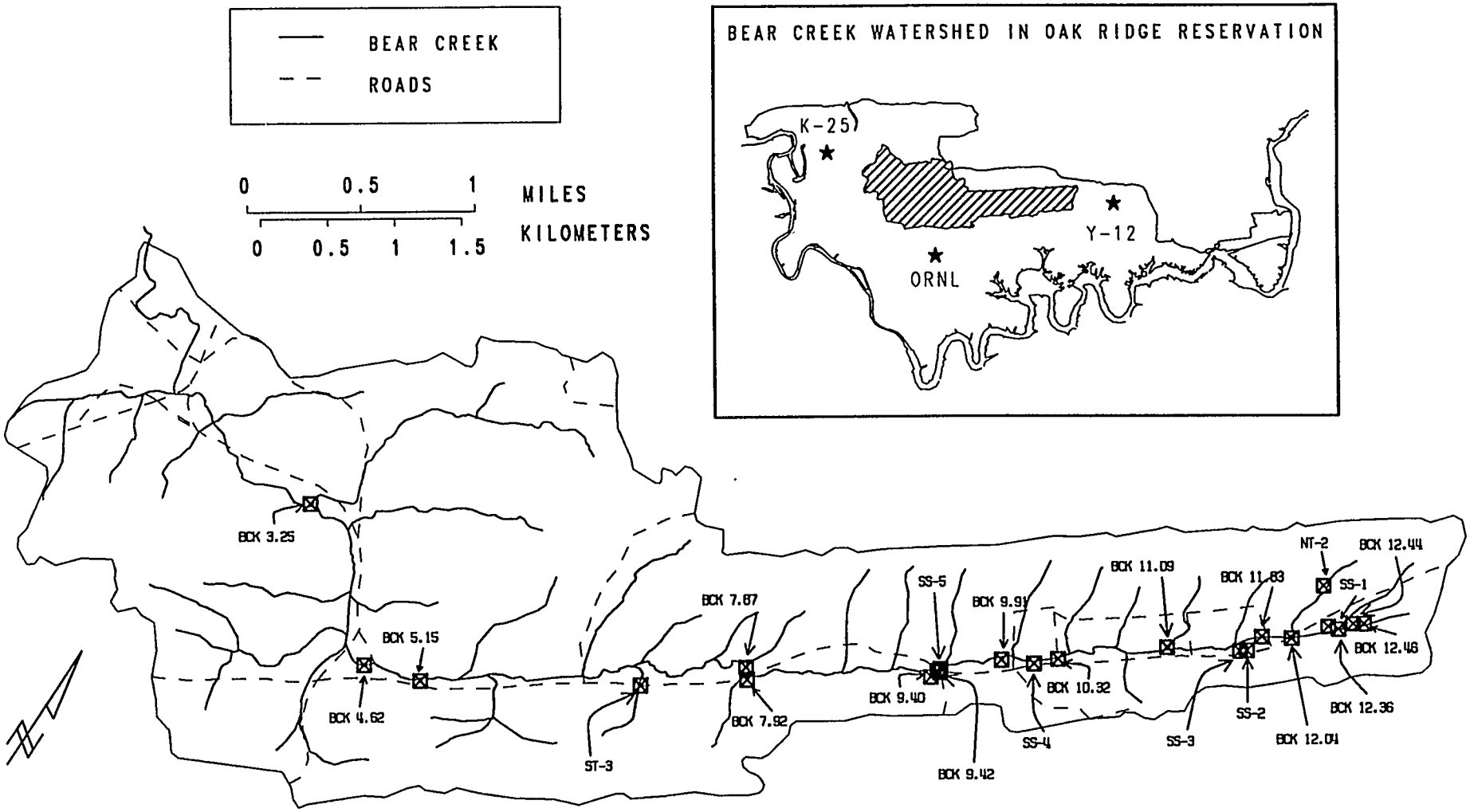


Fig. 7.11. Locations of Bear Creek sediment sampling sites.

Table 7.6. Statistical summary of organic constituents in mainstem Bear Creek sediments. Data are from Bechtel National, Inc. and Roy F. Weston, Inc. sampling campaigns during the period 1983-1986. Values reported as "less than" values were included in the statistical summary after deleting the "<" sign and dividing the given value by 2. Minimum, maximum, and mean values of zero mean "not detected."

| | NUMBER OF OBSERVATIONS | MINIMUM VALUE | MAXIMUM VALUE | MEAN |
|---|---|---|---|---|
| VOLATILE ORGANIC COMPOUNDS (μg/kg) | | | | |
| ACROLEIN | 78 | 0 | 0.0000 | 0.0000 |
| ACRYLONITRILE | 78 | 0 | 0.0000 | 0.0000 |
| BENZENE | 78 | 0 | 15.5000 | 0.6218 |
| BROMOFORM | 78 | 0 | 0.0000 | 0.0000 |
| CARBON TETRACHLORIDE | 78 | 0 | 0.0000 | 0.0000 |
| CHLOROBENZENE | 78 | 0 | 15.5000 | 0.2628 |
| CHLORODIBROMOMETHANE | 78 | 0 | 0.0000 | 0.0000 |
| CHLOROETHANE | 78 | 0 | 0.0000 | 0.0000 |
| 2-CHLOROETHYLVINYL ETHER | 78 | 0 | 0.0000 | 0.0000 |
| CHLOROFORM | 78 | 0 | 21.0000 | 1.2051 |
| BROMODICHLOROMETHANE | 78 | 0 | 0.0000 | 0.0000 |
| DICHLORODIFLUOROMETHANE | 78 | 0 | 0.0000 | 0.0000 |
| 1,1-DICHLOROETHANE | 78 | 0 | 16.0000 | 0.9487 |
| 1,2-DICHLOROETHANE | 78 | 0 | 9.0000 | 0.2436 |
| 1,1-DICHLOROETHENE | 78 | 0 | 12.0000 | 0.3333 |
| 1,2-DICHLOROPROPANE | 78 | 0 | 0.0000 | 0.0000 |
| CIS-1,3-DICHLOROPROPENE | 78 | 0 | 0.0000 | 0.0000 |
| TRANS-1,3-DICHLOROPROPENE | 78 | 0 | 0.0000 | 0.0000 |
| ETHYLBENZENE | 78 | 0 | 0.0000 | 0.0000 |
| BROMOMETHANE | 78 | 0 | 0.0000 | 0.0000 |
| CHLOROMETHANE | 78 | 0 | 29.0000 | 0.7949 |
| METHYLENE CHLORIDE | 78 | 0 | 130.0000 | 16.5833 |
| 1,1,2,2-TETRACHLOROETHANE | 78 | 0 | 0.0000 | 0.0000 |
| TETRACHLOROETHENE | 78 | 0 | 270.0000 | 8.8077 |
| TOLUENE | 78 | 0 | 31.5000 | 1.0385 |
| TRANS-1,2-DICHLOROETHENE | 78 | 0 | 420.0000 | 15.7692 |
| 1,1,1-TRICHLOROETHANE | 78 | 0 | 38.0000 | 2.2564 |
| 1,1,2-TRICHLOROETHANE | 78 | 0 | 0.0000 | 0.0000 |
| TRICHLOROETHENE | 78 | 0 | 59.0000 | 5.0128 |
| FLUOROTRICHLOROMETHANE | 78 | 0 | 21.0000 | 0.8910 |
| VINYL CHLORIDE | 78 | 0 | 13.0000 | 0.4615 |

Table 7.6 (continued)

| | NUMBER OF OBSERVATIONS | MINIMUM VALUE | MAXIMUM VALUE | MEAN |
|---|---|---|---|---|
| PCBs μg/kg) | | | | |
| PCB-AROCLOR-1254 | 8 | 0.0050 | 0.0500 | 0.0256 |
| PCB-AROCLOR-1260 | 14 | 0.0050 | 0.0500 | 0.0346 |
| PCB-AROCLOR-1242,1248,1016 | 4 | 0.0250 | 0.0250 | 0.0250 |
| SEMI-VOLATILE ORGANIC COMPOUNDS (μg/kg) | | | | |
| ACENAPHTHENE | 33 | 0 | 0.0000 | 0.0000 |
| ACENAPHTHYLENE | 33 | 0 | 0.0000 | 0.0000 |
| ANTHRACENE | 33 | 0 | 0.5000 | 0.0152 |
| BENZIDINE | 33 | 0 | 0.0000 | 0.0000 |
| BENZO(A)ANTHRACENE | 33 | 0 | 0.5000 | 0.0606 |
| BENZO(A)PYRENE | 33 | 0 | 0.5000 | 0.0303 |
| 3,4-BENZOFLUORANTHENE | 20 | 0 | 0.5000 | 0.0750 |
| BENZO(GHI)PERYLENE | 33 | 0 | 0.5000 | 0.0152 |
| BIS(2-CHLORETHOXY)METHANE | 33 | 0 | 0.0000 | 0.0000 |
| BIS(2-CHLORETHYL)ETHER | 33 | 0 | 0.0000 | 0.0000 |
| BIS(2-CHLORISOPROPYL)ETHER | 33 | 0 | 0.0000 | 0.0000 |
| BIS(2-ETHYLHEXYL)PHTHALATE | 33 | 0 | 0.0000 | 0.0000 |
| 4-BROMOPHENYL PHENYL ETHER | 33 | 0 | 0.0000 | 0.0000 |
| BUTYL BENZYL PHTHALATE | 33 | 0 | 0.0000 | 0.0000 |
| 2-CHLORONAPHTHALENE | 33 | 0 | 0.0000 | 0.0000 |
| 4-CHLOROPHENYLPHENYL ETHER | 33 | 0 | 0.0000 | 0.0000 |
| CHRYSENE | 33 | 0 | 0.5000 | 0.0152 |
| DIBENZO(A,H)ANTHRACENE | 33 | 0 | 0.0000 | 0.0000 |
| 1,2-DICHLOROBENZENE | 33 | 0 | 0.0000 | 0.0000 |
| 1,3-DICHLOROBENZENE | 33 | 0 | 0.0000 | 0.0000 |
| 1,4-DICHLOROBENZENE | 33 | 0 | 0.0000 | 0.0000 |
| 3,3'-DICHLOROBENZIDINE | 33 | 0 | 0.0000 | 0.0000 |
| DIETHYLPHTHALATE | 33 | 0 | 0.0000 | 0.0000 |
| DIMETHYLPHTHALATE | 33 | 0 | 0.5000 | 0.0152 |
| DI-N-BUTYLPHTHALATE | 33 | 0 | 0.5000 | 0.0152 |
| 2,4-DINITROTOLUENE | 33 | 0 | 0.0000 | 0.0000 |
| 2,6-DINITROTOLUENE | 33 | 0 | 0.0000 | 0.0000 |
| DI-N-OCTYLPHTHALATE | 33 | 0 | 0.0000 | 0.0000 |
| 1,2-DIPHENYLHYDRAZINE | 20 | 0 | 0.0000 | 0.0000 |

Table 7.6 (continued)

| | NUMBER OF OBSERVATIONS | MINIMUM VALUE | MAXIMUM VALUE | MEAN |
|---|---|---|---|---|
| FLUORANTHENE | 33 | 0 | 2.1000 | 0.1370 |
| FLUORENE | 33 | 0 | 0.0000 | 0.0000 |
| HEXACHLOROBENZENE | 33 | 0 | 0.0000 | 0.0000 |
| HEXACHLOROBUTADIENE | 33 | 0 | 0.0000 | 0.0000 |
| HEXACHLOROCYCLOPENTADIENE | 33 | 0 | 0.0000 | 0.0000 |
| HEXACHLOROETHANE | 33 | 0 | 0.0000 | 0.0000 |
| IDENO(1,2,3-CD)PYRENE | 33 | 0 | 0.5000 | 0.0152 |
| ISOPHORONE | 33 | 0 | 0.0000 | 0.0000 |
| NAPHTHALENE | 33 | 0 | 0.0000 | 0.0000 |
| NITROBENZENE | 33 | 0 | 0.0000 | 0.0000 |
| N-NITROSODIMETHYLAMINE | 20 | 0 | 0.0000 | 0.0000 |
| N-NITROSODI-N-PROPYLAMINE | 33 | 0 | 0.0000 | 0.0000 |
| N-NITROSODIPHENYLAMINE | 20 | 0 | 0.0000 | 0.0000 |
| PHENANTHRENE | 33 | 0 | 1.9000 | 0.0994 |
| PYRENE | 33 | 0 | 1.9000 | 0.1042 |
| 1,2,4-TRICHLOROBENZENE | 33 | 0 | 0.0000 | 0.0000 |
| 2,3,7,8-TCDD | 20 | 0 | 0.0000 | 0.0000 |
| BENZO(K)FLUORANTHENE | 13 | 0 | 0.0000 | 0.0000 |
| 1,2-DIPHENYLHYDRAZINE | 13 | 0 | 0.0000 | 0.0000 |
| N-NITROSODIPHENYLAMINE | 13 | 0 | 0.0000 | 0.0000 |
| BENZO(B)FLUORANTHENE | 13 | 0 | 0.0000 | 0.0000 |
| 2-CHLOROPHENOL | 33 | 0 | 0 | 0 |
| 2,4-DICHLOROPHENOL | 33 | 0 | 0 | 0 |
| 2,4-DIMETHYLPHENOL | 33 | 0 | 0 | 0 |
| 4,6-DINITRO-2-METHYLPHENOL | 33 | 0 | 0 | 0 |
| 2,4-DINITROPHENOL | 33 | 0 | 0 | 0 |
| 2-NITROPHENOL | 33 | 0 | 0 | 0 |
| 4-NITROPHENOL | 33 | 0 | 0 | 0 |
| P-CHLORO-M-CRESOL | 33 | 0 | 0 | 0 |
| PENTACHLOROPHENOL | 33 | 0 | 0 | 0 |
| PHENOL | 33 | 0 | 0 | 0 |
| 2,4,6-TRICHLOROPHENOL | 33 | 0 | 0 | 0 |

sediment levels of VOCs indicate the presence of contaminated ground or surface water within the sediments, rather than an accumulation of contaminants in the solid phase. The toxicity of sediments due to VOCs should therefore closely reflect that of the overlying water, which is discussed subsequently (Section 7.4.2).

Traces of methylene chloride and 1,1,1-trichloroethane were detected in Bear Creek sediments in the uppermost reaches, near the S-3 ponds. These compounds are not important constituents of contaminated water further downstream. This indicates that a somewhat different suite of VOCs may contaminate groundwater near the S-3 ponds. Levels are low enough (approximately 10 $\mu$g/L) to be of little ecological concern.

The gravimetric measure of oil and grease in sediments of Bear Creek (run only on 1983/1984 samples) indicated substantial contamination in some sites (more than 200 $\mu$g/g) and little or no contamination in others. A control site on Grassy Creek (GCK 2.4) had the highest value of any mainstem sediment samples. If these high values for oil and grease truly reflect anthropogenic contamination, the sediments should show substantial contamination by polycyclic aromatic hydrocarbons and high molecular weight aliphatic hydrocarbons. However, only occasional samples show even low levels of phenanthrene, pyrene, and fluoranthene (generally less than 2 $\mu$g/g). Similar results are seen for aliphatics. The conclusion is that Bear Creek sediments do show indications of low-level contamination with anthropogenic oils, but the levels are not at all consistent with the gravimetric oil and grease measure. The gravimetric measure is thought to be an analytical artifact, and it should not be assumed to be oil and grease. The low levels of PAH and aliphatics in some sediments are of no ecological significance.

Significant levels of polychlorinated biphenyls (PCBs) were found in Bear Creek between BCK 9.91 and BCK 7.87 (Fig. 7.12 and 7.13). The highest degree of contamination was observed at BCK 9.91, where PCBs averaged 1.7 $\mu$g/g and ranged from 0.39 to 4.2 $\mu$g/g. PCB contamination was evident in three tributaries draining the burial grounds--NT-6, NT-7, and NT-8 (Herbes 1988), with NT-7 having the highest degree of contamination and appearing to have the most impact on PCB levels in Bear Creek sediments.

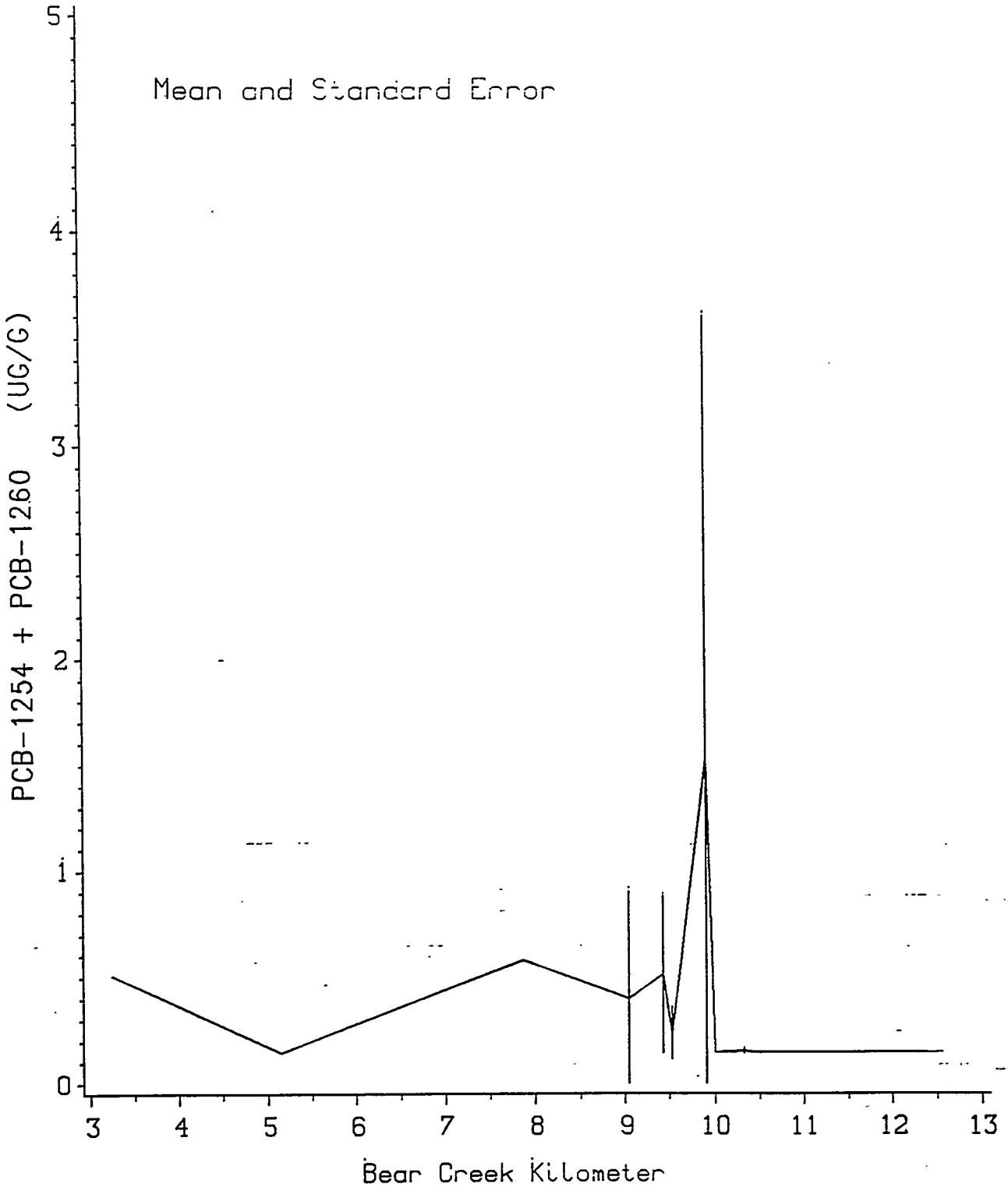


Fig. 7.12. PCBs in Bear Creek sediments--Bechtel National, Inc., data.

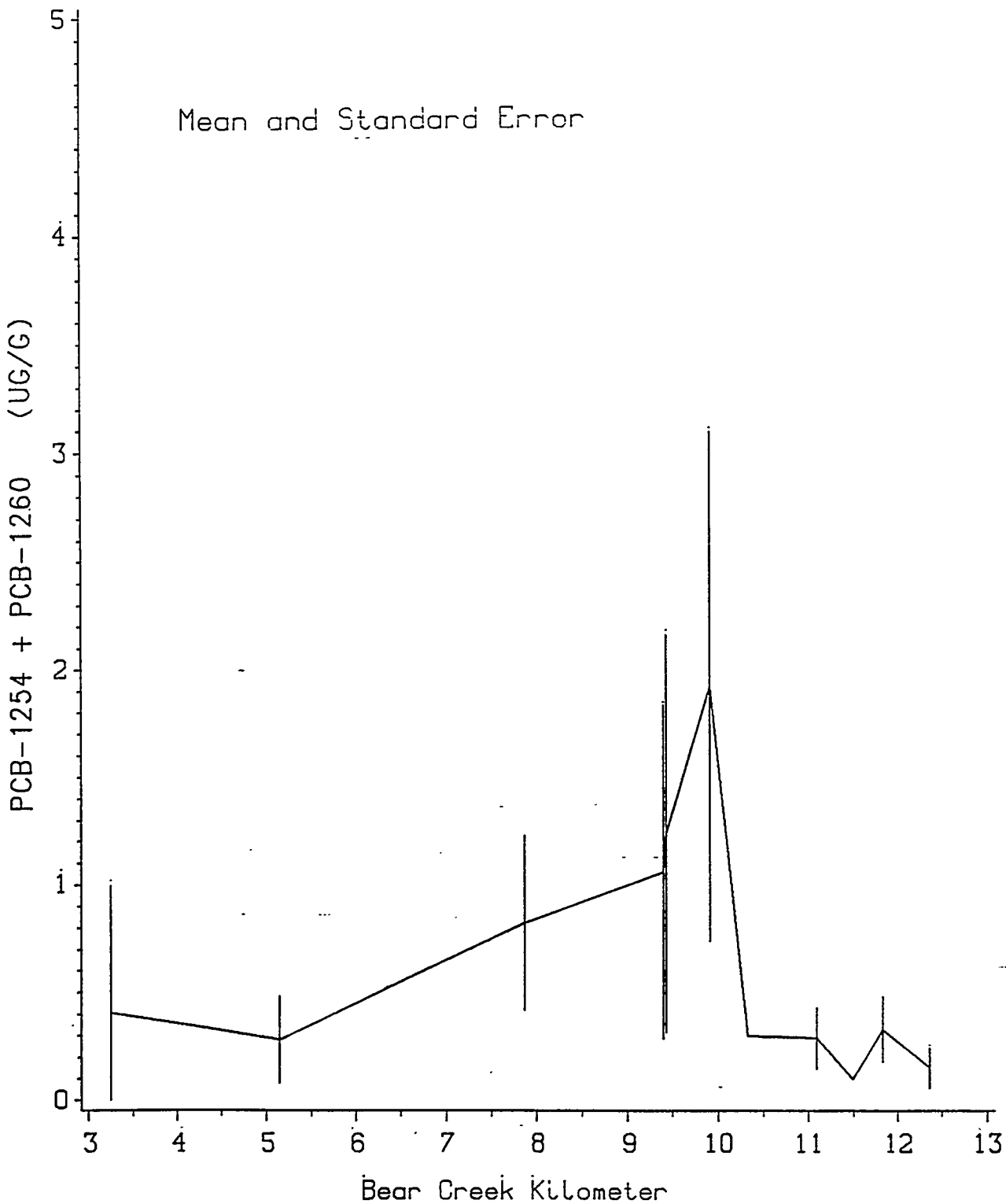


Fig. 7.13. PCBs in Bear Creek sediments--Roy Weston Inc. data.

Sediments in the lower reaches of the creek contained lower levels of PCBs, averaging about 0.2 $\mu$g/g. Traces of PCBs were also found in sediments from most sites upstream from NT-6. The levels of PCBs in Bear Creek sediments are comparable to levels in systems where fish are contaminated to concentrations in excess of 1 $\mu$g/g. PCB contamination in fish from Bear Creek was evident in 1982 (McElhaney 1982), when rock bass collected from the lower reaches of the creek were found to contain 0.65 $\pm$ 0.29 $\mu$g/g (wet wt.) total PCBs (mean $\pm$ std dev). Fish were collected from lower Bear Creek in 1987 as part of an effort to evaluate the importance (relative to other sources) of the East Fork Poplar Creek discharge at New Hope Pond as a source of PCB contamination to lower Poplar Creek and the Clinch River (G.R. Southworth, ORNL ESD, unpublished data). In the 1987 collection, PCBs in rock bass averaged 0.28 $\pm$ 0.12 $\mu$g/g (n = 8), a value comparable to the level of contamination found in sunfish in the lower third of East Fork Poplar Creek, and well above level typical of fish from uncontaminated sites (0.02 $\pm$ 0.01 $\mu$g/g). Clams held in Bear Creek (BCK 4.55) for one month as part of the same study accumulated 1.01 $\mu$g/kg PCBs (vs 0.05 $\mu$g/g in controls), indicating that Bear Creek contains a source of biologically available PCBs at the present time. Whether sediments are an important source or merely a co-indicator of PCB contamination in Bear Creek is not known.

7.3.2.2 Inorganic Contaminants

The levels of many metals in upper Bear Creek sediments (Table 7.7) are high, generally comparable to sediments from polluted sites (Prater and Hoke 1980). However, concentrations of many metals are also high in Grassy Creek sediments (Table 7.7). This suggests that the natural composition of the sediments is high in metals, perhaps due to the high clay content. Comparison of Bear Creek with Grassy Creek indicates several metals that are clearly elevated in Bear Creek sediments: cadmium, copper, lithium, nickel, uranium and zinc. Sediment levels of these metals are highest in the upper reaches of Bear Creek, and decrease to control levels toward the mouth of Bear Creek (Table 7.8). With the exception of lithium, all of these metals are adsorbed to a high degree by

Table 7.7. Statistical summary of inorganic constituents in Bear Creek mainstem sediments. Data are from Bechtel National, Inc. and Roy F. Weston, Inc. sampling campaigns during the period 1983-1986. Values reported as "less than" values were included in the statistical summary after deleting the "<" sign and dividing the given value by 2.

| | NUMBER OF OBSERVATIONS | MINIMUM VALUE | MAXIMUM VALUE | MEAN |
|---|---|---|---|---|
| MISCELLANEOUS CONSTITUENTS (μg/g) | | | | |
| CYANIDE | 8 | 0.2500 | 0.5800 | 0.2912 |
| PHENOLS | 8 | 0.0400 | 0.1600 | 0.0962 |
| OIL & GREASE IN SEDIMENT | 26 | 15.0000 | 683.0000 | 129.3846 |
| LOSS ON IGNITION-%MOIST. | 40 | 23.3000 | 61.0000 | 35.8060 |
| LOSS ON IGNITION-%ASH | 40 | 36.0000 | 73.7000 | 60.9900 |
| LOSS ON IGNITION-%ORG.MAT. | 40 | 1.4000 | 9.5000 | 3.1600 |
| PER CENT SAND | 39 | 13.8000 | 93.0000 | 52.2974 |
| PER CENT SILT | 39 | 6.0000 | 61.0000 | 33.5385 |
| PER CENT CLAY | 39 | 1.0000 | 34.9000 | 14.1641 |
| MOISTURE CONTENT IN SOIL | 40 | 22.5000 | 59.0000 | 35.4350 |
| METALS (μg/g)[a] | | | | |
| ALUMINUM | 82 | 4194.0000 | 78000.0000 | 39722.3293 |
| ANTIMONY | 82 | 2.5000 | 210.0000 | 73.8780 |
| ANTIMONY (AAS) | 40 | 0.2335 | 1.3000 | 0.4946 |
| ARSENIC | 82 | 10.0000 | 220.0000 | 96.6329 |
| ARSENIC (AAS) | 40 | 2.2000 | 27.0000 | 7.7725 |
| BARIUM | 82 | 81.0000 | 1500.0000 | 399.8280 |
| BARIUM (AAS) | 19 | 97.0000 | 440.0000 | 245.0526 |
| BERYLLIUM | 82 | 0.5000 | 51.5000 | 17.8159 |
| BERYLLIUM (AAS) | 0 | . | . | . |
| BORON | 82 | 1.0000 | 11400.0000 | 3157.5915 |
| CADMIUM | 82 | 1.7000 | 70.0000 | 24.5597 |
| CADMIUM (AAS) | 30 | 1.6000 | 33.1000 | 8.9100 |
| CALCIUM | 82 | 84.0000 | 105000.0000 | 12103.3659 |
| CERIUM | 1 | 65.0000 | 65.0000 | 65.0000 |
| CHROMIUM | 82 | 9.9800 | 140.0000 | 61.7400 |
| CHROMIUM (AAS) | 19 | 15.0000 | 35.0000 | 22.3474 |
| COBALT | 82 | 2.4950 | 670.0000 | 48.4103 |
| COPPER | 82 | 1.4750 | 110.0000 | 28.0191 |
| GALLIUM | 1 | 39.0000 | 39.0000 | 39.0000 |

Table 7.7 (continued)

| | NUMBER OF OBSERVATIONS | MINIMUM VALUE | MAXIMUM VALUE | MEAN |
|---|---|---|---|---|
| GERMANIUM | 1 | 1.0000 | 1.0000 | 1.0000 |
| GOLD | 1 | 0.1000 | 0.1000 | 0.1000 |
| IRON | 82 | 8700.0000 | 84200.0000 | 37860.8171 |
| IRON (AAS) | 0 | . | . | . |
| LANTHANUM | 1 | 18.0000 | 18.0000 | 18.0000 |
| LEAD | 82 | 29.0000 | 386.0000 | 149.3494 |
| LEAD (AAS) | 40 | 15.0000 | 330.0000 | 55.6975 |
| LITHIUM | 82 | 0.9850 | 210.0000 | 53.3541 |
| MAGNESIUM | 82 | 830.0000 | 27200.0000 | 5097.5244 |
| MANGANESE | 82 | 700.0000 | 16000.0000 | 3518.6341 |
| MANGANESE (AAS) | 0 | . | . | . |
| MERCURY (AAS) | 67 | 0.0300 | 20.0000 | 1.0766 |
| MOLYBDENUM | 82 | 1.0000 | 51.5000 | 16.9323 |
| NICKEL | 82 | 13.0000 | 520.0000 | 95.5366 |
| NIOBIUM | 0 | . | . | . |
| PHOSPHOROUS | 0 | . | . | . |
| POTASSIUM | 1 | 680.0000 | 680.0000 | 680.0000 |
| SCANDIUM | 0 | . | . | . |
| SELENIUM | 82 | 1.0000 | 1980.0000 | 126.4268 |
| SELENIUM (AAS) | 40 | 0.2310 | 2.4950 | 0.3580 |
| SILICON | 81 | 5.0000 | 5900.0000 | 636.8025 |
| SILVER | 82 | 0.0300 | 51.5000 | 16.5475 |
| SILVER (AAS) | 19 | 0.4250 | 1.2000 | 0.5160 |
| SODIUM | 82 | 81.0000 | 9500.0000 | 3192.3902 |
| SODIUM (AAS) | 0 | . | . | . |
| STRONTIUM | 82 | 5.4000 | 100.0000 | 33.8043 |
| THALLIUM | 81 | 5.0000 | 34100.0000 | 1586.1019 |
| THALLIUM (AAS) | 0 | . | . | . |
| THORIUM | 0 | . | . | . |
| TIN | 82 | 22.0000 | 19000.0000 | 1823.0470 |
| TITANIUM | 82 | 3.9000 | 2600.0000 | 957.9134 |
| URANIUM | 81 | 24.5500 | 315.0000 | 100.5667 |
| URANIUM (FLUOR) | 40 | 8.6200 | 120.0000 | 50.7367 |
| VANADIUM | 82 | 17.0000 | 660.0000 | 59.2287 |
| YTTRIUM | 0 | . | . | . |
| ZINC | 82 | 5.0000 | 870.0000 | 90.2720 |
| ZIRCONIUM | 1 | 6.4000 | 6.4000 | 6.4000 |

Table 7.7 (continued)

| | NUMBER OF OBSERVATIONS | MINIMUM VALUE | MAXIMUM VALUE | MEAN |
|---|---|---|---|---|
| RADIOLOGICALS (pCi/g) | | | | |
| 241 AMERICIUM | 18 | 0.0250 | 0.2000 | 0.0649 |
| 137 CESIUM | 31 | 0.0000 | 0.5470 | 0.1416 |
| 242+243 CURIUM | 18 | 0.0050 | 0.0200 | 0.0094 |
| 244 CURIUM | 18 | 0.0050 | 0.2400 | 0.0303 |
| 237 NEPTUNIUM | 18 | 0.0270 | 2.5400 | 0.9649 |
| 238 PLUTONIUM | 31 | 0.0000 | 0.1700 | 0.0217 |
| 239+240 PLUTONIUM | 31 | 0.0000 | 0.0440 | 0.0100 |
| 232 THORIUM | 31 | 0.3820 | 1.4500 | 0.9980 |
| 230 THORIUM | 31 | 0.3130 | 1.2100 | 0.8527 |
| 233+234 URANIUM | 41 | 1.5400 | 38.5000 | 15.7149 |
| 235 URANIUM | 41 | 0.0650 | 3.5600 | 1.3758 |
| 238 URANIUM | 41 | 1.7200 | 81.0000 | 29.9571 |
| GROSS ALPHA | 39 | 4.0000 | 44.0000 | 16.4359 |
| GROSS BETA | 39 | 6.0000 | 110.0000 | 33.3590 |

[a]Analysis by inductively coupled plasma spectrometry unless indicated otherwise. AAS = Atomic absorption spectrometry; FLUOR = Fluorimetry.

Table 7.8. Concentrations of metals in Bear Creek sediments (μg/g dry wt) that are elevated relative to concentrations in the Grassy Creek (GCK) reference site. Data are only from dates when both Bear Creek and Grassy Creek were sampled

| Metal | Site | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | BCK 12.36 | BCK 11.83 | BCK 11.49 | BCK 11.09 | BCK 10.32 | BCK 9.91 | BCK 9.43 | BCK 7.87 | BCK 5.15 | BCK 3.25 | GCK |
| Barium[1] | 396±217 | 357±28 | 336±25 | 392±82 | 515±249 | 290±132 | 267±72 | 206±52 | 231±58 | 309±133 | 255±63 |
| Cadmium[2] | 15.5±12 | 8.2±1.3 | 11.4±5.6 | 7.7±1.8 | 52±26 | 10.7±7.3 | 10.3±3.3 | 6.5±2.8 | 2.5±0.9 | 2.1±0.5 | 1.2±1.5 |
| Copper[3] | 31 | 82 | 15 | 12 | 45 | 19 | 9 | 7 | 3 | 3 | <2 |
| Lithium[3] | 76 | 40 | 47 | 60 | 210 | 98 | 66 | 38 | 36 | 29 | 31 |
| Nickel[3] | 62 | 78 | 90 | 150 | 520 | 120 | 63 | 48 | 13 | 20 | 27 |
| Uranium[4] | 32±10 | 78±24 | 100±17 | 74 | 101±13 | 42±11 | 68±20 | 41±17 | 16±8 | 10±2 | 2.0±1.2 |
| Zinc[3] | 150 | 130 | 86 | 91 | 190 | 80 | 54 | 55 | 58 | 34 | 63 |

[1]Dates - 8/84, 8/85, 1/86, 5/86.

[2]Dates - 8/84, 1/86, 5/86.

[3]Date - 8/84 (Detection limits too high on other dates).

[4]Date - 8/85, 1/86, 5/86.

Source: 1985, Y-12 HSEAD unpublished (Roy F. Weston, Inc.) data.
McCauley 1985e.

clay minerals and organic coatings (Callahan et al. 1979); thus, high levels in clay sediments could be toxicologically inert. The presence of higher than expected lithium levels in these sediments suggests that this may be the case. Since lithium is far less susceptible to ion-exchange sorption than copper, cadmium, nickel and zinc, its presence suggests that these sediments have a high capacity to sequester cations. It is not possible to evaluate the toxicity of Bear Creek sediments based on chemical analysis alone, since the availability of the metal contaminants is not known. EPA water quality criteria for copper and cadmium, the most important sediment contaminants, are very low. The criterion (chronic) for protection of aquatic life from dissolved cadmium is 1.1 $\mu$g/L in moderately hard water, while for copper the criterion is 12 $\mu$g/L. Cadmium concentration in interstitial water could exceed this criterion, despite its very high affinity for clay soils (assuming $K_d = 10^4$-$10^5$). Copper, however, is unlikely to exceed 12 $\mu$g/L in interstitial waters at sediment concentrations of about 25 $\mu$g/g (assuming $K_d = 10^3$-$10^4$), as are typical of upper Bear Creek. Concentrations of copper and cadmium that produce toxicity in most bioassays exceed 0.5 $\mu$g/L (Cushman et al. 1977). Thus, it is possible that Bear Creek sediments do not exhibit toxicity to biota even if interstitial copper and cadmium concentrations exceed EPA water quality criteria.

Water quality criteria (chronic) for nickel and zinc are 106 $\mu$g/L and 110 $\mu$g/L, respectively. Assuming $K_d = 10^3$ -$10^4$ for these metals, interstitial concentrations are likely to be less than or equal to water quality criteria. Similarly, if $K_d = 10^2$ - $10^3$ for uranium, aqueous concentrations of uranium are unlikely to exceed toxic levels.

Calcium, magnesium, and manganese, are high in a few sediment samples, suggesting the accumulation of precipitated $CaCO_3$ at spots where groundwater which is high in dissolved limestone enters the creek. Mercury does not appear to be a major contaminant in the sediments of Bear Creek. Levels are far below those seen in New Hope Pond sediments 20 $\mu$g/g maximum in Bear Creek, more than 100 $\mu$g/g in New Hope Pond), but range up to 40 times the levels found in control sediments. Fish from lower Bear Creek contained elevated levels of mercury (0.2-0.5 $\mu$g/g) in 1982 (Van Winkle et

al. 1984) 1984 (TVA 1985), and 1988 (G.R. Southworth, ORNL ESD, unpublished data) in recent investigations. While well below the FDA action limit, these data do indicate the presence of biologically available mercury in the Bear Creek system.

### 7.3.3 Post-Excavation Results for BCK-12.46

During the period April-June 1988 two small lagoons (collectively known as 'Blue Lagoon') in upper Bear Creek were excavated to remove contaminated sludge derived from the S-3 Ponds (HSEAD 1988a). As each section (approximately 12 ft by 20 ft) was excavated to undisturbed underlying clay, a series of soil samples were collected to document the nature and concentration of any remaining contaminants. The purpose of this remediation was to remove only the easily erodable materials from the upper Bear Creek stream channel and thus no additional excavation to remove residual contamination was planned or carried out. Following excavation, the creek channel and banks were stabilized with stone riprap.

Thirty-two samples of the soil remaining after excavation of the lagoons were analyzed for metals, volatile organic compounds and radioactivity (including strontium-90, tritium, technetium-99 and isotopes of uranium and selected transuranics. Complete results and maps of sampling locations are given in McMahon (1988) and in Appendix K. The analytical results reveal that concentrations of uranium, one of the main contaminants of concern (See Turner and Kamp 1985), were reduced by a factor of ten or more over concentrations in the unconsolidated sludges. Nonetheless, most of the samples still exceeded the DOE/NRC and Y-12 Plant guideline of 30-35 pCi/g uranium for soil with unrestricted access. Other contaminants, such as mercury, gross alpha, gross beta, technetium-99 and cadmium exceeded background concentrations. Clean-up to background levels was not expected in this area due to the presence of the plume from the S-3 Ponds and extensive fill.

### 7.3.4 Conclusions and Recommendations

The previous extensive characterization of sediment from Bear Creek and its tributaries has suggested that PCBs, uranium and cadmium are the

chief contaminants of concern in this media. Some other contaminants, such as other metals (e.g., mercury), volatile organic compounds, phenolics and polynuclear aromatic compounds (e.g., chrysene) also occur at detectable levels or above expected background. The results suggest that the S-3 Ponds have been a major source for uranium and cadmium in sediment and that the Burial Grounds have been the major source of PCBs in sediment.

Although the characterization of sediment in Bear Creek and its tributaries has been generally adequate for the purpose of evaluating the nature and sources of contaminant releases from the upstream SWMUs, the characterization of floodplain soils, which may contain contaminants from historic releases, is insufficient to evaluate whether these deposits pose a continuing human health or ecological risk. Relatively high concentrations of PCBs and uranium in floodplain soils have been found several miles downstream of the suspected sources of these contaminants. Additional pockets of high concentrations may exist elsewhere and need to be located to complete the characterization of this medium. The ease with which these contaminated soils can be resuspended by storm flow and transported further downstream also needs to be evaluated.

In view of the on-going and planned corrective measures in the upstream SWMUs and uncertainty in how these measures may affect runoff and peak discharges in Bear Creek and its tributaries, it may be advantageous to delay further characterization of sediment and floodplain soils until the corrective measures are fully implemented.

## 7.4 SURFACE WATER DATA

### 7.4.1 Introduction

Surface water in the Bear Creek watershed is impacted by surface and subsurface drainage from waste burial grounds, the oil landfarm, the S-3 ponds, construction-related land disturbances, and several large springs. These sources have contributed organic and inorganic chemical contaminants to Bear Creek. In recent years, actions have been taken to reduce the input of contaminants to Bear Creek from several of these sources. Intensive monitoring of stream chemistry was initiated at about the same time many of these actions were being taken (see Figure 7.14).

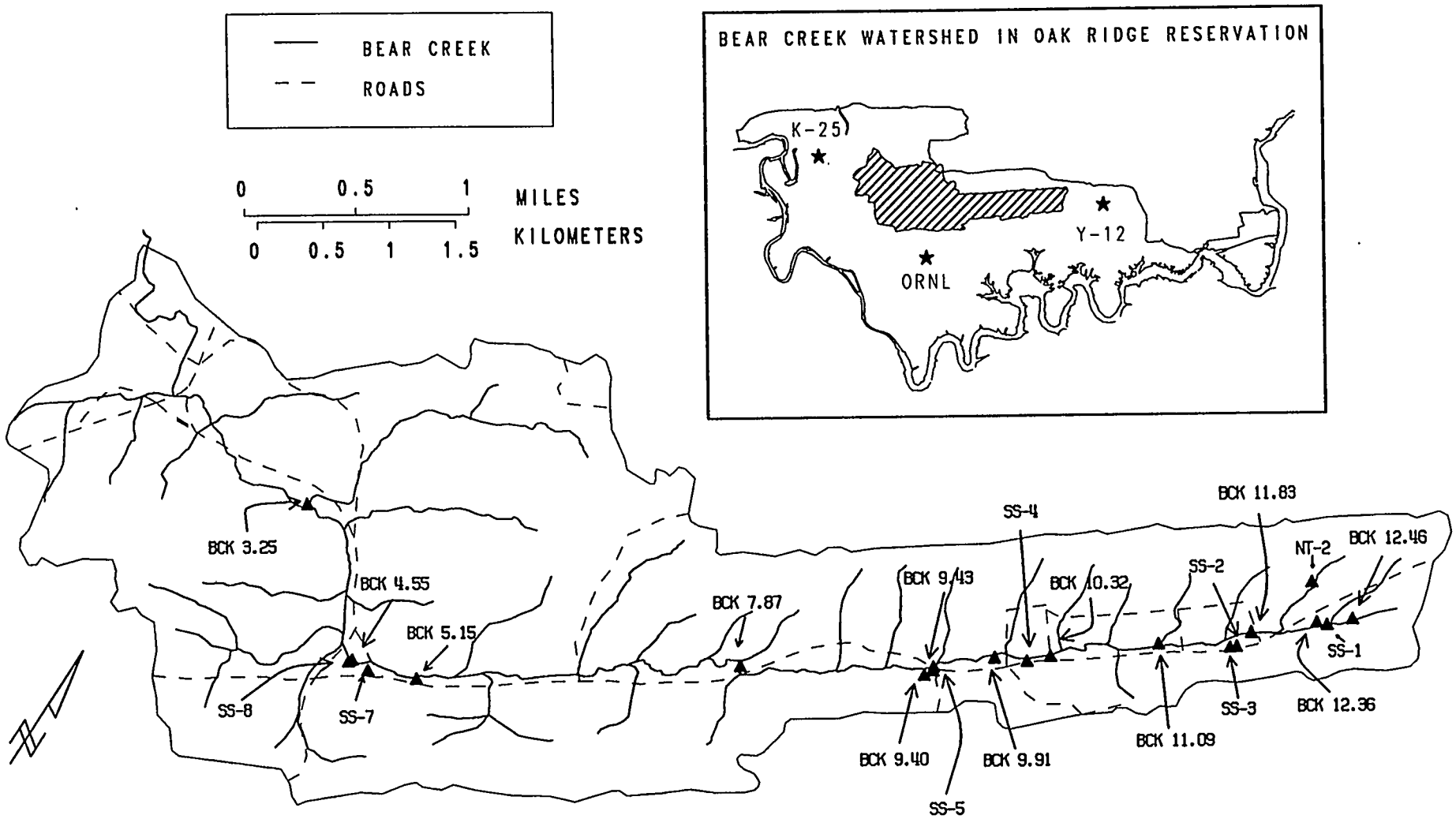


Fig. 7.14. Location of surface water monitoring sites.

7.4.2 Organic contaminants

Surface waters from Bear Creek and tributaries were analyzed for a broad spectrum of organic priority pollutants in 1983-1984 (McCauley 1985e). Further sampling conducted in 1985 - 1986 was restricted to mainstream Bear Creek. Only the volatile organic compounds (VOCs) were detected in the aqueous phase in the mainstream of Bear Creek (Table 7.9). This class of compounds consists primarily of halogenated aliphatics and low molecular weight aromatics. Trace levels of tetrachloroethene, toluene, and trichloroethene were detected (about 10 $\mu$g/L each) in the uppermost reaches of Bear Creek (BCK 12.36), while much higher levels of organics were detected farther downstream in the vicinity of the burial grounds. Trans 1,2 dichloroethene, tetrachloroethene, trichloroethylene, and vinyl chloride predominated, with traces of other halogenated aliphatics. The highest summed concentrations of VOCs were detected at BCK 9.91 (Table 7.10). VOC concentrations decreased rapidly downstream from this site, undoubtedly due to volatilization (Callahan et al. 1979). Concentrations generally dropped to about 5% of the level at BCK 9.91 within 0.5 km, and were always less than 10 $\mu$g/L at BCK 7.87 (Table 7.10). Sources of the VOCs in this area are the burial grounds A-D, which are underlain by groundwater that is highly contaminated by VOCs and drained by tributaries (NT-7, NT-8) that are contaminated with VOCs to levels 10-20 times those observed in Bear Creek.

The toxicities of VOCs to aquatic life are not extremely high. Listed toxicities in EPA water quality criteria (Appendix G) indicate that acute toxicity has been observed at levels of 5-118 mg/L for these compounds. Acute toxicity was observed at 11.6 and 5.3 mg/L for dichloroethene and tetrachloroethene, respectively. Chronic effects were observed at 0.84 mg/L for tetrachloroethene. Maximum concentrations of these compounds (which account for about 90% of total VOCs) in Bear Creek are thus about a factor of 4 below levels known to exhibit chronic toxicity. Levels of summed VOCs in sections of tributaries NT-7 and NT-8 exceeded 2-3 mg/L in March and August 1984. The high levels of VOCs observed at BCK 9.91 in September 1983 and January 1986, when tributaries were not sampled, suggest

Table 7.9. Statistical summary of organic constituents in mainstem Bear Creek surface waters. Data are from Bechtel National, Inc. and Roy F. Weston, Inc. sampling campaigns during the period 1983-1986. Values reported as "less than" values were included in the statistical summary after deleting the "<" sign and dividing the given value by 2. Minimum, maximum, and mean values of zero mean "not detected."

| | NUMBER OF OBSERVATIONS | MINIMUM VALUE | MAXIMUM VALUE | MEAN |
|---|---|---|---|---|
| VOLATILE ORGANIC COMPOUNDS (μg/L) | | | | |
| ACROLEIN | 80 | 0 | 0.0000 | 0.0000 |
| ACRYLONITRILE | 80 | 0 | 0.0000 | 0.0000 |
| BENZENE | 80 | 0 | 12.0000 | 0.4000 |
| BROMOFORM | 80 | 0 | 0.0000 | 0.0000 |
| CARBON TETRACHLORIDE | 80 | 0 | 11.0000 | 0.1375 |
| CHLOROBENZENE | 80 | 0 | 0.0000 | 0.0000 |
| CHLORODIBROMOMETHANE | 80 | 0 | 0.0000 | 0.0000 |
| CHLOROETHANE | 80 | 0 | 5.0000 | 0.1250 |
| 2-CHLOROETHYLVINYL ETHER | 80 | 0 | 0.0000 | 0.0000 |
| CHLOROFORM | 80 | 0 | 25.0000 | 1.1500 |
| BROMODICHLOROMETHANE | 80 | 0 | 0.0000 | 0.0000 |
| DICHLORODIFLUOROMETHANE | 80 | 0 | 0.0000 | 0.0000 |
| 1,1-DICHLOROETHANE | 80 | 0 | 50.0000 | 2.3375 |
| 1,2-DICHLOROETHANE | 80 | 0 | 10.0000 | 0.3125 |
| 1,1-DICHLOROETHENE | 80 | 0 | 25.0000 | 0.9250 |
| 1,2-DICHLOROPROPANE | 80 | 0 | 0.0000 | 0.0000 |
| CIS-1,3-DICHLOROPROPENE | 80 | 0 | 0.0000 | 0.0000 |
| TRANS-1,3-DICHLOROPROPENE | 80 | 0 | 0.0000 | 0.0000 |
| ETHYLBENZENE | 80 | 0 | 0.0000 | 0.0000 |
| BROMOMETHANE | 80 | 0 | 0.0000 | 0.0000 |
| CHLOROMETHANE | 80 | 0 | 5.0000 | 0.0625 |
| METHYLENE CHLORIDE | 80 | 0 | 65.0000 | 4.1000 |
| 1,1,2,2-TETRACHLOROETHANE | 80 | 0 | 0.0000 | 0.0000 |
| TETRACHLOROETHENE | 80 | 0 | 102.0000 | 4.8125 |
| TOLUENE | 80 | 0 | 63.0000 | 1.1000 |
| TRANS-1,2-DICHLOROETHENE | 80 | 0 | 831.0000 | 36.2500 |
| 1,1,1-TRICHLOROETHANE | 80 | 0 | 68.0000 | 3.3250 |
| 1,1,2-TRICHLOROETHANE | 80 | 0 | 5.0000 | 0.0625 |
| TRICHLOROETHENE | 80 | 0 | 82.0000 | 4.4250 |
| FLUOROTRICHLOROMETHANE | 80 | 0 | 25.0000 | 0.9375 |
| VINYL CHLORIDE | 80 | 0 | 92.0000 | 3.1625 |

Table 7.9 (continued)

| | NUMBER OF OBSERVATIONS | MINIMUM VALUE | MAXIMUM VALUE | MEAN |
|---|---|---|---|---|
| PESTICIDES, HERBICIDES, AND PCBs (μg/L) | | | | |
| ALDRIN | 16 | 0.0000 | 0.0000 | 0.0000 |
| ALPHA-BHC | 16 | 0.0000 | 0.0000 | 0.0000 |
| BETA-BHC | 16 | 0.0000 | 0.0000 | 0.0000 |
| GAMMA-BHC (LINDANE) | 27 | 0.0000 | 0.0250 | 0.0102 |
| DELTA-BHC | 16 | 0.0000 | 0.0000 | 0.0000 |
| CHLORDANE | 16 | 0.0000 | 0.0000 | 0.0000 |
| 4,4'-DDT | 16 | 0.2500 | 0.2500 | 0.2500 |
| 4,4'-DDE | 16 | 0.2500 | 0.2500 | 0.2500 |
| 4,4'-DDD | 16 | 0.2500 | 0.2500 | 0.2500 |
| DIELDRIN | 16 | 0.2500 | 0.2500 | 0.2500 |
| ALPHA-ENDOSULFAN | 16 | 0.0000 | 0.0000 | 0.0000 |
| BETA-ENDOSULFAN | 16 | 0.2500 | 0.2500 | 0.2500 |
| ENDOSULFAN SULFATE | 16 | 0.2500 | 0.2500 | 0.2500 |
| ENDRIN | 27 | 0.0500 | 0.2500 | 0.1685 |
| ENDRIN ALDEHYDE | 16 | 0.2500 | 0.2500 | 0.2500 |
| HEPTACHLOR | 16 | 0.0000 | 0.0000 | 0.0000 |
| HEPTACHLOR EPOXIDE | 16 | 0.0000 | 0.0000 | 0.0000 |
| TOXAPHENE | 27 | 0.0000 | 0.5000 | 0.2037 |
| METHOXYCHLOR | 27 | 0.0000 | 0.2500 | 0.1019 |
| 2,4,5-TP | 27 | 0.5000 | 2.5000 | 0.6481 |
| 2,4-D | 27 | 0.0000 | 2.5000 | 0.3519 |
| ENDRIN KETONE | 16 | 0.2500 | 0.2500 | 0.2500 |
| 2,4,5-T | 16 | 0.5000 | 0.5000 | 0.5000 |
| PCB-AROCLOR-1016 | 16 | 2.5000 | 2.5000 | 2.5000 |
| PCB-AROCLOR-1221 | 16 | 0.0000 | 0.0000 | 0.0000 |
| PCB-AROCLOR-1232 | 16 | 2.5000 | 2.5000 | 2.5000 |
| PCB-AROCLOR-1242 | 16 | 2.5000 | 2.5000 | 2.5000 |
| PCB-AROCLOR-1248 | 16 | 2.5000 | 2.5000 | 2.5000 |
| PCB-AROCLOR-1254 | 16 | 2.5000 | 2.5000 | 2.5000 |
| PCB-AROCLOR-1260 | 16 | 2.5000 | 2.5000 | 2.5000 |



| | | | | |
|---|---|---|---|---|
| 1,4-DICHLOROBENZENE | 4 | 0 | 0 | 0 |

Table 7.9 (continued)

| | NUMBER OF OBSERVATIONS | MINIMUM VALUE | MAXIMUM VALUE | MEAN |
|---|---|---|---|---|
| PCBs IN TOTAL SUSPENDED PARTICULATES (μg/L) | | | | |
| PCB-AROCLOR-1254 | 8 | 0.1500 | 0.1500 | 0.1500 |
| PCB-AROCLOR-1260 | 8 | 0.1500 | 0.1500 | 0.1500 |
| PCB-AROCLOR-1242,1248,1016 | 8 | 0.0500 | 0.0500 | 0.0500 |
| DISSOLVED PCBs (μg/L) | | | | |
| PCB-AROCLOR-1254 | 10 | 0.1500 | 1.2000 | 0.2550 |
| PCB-AROCLOR-1260 | 10 | 0.1500 | 0.4000 | 0.1750 |
| PCB-AROCLOR-1242,1248,1016 | 10 | 0.0500 | 0.4000 | 0.0850 |
| SEMI-VOLATILE ORGANIC COMPOUNDS (μg/L) | | | | |
| ACENAPHTHENE | 4 | 0 | 0 | 0 |
| ACENAPHTHYLENE | 4 | 0 | 0 | 0 |
| ANTHRACENE | 4 | 0 | 0 | 0 |
| BENZIDINE | 4 | 0 | 0 | 0 |
| BENZO(A)ANTHRACENE | 4 | 0 | 0 | 0 |
| BENZO(A)PYRENE | 4 | 0 | 0 | 0 |
| 3,4-BENZOFLUORANTHENE | 4 | 0 | 0 | 0 |
| BENZO(GHI)PERYLENE | 4 | 0 | 0 | 0 |
| BIS(2-CHLORETHOXY)METHANE | 4 | 0 | 0 | 0 |
| BIS(2-CHLORETHYL)ETHER | 4 | 0 | 0 | 0 |
| BIS(2-CHLORISOPROPYL)ETHER | 4 | 0 | 0 | 0 |
| BIS(2-ETHYLHEXYL)PHTHALATE | 4 | 0 | 0 | 0 |
| 4-BROMOPHENYL PHENYL ETHER | 4 | 0 | 0 | 0 |
| BUTYL BENZYL PHTHALATE | 4 | 0 | 0 | 0 |
| 2-CHLORONAPHTHALENE | 4 | 0 | 0 | 0 |
| 4-CHLOROPHENYLPHENYL ETHER | 4 | 0 | 0 | 0 |
| CHRYSENE | 4 | 0 | 0 | 0 |
| DIBENZO(A,H)ANTHRACENE | 4 | 0 | 0 | 0 |
| 1,2-DICHLOROBENZENE | 4 | 0 | 0 | 0 |
| 1,3-DICHLOROBENZENE | 4 | 0 | 0 | 0 |
| 1,4-DICHLOROBENZENE | 4 | 0 | 0 | 0 |
| 3,3'-DICHLOROBENZIDINE | 4 | 0 | 0 | 0 |
| DIETHYLPHTHALATE | 4 | 0 | 0 | 0 |

Table 7.9 (continued)

| | NUMBER OF OBSERVATIONS | MINIMUM VALUE | MAXIMUM VALUE | MEAN |
|---|---|---|---|---|
| DIMETHYLPHTHALATE | 4 | 0 | 0 | 0 |
| DI-N-BUTYLPHTHALATE | 4 | 0 | 0 | 0 |
| 2,4-DINITROTOLUENE | 4 | 0 | 0 | 0 |
| 2,6-DINITROTOLUENE | 4 | 0 | 0 | 0 |
| DI-N-OCTYLPHTHALATE | 4 | 0 | 0 | 0 |
| 1,2-DIPHENYLHYDRAZINE | 4 | 0 | 0 | 0 |
| FLUORANTHENE | 4 | 0 | 0 | 0 |
| FLUORENE | 4 | 0 | 0 | 0 |
| HEXACHLOROBENZENE | 4 | 0 | 0 | 0 |
| HEXACHLOROBUTADIENE | 4 | 0 | 0 | 0 |
| HEXACHLOROCYCLOPENTADIENE | 4 | 0 | 0 | 0 |
| HEXACHLOROETHANE | 4 | 0 | 0 | 0 |
| IDENO(1,2,3-CD)PYRENE | 4 | 0 | 0 | 0 |
| ISOPHORONE | 4 | 0 | 0 | 0 |
| NAPHTHALENE | 4 | 0 | 0 | 0 |
| NITROBENZENE | 4 | 0 | 0 | 0 |
| N-NITROSODIMETHYLAMINE | 4 | 0 | 0 | 0 |
| N-NITROSODI-N-PROPYLAMINE | 4 | 0 | 0 | 0 |
| N-NITROSODIPHENYLAMINE | 4 | 0 | 0 | 0 |
| PHENANTHRENE | 4 | 0 | 0 | 0 |
| PYRENE | 4 | 0 | 0 | 0 |
| 1,2,4-TRICHLOROBENZENE | 4 | 0 | 0 | 0 |
| 2,3,7,8-TCDD | 4 | 0 | 0 | 0 |
| 2-CHLOROPHENOL | 4 | 0 | 0 | 0 |
| 2,4-DICHLOROPHENOL | 4 | 0 | 0 | 0 |
| 2,4-DIMETHYLPHENOL | 4 | 0 | 0 | 0 |
| 4,6-DINITRO-2-METHYLPHENOL | 4 | 0 | 0 | 0 |
| 2,4-DINITROPHENOL | 4 | 0 | 0 | 0 |
| 2-NITROPHENOL | 4 | 0 | 0 | 0 |
| 4-NITROPHENOL | 4 | 0 | 0 | 0 |
| P-CHLORO-M-CRESOL | 4 | 0 | 0 | 0 |
| PENTACHLOROPHENOL | 4 | 0 | 0 | 0 |
| PHENOL | 4 | 0 | 0 | 0 |
| 2,4,6-TRICHLOROPHENOL | 4 | 0 | 0 | 0 |

Table 7.10. Summed concentrations (μg/L) of volatile organic compounds in Bear Creek surface water at various sites

| Site | Date | | | | | | |
|---|---|---|---|---|---|---|---|
| | 9/83 | 3/84 | 8/84 | 8/85 | 1/86 | 5/86 | 9/86 |
| BCK 12.39 | --- | --- | <10 | <10 | <10 | <10 | <10 |
| BCK 11.83 | --- | --- | <10 | <10 | 10 | <10 | <10 |
| BCK 11.49 | ND | <10 | ND | <10 | <10 | <10 | --- |
| BCK 11.09 | ND | ND | --- | --- | 10 | --- | <10 |
| BCK 10.32 | --- | ND | --- | <10 | <10 | --- | <10 |
| BCK 9.91 | 1291 | 201 | 225 | 147 | 874 | 210 | 210 |
| BCK 9.43 | 52 | 97 | 11 | 46 | 225 | 11 | 23 |
| BCK 9.40 | --- | --- | --- | 24 | 34 | <10 | 12 |
| BCK 7.87 | --- | --- | <10 | <10 | <10 | <10 | <10 |
| BCK 5.15 | --- | --- | --- | <10 | <10 | <10 | <10 |
| BCK 3.25 | --- | --- | --- | 65 | <10 | <10 | <10 |

Source: Y-12 HSEAD unpublished (Roy F. Weston, Inc.) data. McCauley 1985e.

that levels of VOCs in NT-7 and/or NT-8 may sometimes exceed the observed levels by several fold. The observed levels approach those known to produce acute toxicity in sensitive species, and could be chronically toxic to stream biota. Reduced survival and growth were observed in the toxicity tests conducted on water from NT-7 in October 1984 (Southworth 1988), but it is unlikely that VOCs were the cause of the toxicity, because they would be rapidly lost from the test solutions via volatilization.

### 7.4.3 Inorganic Contaminants

Prior to the discontinuation of use and neutralization of the S-3 ponds at the headwaters of Bear Creek, the upper reaches of the stream were acidic and highly enriched with many inorganic constituents (ERDA 1975; Turner and Kamp 1984; Anonymous 1983; HSEAD 1984a,b). In 1974-75, upper Bear Creek (BCK 11.1, 11.9) exhibited pH values ranging from 3.5 to 6.8 over a five month period (ERDA 1975), while in 1981-1983 a pH range of 3.9 to 7.5 was observed in reaches closer to the S-3 ponds (BCK 12.1, 12.5) (Table 7.11). Prior to neutralization of the S-3 ponds in summer 1983, upper Bear Creek (BCK 12.55) pH ranged from 4.0 to 4.5 during July-September (HSEAD 1984a,b). High levels of aluminum (more than 100 ppm) were noted in the acidified waters. The levels of acidity and aluminum observed prior to September 1983 are toxic to fish and sensitive aquatic invertebrates (Altshuler and Linthurst 1983), and would adversely affect the biotic community of Bear Creek. The acidity in the upper reaches of Bear Creek was neutralized as it was carried farther downstream. The limited historical data show nearly neutral pH below BCK 6.3 in the 1981-1982 samples, and below BCK 4.3 in 1974-75 (Table 7.11). Neutral conditions probably existed much further upstream in 1974 (Anonymous 1983; ERDA 1975). It is safe to assume that toxic conditions existed in upper Bear Creek prior to neutralization of the S3 ponds, and that this toxicity may have diminished within several kilometers downstream.

Profound changes in the chemistry of upper Bear Creek occurred following neutralization of the S-3 ponds in 1983. Within several months, pH rose to more than 7.0 (Fig. 7.15), aluminum dropped from 97 mg/l to 4 mg/l, nitrate decreased from 1900 to 300 mg/L (Fig. 7.16), uranium

Table 7.11. Mean pH (range in parentheses) of Bear Creek in three surveys conducted over the past 10 years. Hydrogen ion concentrations were used in the calculation of mean pH. NS = not sampled.

| | Sampling period | | |
|---|---|---|---|
| | October-March 1974-1975 (ERDA 1975) | December-May 1981-1982 (Anonymous 1983) | July-January 1983-1984 (HSEAD 1984a,b) |
| Sampling frequency | Monthly[a] | Monthly | Weekly[b] |
| Total no. of measurements | 5 | 6 | 24 |
| Sampling sites (BCK) | | | |
| 12.55 | NS | NS | 4.4(4.0-4.6)[c] |
| | | | 6.7(6.1-7.3)[d] |
| 12.5 | NS | 5.5(3.9-5.9) | NS |
| 12.0 | NS | 7.395.6-7.5) | NS |
| 11.9 | 4.68(3.50-5.09) | NS | NS |
| 11.1 | 6.32(3.90-6.80) | NS | NS |
| 6.3 | NS | 7.8(7.3-8.0) | NS |
| 4.3 | 7.21(6.95-7.58) | NS | NS |
| 1.8 | 7.12(6.88-7.30) | NS | NS |

[a]No samples collected in February.

[b]Daily samples were collected from September 19-23, 1983; one sample collected in November.

[c]Before September 29, 1983.

[d]After September 29, 1983.

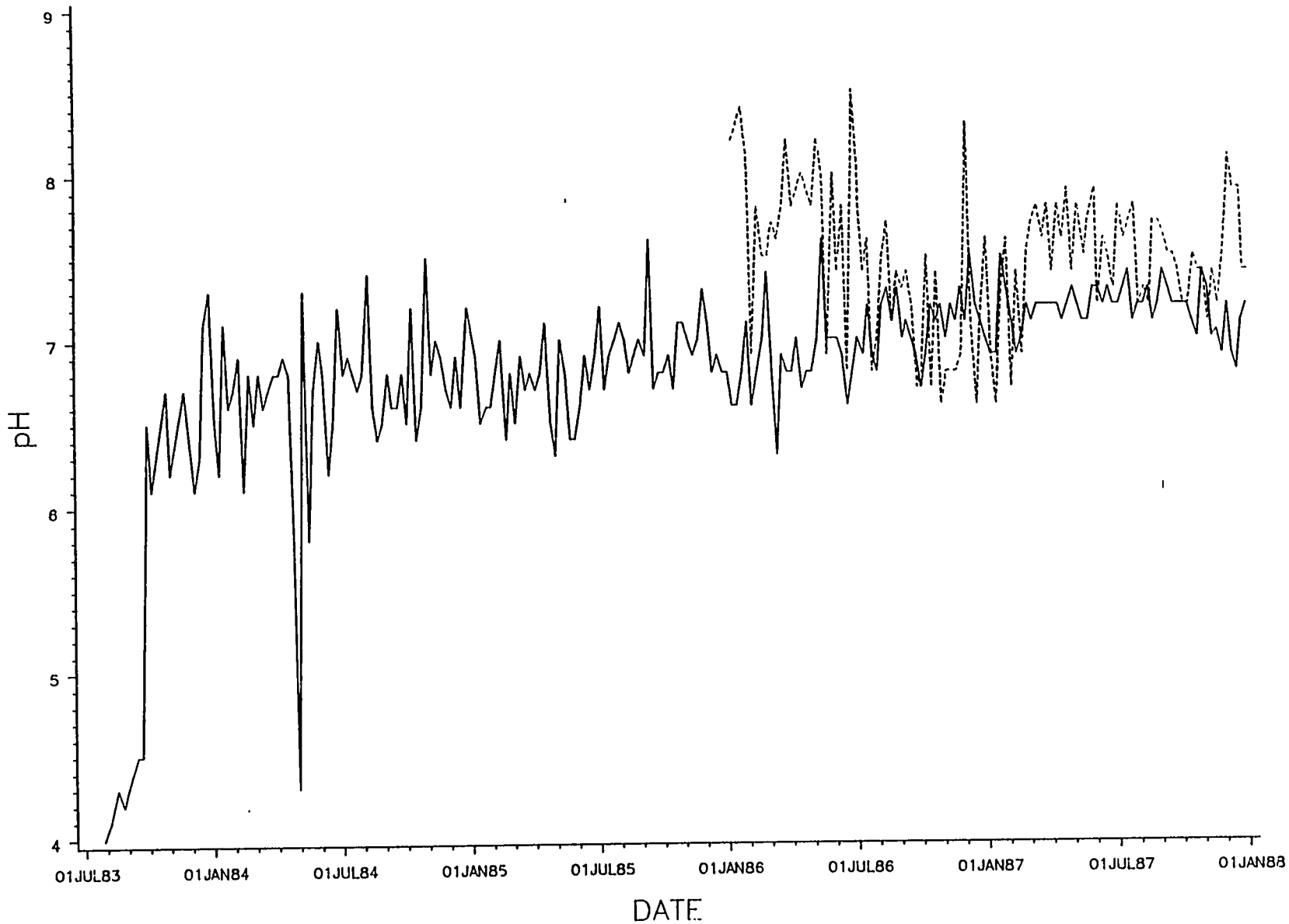


Fig. 7.15. Temporal variation in pH at Bear Creek sites BCK-12.46 and BCK-4.55 (NPDES monitoring site).

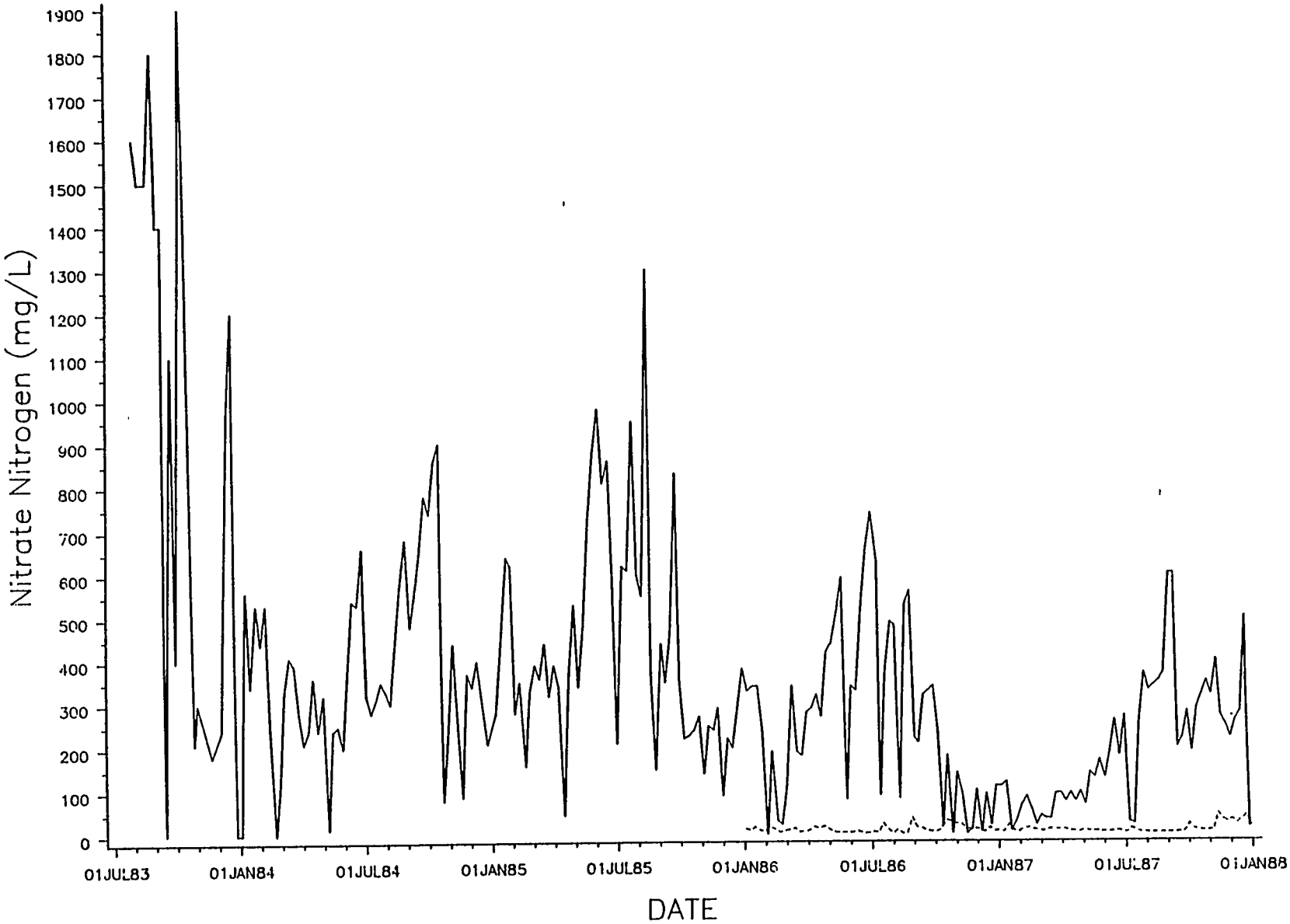


Fig. 7.16. Temporal variation in nitrate-nitrogen concentration at Bear Creek sites BCK-12.46 and BCK-4.55.

decreased from 21 to 1 mg/L (Fig. 7.17) and other metals also declined significantly (HSEAD 1984a,b). Intensive chemical and biological monitoring of the Bear Creek watershed was initiated after these changes took place.

Chemical analyses of Bear Creek surface waters since the S-3 ponds were neutralized in 1983 have been conducted by Bechtel Inc. (McCauley 1985e), Royy F. Weston, Inc. (HSEAD, unpublished data), TVA (TVA 1985), Y-12 (HSEAD 1985, HSEAD 1986), U. S. Geologic Survey (Pulliam 1985a,b), and ORNL (G.R. Southworth, ORNL ESD, unpublished data). Tables 7.12 through 7.15 summarize some of these extensive data sets. These analyses show high concentrations of dissolved inorganic salts in the upper reaches of Bear Creek, typified by electrical conductivities of 2000 - 4000 $\mu$mho/cm and total dissolved solids concentrations of 2000 - 5000 $\mu$g/L. Both of these concentrations are roughly 10 - 20 fold greater than values typical of reference sites. The contribution of solutes from the S-3 Pond groundwater plume dominates the major ion inorganic chemistry of Bear Creek. The total salt content, as indexed by conductivity, closely follows the pattern expected if Bear Creek water was diluted only with uncontaminated groundwater downstream from BCK 12.4 (Table 7.16). Solute inputs and dilution vary as a result of variations in precipitation runoff and infiltration (Fig. 7.18), with the highest solute concentrations generally occurring during periods of low flow.

Bear Creek surface water is currently highly enriched (relative to Grassy Creek reference sites) in many inorganic ions. The downstream variation in major ion chemistry is depicted in Table 7.17. Aluminum, barium, calcium, chloride, magnesium, manganese, nitrate, potassium, sodium, sulfate, strontium, and uranium are conspiciously high in the headwaters of Bear Creek, and decline gradually in concentration downstream. Lithium and boron are slightly elevated in the headwaters, but the highest levels occur below the burial grounds. Ammonia, beryllium, cadmium, cobalt, copper, lead, nickel, silver, and zinc are elevated in the uppermost reaches of Bear Creek, but decline to approximately control levels or below detection limits within a short distance downstream. A comparison of maximum concentrations in Bear and Grassy Creeks, reported

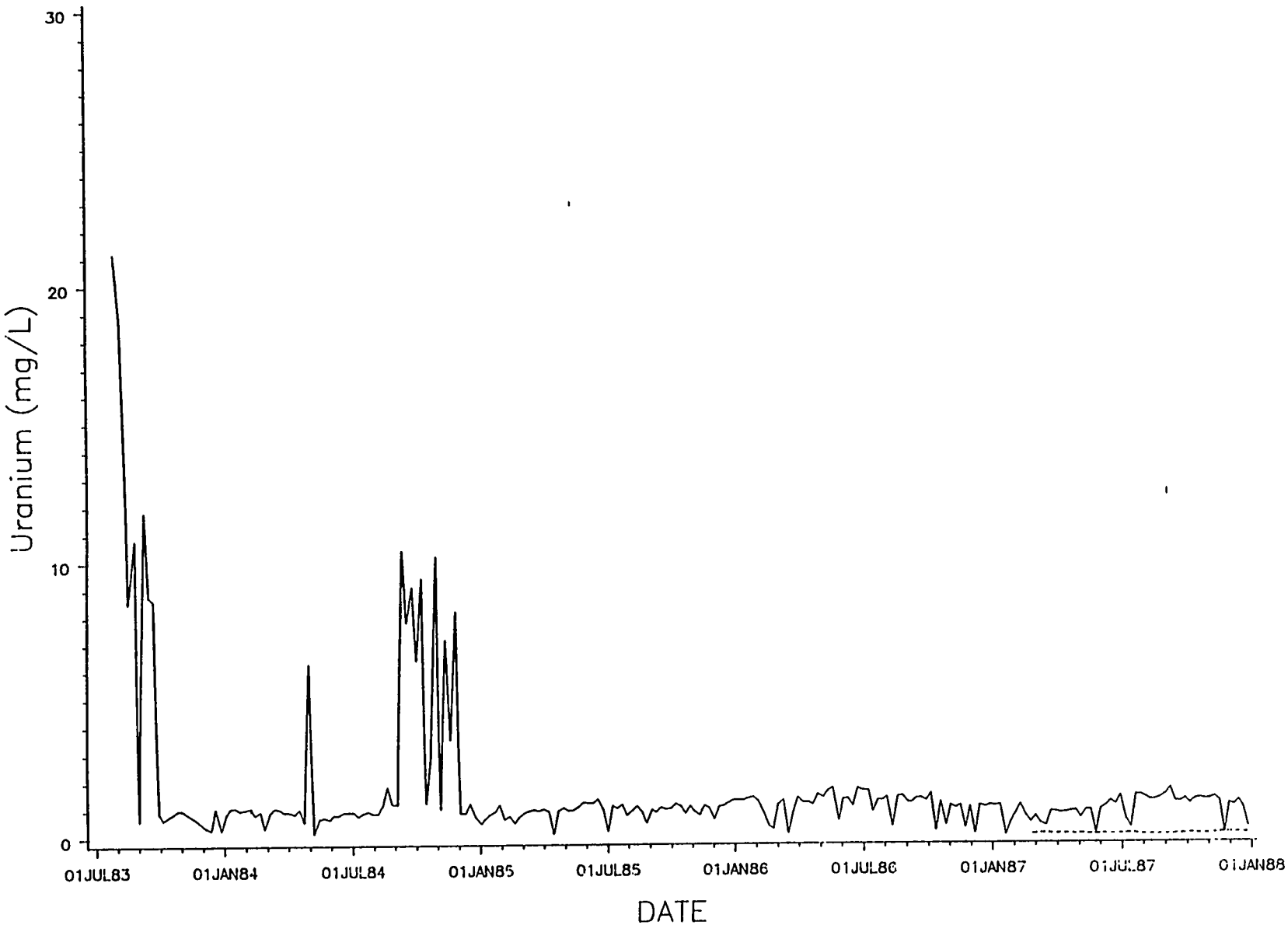


Fig. 7.17. Temporal variation in total uranium concentration at Bear Creek sites BCK-12.46 and BCK-4.55.

Table 7.12. Statistical summary of inorganic constituents in mainstem Bear Creek surface waters. Data are from Bechtel National, Inc. and Roy F. Weston, Inc. sampling campaigns during the period 1983-1986. Values reported as "less than" values were included in the statistical summary after deleting the "L" sign and dividing the given value by 2. Minimum, maximum, and mean values of zero mean "not detected."

| | NUMBER OF OBSERVATIONS | MINIMUM VALUE | MAXIMUM VALUE | MEAN |
|---|---|---|---|---|
| MISCELLANEOUS CONSTITUENTS (mg/L) | | | | |
| TOTAL SUSPENDED SOLIDS | 76 | 0.5000 | 146.0000 | 12.2171 |
| RESIDUE - SUSPENDED | 0 | . | . | . |
| TOTAL DISSOLVED SOLIDS | 10 | 200.0000 | 1850.0000 | 795.2000 |
| ALK., BICARB. AS CACO3 | 46 | 22.0000 | 380.0000 | 147.2609 |
| METHYL ORG. ALK. AS CACO3 | 40 | 62.0000 | 266.0000 | 137.1250 |
| PHENOLPHTH. ALK. AS CACO3 | 40 | 0.5000 | 0.5000 | 0.5000 |
| ALK., CARB. AS CACO3 | 46 | 0.5000 | 1.0000 | 0.7283 |
| NITRATE/NITRITE-N | 86 | 0.4000 | 440.0000 | 64.3401 |
| AMMONIA - N | 86 | 0.0150 | 0.6400 | 0.1042 |
| TOTAL KJELDAHL NITROGEN | 86 | 0.0300 | 1.1000 | 0.2337 |
| SULFATE | 86 | 6.6000 | 109.0000 | 41.1721 |
| CHLORIDE | 56 | 4.0000 | 230.0000 | 46.0107 |
| FLUORIDE | 36 | 0.1000 | 3.0000 | 0.6934 |
| ORTHO PHOSPHATE - P | 40 | 0.0050 | 0.0200 | 0.0057 |
| CHEMICAL OXYGEN DEMAND | 40 | 1.0000 | 47.0000 | 14.8650 |
| BIOCHEMICAL OXYGEN DEMAND | 25 | 1.0000 | 4.0000 | 2.1200 |
| DISSOLVED ORGANIC CARBON | 10 | 0.5000 | 9.0000 | 4.8000 |
| OIL & GREASE IN WATER | 10 | 0.2000 | 2.9000 | 0.8500 |
| CYANIDE | 10 | 0.0050 | 0.0300 | 0.0145 |
| PHENOLS | 8 | 0.0050 | 0.0050 | 0.0050 |
| DISSOLVED OXYGEN | 82 | 7.4000 | 15.3000 | 9.8366 |
| PH (IN PH UNITS) | 87 | 5.6000 | 8.9000 | 7.2175 |
| WATER TEMP (DEG CENT) | 89 | 1.0000 | 24.9000 | 13.5640 |
| REDOX (IN MV) | 86 | -50.0000 | 566.0000 | 190.2326 |
| CONDUCTIVITY (UMHOS/CM) | 88 | 210.0000 | 3613.0000 | 986.1023 |
| RADIOLOGICALS (pCi/L) | | | | |
| 241 AMERICIUM | 1 | 0.0880 | 0.0880 | 0.0880 |
| 242+243 CURIUM | 1 | 0.0000 | 0.0000 | 0.0000 |
| 244 CURIUM | 1 | 0.0000 | 0.0000 | 0.0000 |
| 237 NEPTUNIUM | 1 | 0.6410 | 0.6410 | 0.6410 |
| 238 PLUTONIUM | 1 | 0.0000 | 0.0000 | 0.0000 |
| 239+240 PLUTONIUM | 1 | 0.0000 | 0.0000 | 0.0000 |
| 232 THORIUM | 1 | 0.0000 | 0.0000 | 0.0000 |
| 230 THORIUM | 1 | 0.3900 | 0.3900 | 0.3900 |
| 233+234 URANIUM | 34 | 9.4100 | 111.0000 | 45.7385 |
| 235 URANIUM | 34 | 0.6750 | 16.5000 | 3.7514 |
| 238 URANIUM | 34 | 14.7000 | 245.0000 | 83.1971 |
| GROSS ALPHA | 44 | 5.0000 | 210.0000 | 62.0455 |
| GROSS BETA | 44 | 17.0000 | 700.0000 | 161.6818 |

Table 7.12 (continued)

| | NUMBER OF OBSERVATIONS | MINIMUM VALUE | MAXIMUM VALUE | MEAN |
|---|---|---|---|---|
| TOTAL METALS (mg/L) | | | | |
| ALUMINUM | 73 | 0.0250 | 5.8000 | 0.9003 |
| ANTIMONY | 73 | 0.0250 | 0.2500 | 0.1226 |
| ANTIMONY (AAS) | 30 | 0.0025 | 0.0125 | 0.0058 |
| ARSENIC | 73 | 0.1000 | 0.2500 | 0.1836 |
| ARSENIC (AAS) | 30 | 0.0025 | 0.0050 | 0.0042 |
| BARIUM | 73 | 0.0730 | 1.2000 | 0.3260 |
| BARIUM (AAS) | 30 | 0.0640 | 1.2000 | 0.3644 |
| BERYLLIUM | 73 | 0.0005 | 0.2500 | 0.1030 |
| BERYLLIUM (AAS) | 0 | . | . | . |
| BORON | 73 | 0.0050 | 4.3000 | 0.4304 |
| CADMIUM | 73 | 0.0010 | 0.2500 | 0.1059 |
| CADMIUM (AAS) | 30 | 0.0012 | 0.1600 | 0.0117 |
| CALCIUM | 73 | 14.0000 | 600.0000 | 153.6438 |
| CERIUM | 0 | . | . | . |
| CHROMIUM | 73 | 0.0050 | 2.0000 | 0.1392 |
| CHROMIUM (AAS) | 30 | 0.0050 | 0.0130 | 0.0053 |
| COBALT | 73 | 0.0050 | 0.2500 | 0.1067 |
| COPPER | 73 | 0.0050 | 0.2500 | 0.1088 |
| GALLIUM | 0 | . | . | . |
| GERMANIUM | 0 | . | . | . |
| GOLD | 0 | . | . | . |
| IRON | 73 | 0.0270 | 7.8000 | 0.5654 |
| IRON (AAS) | 0 | . | . | . |
| LANTHANUM | 0 | . | . | . |
| LEAD | 73 | 0.0250 | 0.4000 | 0.1377 |
| LEAD (AAS) | 30 | 0.0025 | 0.0150 | 0.0040 |
| LITHIUM | 73 | 0.0150 | 1.4000 | 0.2443 |
| MAGNESIUM | 73 | 7.6000 | 82.0000 | 24.5137 |
| MANGANESE | 73 | 0.0040 | 8.8000 | 0.9446 |
| MANGANESE (AAS) | 0 | . | . | . |
| MERCURY (AAS) | 64 | 0.0001 | 0.0010 | 0.0004 |
| MOLYBDENUM | 73 | 0.0100 | 0.2500 | 0.1117 |
| NICKEL | 73 | 0.0050 | 0.9700 | 0.1349 |
| NIOBIUM | 0 | . | . | . |
| PHOSPHOROUS | 0 | . | . | . |
| POTASSIUM | 30 | 1.0000 | 14.0000 | 5.1533 |
| SCANDIUM | 0 | . | . | . |
| SELENIUM | 73 | 0.1000 | 0.2500 | 0.1616 |
| SELENIUM (AAS) | 30 | 0.0025 | 0.0050 | 0.0033 |
| SILICON | 73 | 0.2800 | 5.2000 | 2.9422 |
| SILVER | 73 | 0.0050 | 0.2500 | 0.1103 |
| SILVER (AAS) | 19 | 0.0050 | 0.0120 | 0.0054 |
| SODIUM | 73 | 2.3000 | 72.0000 | 18.5795 |
| SODIUM (AAS) | 0 | . | . | . |
| STRONTIUM | 73 | 0.0440 | 1.5000 | 0.4146 |
| THALLIUM | 72 | 0.1500 | 0.8500 | 0.2812 |
| THALLIUM (AAS) | 0 | . | . | . |
| THORIUM | 0 | . | . | . |
| TIN | 73 | 0.1000 | 0.6500 | 0.2055 |

Table 7.12 (continued)

| | NUMBER OF OBSERVATIONS | MINIMUM VALUE | MAXIMUM VALUE | MEAN |
|---|---|---|---|---|
| TITANIUM | 73 | 0.0015 | 0.2500 | 0.1067 |
| URANIUM | 73 | 0.2500 | 2.4000 | 0.7814 |
| URANIUM (FLUOR) | 30 | 0.0005 | 0.5800 | 0.0928 |
| VANADIUM | 73 | 0.0050 | 0.2500 | 0.1079 |
| YTTRIUM | 0 | . | . | . |
| ZINC | 73 | 0.0015 | 0.3300 | 0.1116 |
| ZIRCONIUM | 0 | . | . | . |
| DISSOLVED METALS (mg/L) | | | | |
| ALUMINUM | 53 | 0.0250 | 2.4000 | 0.6826 |
| ANTIMONY | 53 | 0.0250 | 10.0000 | 0.3958 |
| ANTIMONY (AAS) | 44 | 0.0025 | 0.0125 | 0.0068 |
| ARSENIC | 53 | 0.1000 | 0.2500 | 0.2245 |
| ARSENIC (AAS) | 44 | 0.0025 | 0.0050 | 0.0036 |
| BARIUM | 53 | 0.1390 | 1.3000 | 0.3919 |
| BARIUM (AAS) | 44 | 0.0260 | 1.7000 | 0.3850 |
| BERYLLIUM | 53 | 0.0005 | 0.2500 | 0.2076 |
| BERYLLIUM (AAS) | 0 | . | . | . |
| BORON | 53 | 0.0700 | 7.4000 | 0.7249 |
| CADMIUM | 53 | 0.0010 | 0.2500 | 0.2081 |
| CADMIUM (AAS) | 44 | 0.0012 | 0.1600 | 0.0099 |
| CALCIUM | 53 | 40.2000 | 590.0000 | 164.2792 |
| CERIUM | 0 | . | . | . |
| CHROMIUM | 53 | 0.0100 | 5.0000 | 0.3098 |
| CHROMIUM (AAS) | 44 | 0.0050 | 0.0050 | 0.0050 |
| COBALT | 53 | 0.0050 | 0.2500 | 0.2086 |
| COPPER | 53 | 0.0050 | 0.2500 | 0.2084 |
| GALLIUM | 0 | . | . | . |
| GERMANIUM | 0 | . | . | . |
| GOLD | 0 | . | . | . |
| IRON | 53 | 0.0025 | 21.0000 | 0.7166 |
| IRON (AAS) | 0 | . | . | . |
| LANTHANUM | 0 | . | . | . |
| LEAD | 53 | 0.0250 | 0.7000 | 0.2849 |
| LEAD (AAS) | 44 | 0.0025 | 0.0220 | 0.0043 |
| LITHIUM | 53 | 0.0500 | 2.6000 | 0.4266 |
| MAGNESIUM | 53 | 6.7000 | 69.0000 | 24.2623 |
| MANGANESE | 53 | 0.0005 | 7.4000 | 0.8824 |
| MANGANESE (AAS) | 0 | . | . | . |
| MERCURY (AAS) | 44 | 0.0001 | 0.0010 | 0.0002 |
| MOLYBDENUM | 53 | 0.0100 | 0.2500 | 0.2092 |
| NICKEL | 53 | 0.0100 | 2.4000 | 0.2526 |
| NIOBIUM | 0 | . | . | . |
| PHOSPHOROUS | 0 | . | . | . |
| POTASSIUM | 44 | 0.2500 | 17.0000 | 3.0659 |
| SCANDIUM | 0 | . | . | . |
| SELENIUM | 53 | 0.1000 | 0.2500 | 0.2245 |
| SELENIUM (AAS) | 44 | 0.0025 | 0.0050 | 0.0031 |
| SILICON | 51 | 0.2500 | 10.1000 | 3.3245 |

Table 7.12 (continued)

| | NUMBER OF OBSERVATIONS | MINIMUM VALUE | MAXIMUM VALUE | MEAN |
|---|---|---|---|---|
| SILVER | 53 | 0.0050 | 0.2500 | 0.2046 |
| SILVER (AAS) | 19 | 0.0050 | 0.0050 | 0.0050 |
| SODIUM | 53 | 2.7000 | 70.0000 | 21.0887 |
| SODIUM (AAS) | 0 | . | . | . |
| STRONTIUM | 53 | 0.0740 | 1.5000 | 0.4404 |
| THALLIUM | 53 | 0.1500 | 1.9000 | 0.6121 |
| THALLIUM (AAS) | 0 | . | . | . |
| THORIUM | 0 | . | . | . |
| TIN | 53 | 0.1000 | 0.2500 | 0.2245 |
| TITANIUM | 53 | 0.0015 | 0.2500 | 0.2078 |
| URANIUM | 53 | 0.2500 | 1.3000 | 0.5006 |
| URANIUM (FLUOR) | 19 | 0.0005 | 0.5590 | 0.1403 |
| TOTAL URANIUM (FLUOR) | 14 | 0.0510 | 0.7100 | 0.2848 |
| VANADIUM | 53 | 0.0050 | 0.2500 | 0.2087 |
| YTTRIUM | 0 | . | . | . |
| ZINC | 53 | 0.0050 | 0.2500 | 0.2084 |
| ZIRCONIUM | 0 | . | . | . |

Table 7.13. Summary Statistics for Weekly Composite Sample Data for Upper Bear Creek Site BCK-12.46 (July 1983-December 1987). Concentrations in mg/L unless otherwise indicated. (d.l.=detection limit)

| Parameter | N | # Times < d.l. | Mean | Maximum | Minimum |
|---|---|---|---|---|---|
| pH | 225 | 0 | 6.81 | 7.60 | 4.00 |
| Dissolved oxygen | 224 | 0 | 6.6 | 12.0 | 2.0 |
| Suspended solids | 224 | 81 | 17. | 250. | 1. |
| Total dissolved solids | 225 | 0 | 2772. | 10100. | 56. |
| Chloroform | 198 | 192 | 0.006 | 0.080 | 0.005 |
| Methylene chloride | 216 | 154 | 0.012 | 0.100 | 0.005 |
| Perchloroethylene | 216 | 192 | 0.007 | 0.100 | 0.005 |
| Trichloroethylene | 197 | 197 | 0.005 | 0.005 | 0.005 |
| Trichloroethane | 187 | 181 | 0.005 | 0.020 | 0.005 |
| PCB | 226 | 219 | 0.0003 | 0.010 | 0.0003 |
| Phenol | 224 | 136 | 0.003 | 0.140 | 0.0005 |
| $^{241}Am$ (pCi/L) | 226 | 206 | 1.16 | 12.00 | 0.05 |
| $^{237}Np$ (pCi/L) | 225 | 83 | 5.4 | 86.0 | 0.2 |
| $^{238}Pu$ (pCi/L) | 224 | 211 | 0.72 | 28.00 | 0.02 |
| $^{239,240}Pu$ (pCi/L) | 225 | 206 | 0.85 | 21.00 | 0.02 |
| $^{99}Tc$ (pCi/L) | 225 | 15 | 1.09 | 20.00 | 0.02 |
| $^{235}U$ (pCi/L) | 52 | 14 | 9.8 | 40.0 | 0.3 |
| $^{235}U$ (%) | 226 | 0 | 0.39 | 5.44 | 0.21 |
| Ag | 226 | 220 | 0.004 | 0.04 | 0.002 |
| Al | 226 | 7 | 5.02 | 190.00 | 0.005 |
| As | 226 | 224 | 0.03 | 0.11 | 0.02 |
| B | 213 | 1 | 0.10 | 0.19 | 0.01 |
| Ba | 226 | 146 | 0.10 | 0.40 | 0.03 |
| Be | 226 | 153 | 0.0007 | 0.016 | 0.0001 |
| Ca | 226 | 0 | 428. | 1300. | 37. |
| Cd | 226 | 17 | 0.016 | 0.170 | 0.001 |
| Ce | 226 | 211 | 0.026 | 0.460 | 0.010 |
| Cn | 224 | 71 | 0.009 | 0.200 | 0.001 |
| Co | 226 | 91 | 0.011 | 0.280 | 0.001 |
| Cr | 226 | 206 | 0.006 | 0.040 | 0.003 |
| Cu | 226 | 102 | 0.009 | 0.160 | 0.001 |
| F | 224 | 4 | 2.05 | 40.00 | 0.05 |
| Fe | 226 | 74 | 0.44 | 11.70 | 0.01 |
| Ga | 226 | 220 | 0.016 | 0.10 | 0.005 |
| Hg | 226 | 110 | 0.0008 | 0.019 | 0.0001 |
| K | 226 | 0 | 11.1 | 44.0 | 2.7 |
| La | 226 | 212 | 0.008 | 0.150 | 0.0015 |
| Li | 226 | 0 | 0.04 | 0.28 | 0.010 |
| Mg | 226 | 0 | 76.8 | 210.0 | 8.2 |
| Mn | 226 | 0 | 4.21 | 37.00 | 0.02 |
| Mo | 226 | 226 | 0.04 | 0.05 | 0.003 |
| Na | 226 | 0 | 121.1 | 570.0 | 2.9 |
| Nb | 226 | 145 | 0.02 | 0.09 | 0.005 |
| Ni | 226 | 73 | 0.09 | 2.50 | 0.004 |
| $N\text{-}NO_3$ | 223 | 0 | 365.1 | 1900.0 | 0.3 |
| P | 226 | 189 | 0.05 | 1.70 | 0.015 |
| Pb | 226 | 216 | 0.01 | 0.04 | 0.005 |
| Sc | 226 | 204 | 0.001 | 0.013 | 0.0002 |
| Sr | 226 | 0 | 0.99 | 2.70 | 0.13 |
| Th | 226 | 223 | 0.01 | 0.06 | 0.005 |
| Ti | 226 | 165 | 0.004 | 0.119 | 0.0005 |
| U | 226 | 0 | 1.66 | 21.20 | 0.02 |
| V | 226 | 214 | 0.002 | 0.033 | 0.0015 |
| Y | 156 | 23 | 0.022 | 0.440 | 0.0005 |
| Zn | 226 | 119 | 0.027 | 0.420 | 0.0005 |
| Zr | 226 | 180 | 0.0012 | 0.028 | 0.0005 |

Table 7.14. Summary Statistics for Weekly Composite Sample Data for Bear Creek Site BCK-4.55 (January 1987-December 1987). Concentrations in mg/L unless otherwise indicated. (d.l.=detection limit)

| Parameter | N | # Times < d.l. | Mean | Maximum | Minimum |
|---|---|---|---|---|---|
| pH* | 118 | 0 | 7.49 | 8.50 | 6.60 |
| Conductance* (μS/cm) | 117 | 0 | 420. | 900. | 130. |
| Dissolved oxygen* | 117 | 0 | 9.3 | 12.5 | 5.7 |
| Suspended solids* | 116 | 71 | 9.6 | 78.0 | 2.5 |
| Total dissolved solids* | 116 | 0 | 251. | 610. | 86. |
| Turbidity* (NTU) | 117 | 0 | 10.9 | 125.0 | 0.1 |
| Biological oxygen demand* | 117 | 107 | 3.1 | 40.0 | 2.5 |
| Chemical oxygen demand* | 117 | 27 | 9.5 | 93.0 | 1.9 |
| Oil* | 117 | 112 | 1.2 | 10.0 | 1.0 |
| Surfactants | 50 | 48 | 0.027 | 0.120 | 0.025 |
| Chloride | 49 | 1 | 11.4 | 30.0 | 1.0 |
| Flouride | 49 | 14 | 0.25 | 2.00 | 0.005 |
| Nitrate-Nitrogen* | 117 | 0 | 9.8 | 44.0 | 0.1 |
| Sulfate | 50 | 8 | 18.6 | 55.0 | 5.0 |
| Ag | 51 | 51 | 0.002 | 0.002 | 0.002 |
| Al | 51 | 0 | 0.84 | 12.30 | 0.05 |
| As | 51 | 51 | 0.02 | 0.02 | 0.02 |
| B | 51 | 0 | 0.22 | 1.22 | 0.009 |
| Ba | 51 | 0 | 0.08 | 0.15 | 0.05 |
| Be | 51 | 48 | 0.0001 | 0.0004 | 0.0001 |
| Ca | 51 | 0 | 54.3 | 102.0 | 30.6 |
| Cd | 51 | 51 | 0.002 | 0.002 | 0.002 |
| Ce | 51 | 51 | 0.010 | 0.010 | 0.010 |
| Co | 51 | 50 | 0.001 | 0.005 | 0.001 |
| Cr | 51 | 50 | 0.003 | 0.014 | 0.003 |
| Cu | 51 | 42 | 0.001 | 0.008 | 0.001 |
| Fe | 51 | 0 | 0.73 | 10.20 | 0.080 |
| Ga | 51 | 51 | 0.005 | 0.005 | 0.005 |
| Hg | 51 | 33 | 0.0003 | 0.0046 | 0.0001 |
| K | 51 | 0 | 1.5 | 4.5 | 0.8 |
| La | 51 | 51 | 0.002 | 0.002 | 0.002 |
| Li | 51 | 0 | 0.08 | 0.47 | 0.003 |
| Mg | 51 | 0 | 15.9 | 24.9 | 6.7 |
| Mn | 51 | 0 | 0.06 | 0.21 | 0.014 |
| Mo | 51 | 51 | 0.003 | 0.003 | 0.003 |
| Na | 51 | 0 | 5.0 | 12.4 | 1.18 |
| Nb | 51 | 51 | 0.005 | 0.005 | 0.005 |
| Ni | 51 | 49 | 0.004 | 0.012 | 0.004 |
| P | 51 | 50 | 0.03 | 0.16 | 0.03 |
| Pb | 51 | 51 | 0.010 | 0.010 | 0.010 |
| Sc | 51 | 46 | 0.0003 | 0.002 | 0.0002 |
| Sr | 51 | 1 | 0.099 | 0.238 | 0.039 |
| Th | 51 | 51 | 0.005 | 0.005 | 0.005 |
| Ti | 51 | 5 | 0.007 | 0.072 | 0.001 |
| U | 45 | 0 | 0.036 | 0.080 | 0.004 |
| $^{235}U$ (%) | 45 | 0 | 0.44 | 1.38 | 0.32 |
| V | 51 | 49 | 0.002 | 0.016 | 0.002 |
| Zn | 51 | 1 | 0.005 | 0.029 | 0.001 |
| Zr | 51 | 50 | 0.001 | 0.004 | 0.001 |

* Weekly grab samples (January 1986-March 1988).

Table 7.15. Summary of USGS Water Quality Data for Bear Creek and Selected Tributaries, 1984 (from Pulliam 1985a, 1985b). Values reported as "less than" values were included in the summary after deleting the "<" sign and dividing the given value by 2. Complete data are given in Appendix E.

| | N | # Times < d.l. | Mean | Maximum | Minimum |
|---|---|---|---|---|---|
| Temperature (°C) | 32 | 0 | 14.52 | 22.00 | 9.500 |
| Conductance (μS/cm) | 32 | 0 | 1102. | 7300. | 35. |
| pH | 26 | 0 | 7.5 | 9.2 | 5.9 |
| Field Alkalinity (mg/L as $CaCO_3$) | 10 | 0 | 162. | 230. | 7. |
| Dissolved Oxygen (mg/L) | 26 | 0 | 9.1 | 16.8 | 1.6 |
| Discharge (cfs) | 32 | 3 | 0.38 | 4.3 | 0.005 |
| Ca, dissolved (mg/L) | 26 | 0 | 131. | 820. | 2.6 |
| Mg, dissolved (mg/L) | 26 | 0 | 24.2 | 150. | 1.0 |
| Na, dissolved (mg/L) | 26 | 0 | 22.6 | 180. | 0.5 |
| K, dissolved (mg/L) | 26 | 0 | 3.06 | 20.00 | 0.4 |
| Lab Alkalinity (mg/L as $CaCO_3$) | 17 | 0 | 103. | 314. | 7. |
| Cl, dissolved (mg/L) | 26 | 0 | 25.2 | 220. | 1.2 |
| $SO_4$, dissolved (mg/L) | 26 | 0 | 34.1 | 250. | 1.1 |
| $NO_2$+$NO_3$, dissolved (mg/L as N) | 26 | 7 | 77.1 | 610. | 0.050 |
| Ammonia, dissolved (mg/L as N) | 11 | 6 | 0.09 | 0.52 | 0.005 |
| Nitrogen, Kjeldahl (mg/L as N) | 11 | 2 | 0.15 | 0.40 | 0.050 |
| Orthophosphate, dissolved (mg/L as P) | 11 | 8 | 0.01 | 0.05 | 0.005 |
| Σ Phosphate, dissolved (mg/L as P) | 26 | 22 | 0.01 | 0.05 | 0.005 |
| Σ Phosphate, total (mg/L as P) | 10 | 9 | 0.01 | 0.05 | 0.005 |
| Total dissolved solids (mg/L) | 15 | 0 | 222. | 585. | 20. |
| As, total recoverable (μg/L) | 11 | 3 | 0.9 | 1. | 0.5 |
| Ba, total recoverable (μg/L) | 26 | 8 | 273. | 2400. | 50. |
| Be, total recoverable (μg/L) | 26 | 26 | 5. | 5. | 5. |
| Cd, total recoverable (μg/L) | 26 | 20 | 5.0 | 58. | 0.5 |
| Cr, total recoverable (μg/L) | 26 | 10 | 3.0 | 30. | 0.5 |
| Co, total recoverable (μg/L) | 25 | 12 | 2.9 | 20. | 0.5 |
| Cu, total recoverable (μg/L) | 26 | 1 | 1.8 | 4. | 0.5 |
| Cn, total (mg/L) | 26 | 18 | 0.01 | 0.07 | 0.005 |
| Fe, total recoverable (μg/L) | 26 | 0 | 350. | 940. | 100. |
| Pb, total recoverable (μg/L) | 26 | 0 | 3. | 6. | 1. |
| Li, total recoverable (μg/L) | 26 | 7 | 51. | 350. | 5. |
| Mn, total recoverable (μg/L) | 26 | 1 | 757. | 9200. | 5. |
| Hg, total recoverable (μg/L) | 26 | 16 | 0.11 | 0.40 | 0.05 |
| Mo, total recoverable (μg/L) | 26 | 13 | 0.8 | 1. | 0.5 |
| Ni, total recoverable (μg/L) | 11 | 1 | 13. | 95. | 0.5 |
| Se, total (μg/L) | 11 | 11 | 0.5 | 0.5 | 0.5 |
| Sr, total recoverable (μg/L) | 25 | 1 | 278. | 1900. | 5. |
| U, dissolved extractable (μg/L) | 9 | 1 | 0.2 | 1. | 0.005 |
| Natural Uranium, dissolved (μg/L) | 17 | 0 | 272.1 | 1300. | 0.8 |
| V, dissolved (μg/L) | 26 | 22 | 0.6 | 2. | 0.5 |
| Zn, total recoverable (μg/L) | 26 | 4 | 20. | 50. | 5. |
| Total organic carbon (mg/L as C) | 15 | 0 | 1.5 | 2.7 | 0.5 |
| Dissolved organic carbon (mg/L as C) | 17 | 0 | 4.8 | 21. | 0.5 |
| Total suspended organic carbon (mg/L as C) | 11 | 0 | 0.25 | 0.60 | 0.10 |
| Gross alpha, dissolved (μg/L as U-Nat) | 10 | 4 | 176. | 1300. | 0.5 |
| Gross alpha, Σ suspended (μg/L as U-Nat) | 10 | 3 | 6.5 | 37. | 0.2 |
| Gross beta, dissolved (pCi/L as $^{137}Cs$) | 10 | 2 | 172. | 1200. | 0.9 |
| Gross beta, dissolved (pCi/L as $^{90}Sr$&$^{90}Y$) | 10 | 2 | 155. | 1100. | 0.8 |
| Gross beta, Σ suspended (pCi/L as $^{137}Cs$) | 10 | 2 | 54. | 280. | 0.2 |
| Gross beta, Σ suspended (pCi/L as $^{90}Sr$&$^{90}Y$) | 10 | 2 | 48. | 240. | 0.2 |

Table 7.16. Dilution of upper Bear Creek solutes in Bear Creek. Data are mean ± s.d., n = 4 unless noted

| Site | Flow Dilution[a] | Conductivity Dilution[b] |
|---|---|---|
| BCK 12.36 | 1.0 | 1.0 |
| BCK 11.83 | 0.58 ± 0.28 | 0.61 ± 0.27 |
| BCK 11.49 | 0.21 ± 0.01 (n=2) | 0.32 ± 0.08 (n=2) |
| BCK 11.09 | 0.43 ± 0.33 (n=2) | 0.45 ± 0.44 (n=2) |
| BCK 10.32 | 0.35 ± 0.27 (n=3) | 0.28 ± 0.28 (n=3) |
| BCK 9.91 | 0.15 ± 0.09 | 0.16 ± 0.04 |
| BCK 9.43 | 0.15 ± 0.09 | 0.13 ± 0.05 |
| BCK 9.40 | 0.12 ± 0.10 | 0.11 ± 0.06 |
| BCK 7.87 | 0.09 ± 0.06 | 0.09 ± 0.05 |

[a]Dilution factor calculated from ratio of flow at BCK 12.36 to flow at other sites. Flow data from D. D. Huff, ORNL/ESD, for measurements made during the week analytical measurements were made.

[b]Dilution factor calculated from ratio of conductivity at Bear Creek sites minus 250 to conductivity at BCK 12.36 minus 250. Units are μmho/cm, 250 is estimated conductivity of uncontaminated groundwater infiltrating Bear Creek. Conductivity measurements are from samples collected by Roy F.Weston, Inc, for chemical analysis, 1985/1986 (Y-12 HSEAD, unpublished data).

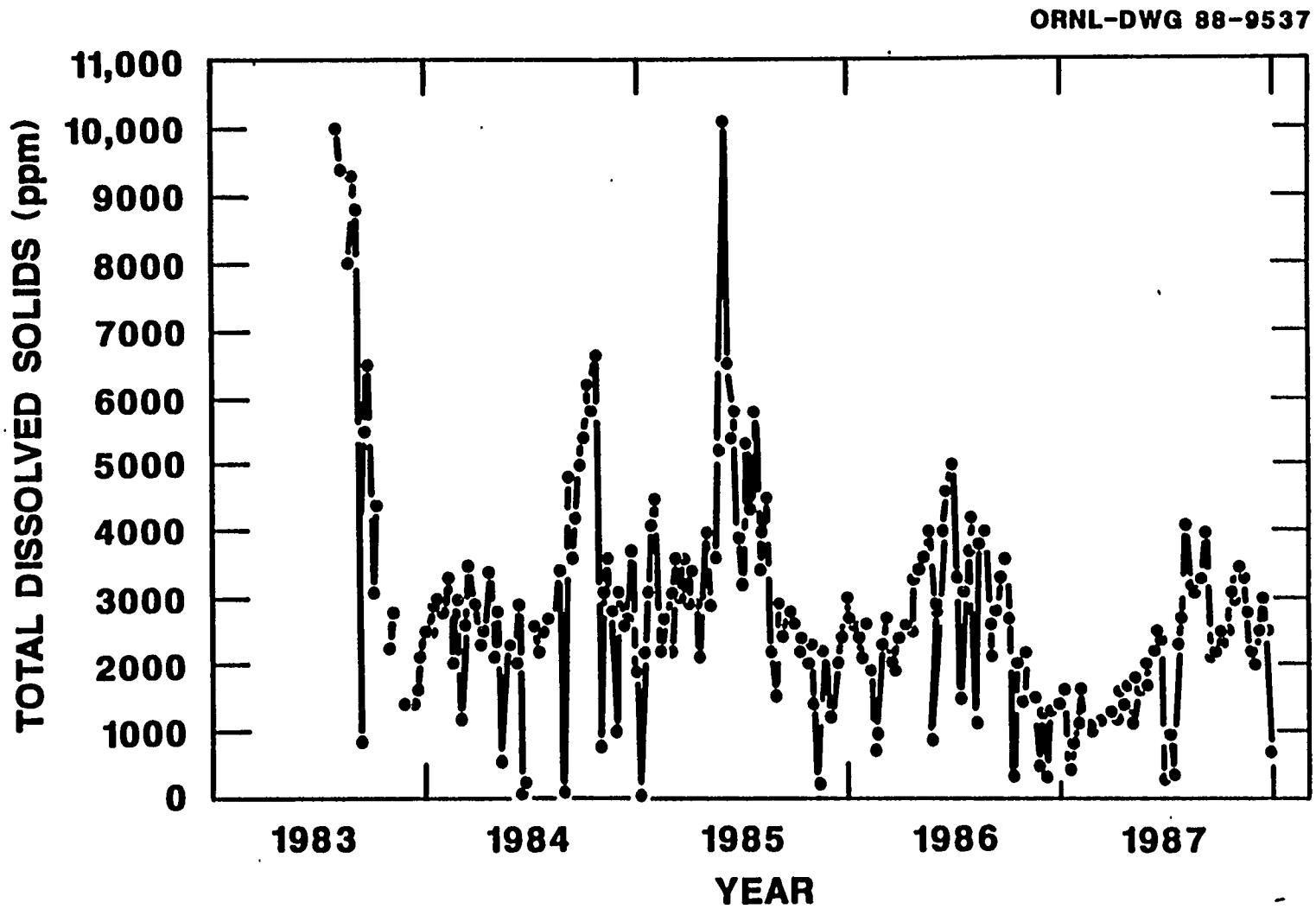


Fig. 7.18. Total dissolved solids in Bear Creek surface water at BCK-12.46, 1983-1987.

Table 7.17. Concentrations (mg/L) of major ions in unfiltered Bear Creek water at various sites downstream from the S3 ponds. Values are mean ± s.d., range in parentheses

| Metal<br>Site | BCK 12.36 | BCK 11.81 | BCK 11.09 | BCK 9.91 | BCK 9.40 | BCK 7.87 | BCK 3.25 | GCK 1.4, 2.4 |
|---|---|---|---|---|---|---|---|---|
| Calcium | 510 ± 68<br>(440 - 600) | 305 ± 105<br>(200 - 440) | 2701<br>(190 - 350) | 18 ± 24<br>(83 - 130) | 96 ± 24<br>(68 - 110) | 95 ± 22<br>(66 - 120) | 64 ± 20<br>(49 - 93) | 33 ± 7<br>(26 - 42) |
| Magnesium | 69 ± 9<br>(61 - 82) | 39 ± 17<br>(25 - 60) | 39<br>(27 - 51) | 22 ± 2.6<br>(19 - 25) | 19 ± 2.6<br>(16 - 21) | 18 ± 2.2<br>(16 - 21) | 17 ± 2.6<br>(14 - 20) | 14 ± 3<br>(9 - 17) |
| Sodium | 59 ± 10<br>(45 - 67) | 37 ± 24<br>(19 - 72) | 30<br>(18 - 43) | 17 ± 1<br>(16 - 18) | 12 ± 4.6<br>(8 - 17) | 12 ± 4.1<br>(9.3 - 18) | 7.8 ± 6.8<br>(4 - 18) | 1.1 ± 0.8<br>(<0.5 - 2.2) |
| Potassium | 11.5 ± 2.2<br>(9.6 - 14) | 7.3 ± 1.7<br>(6 - 9.2) | 6.2<br>(4.3 - 8) | 4.4 ± 0.2<br>(4.2 - 4.6) | 3.1 ± 0.3<br>(2.8 - 3.4) | 5.3 ± 2.5<br>(3 - 8) | 2.3 ± 0.6<br>(1.8 - 3) | 1.0 ± 0.3<br>(0.73 - 1.4) |
| Manganese | 4.4 ± 3.1<br>(1.4 - 8.8) | 1.5 ± 1.4<br>(<0.5 - 2.3) | 4.1<br>(1.5 - 6.6) | 0.82 ± 0.29<br>(<0.5 - 1.2) | <0.5<br><0.5 | 0.008<br>(<0.5 - 0.008) | 0.023<br>(<0.5 - 0.023) | 0.087<br>(<0.5 - 0.087) |
| Aluminum | 3.4 ± 2.5<br>(<0.5 - 5.8) | 1.4 ± 0.79<br>(<0.5 - 2.3) | 0.83<br>(<0.5 - 0.83) | 0.90 ± 0.55<br>(<0.5 - 1.7) | 0.53<br>(<0.5 - 0.53) | 0.68 ± 0.29<br>(<0.5 - 1.1) | 0.57 ± 0.08<br>(<0.5 - 0.66) | 0.6<br>(<0.5 - 0.6) |
| Strontium | 1.3 ± 0.24<br>(0.97 - 1.5) | 0.86 ± 0.40<br>(0.52 - 1.4) | 0.81<br>(0.51 - 1.1) | 0.31<br>(<0.5 - 0.31) | <0.5<br><0.5 | 0.23<br>(<0.5 - 0.23) | 0.18<br>(0.5 - 0.18 | 0.059<br>(<0.5 - 0.069) |
| Barium | 0.83 ± 0.27<br>(0.57 - 1.2) | 0.58 ± 0.26<br>(0.32 - 0.93) | 0.58<br>(0.57 - 0.59) | 0.25 ± 0.07<br>(0.19 - 0.34) | 0.12 ± 0.09<br>(0.15 - 0.21) | 0.17 ± 0.03<br>(0.15 - 0.20) | 0.10 ± 0.05<br>(0.06 - 0.17) | 0.06 ± 0.03<br>(0.03 - 0.11) |
| Uranium[1] | 0.51 | 0.58 | 0.48 | 0.16 | 0.15 | 0.14 | 0.10 | ----- |
| Nitrate<br>($NO^{03}$-N) | 279 ± 121<br>150 - 440 | 161<br>(82 - 240) | 72<br>(38 - 46) | 4234 ±<br>(23 - 50) | 1221 ±<br>(5.8 - 40) | 1729 ±<br>(14 - 43) | 128.0 ± 4.8<br>(2.4 - 14) | 0.14 ± 0.14<br>(0.04 - 0.39) |
| Sulfate | 65 ± 31<br>(21 - 86) | 68 ± 15<br>(52 - 85) | 64<br>(48 - 80) | 37 ± 8<br>(25 - 44) | 25 ± 5<br>(21 - 31) | 36 ± 19<br>(21 - 64) | 32 ± 5<br>(27 - 37) | <5<br>(<5 - 6.4) |
| Chloride | 123 ± 93<br>(69 - 230) | 62 ± 19<br>(42 - 80) | 41<br>(24 - 58) | 82 ± 23<br>(56 - 100) | 36 ± 22<br>(21 - 62) | 32 ± 16<br>(22 - 51) | 19 ± 15<br>(10 - 36) | <5<br>(<5 - 7.7) |
| Alkalinity<br>(as CaCO3) | 149 ± 86<br>(42 - 230) | 156 ± 38<br>(120 - 210) | 135<br>(120 - 190) | 173 ± 21<br>(150 - 190) | 260 ± 120<br>(140 - 380) | 161 ± 21<br>(140 - 182) | 145 ± 23<br>(120 - 165) | 133 ± 23<br>(110 - 166) |

[1]Low U results from 1/86 and 5/86 were excluded due to presumed inadequate digestion.

Source: NcCauley 1985e, Y-12 HSEAD unpublished (Roy F. Weston, Inc.) data for 8/85, 1/86, 5/86, and 9/86.

toxicity values, and EPA water quality criteria for the protection of freshwater biota are presented in Table 7.18. Most of these inorganics are relatively nontoxic; many, such as calcium, magnesium, sodium, and sulfate are typical dissolved constituents of fresh waters. The pH of Bear Creek was generally between 6 and 7 from late 1983-present. The high acidity noted prior to 1983 was not observed.

Toxicity tests were conducted in March 1988 on ambient Bear Creek water using both fathead minnows and Ceriodaphnia dubia/affinis (Southworth et al. 1988). Water from the S-3 Pond plume (from well GW101, a highly contaminated well west of the S-3 ponds) was tested at the same time. Concentrations of metals were determined on unfiltered water samples in an effort to determine what might be responsible for the observed toxicity. Only a very few metals (Cd, Co, Mn, and Ni) were found at higher concentrations in water causing Ceriodaphnia mortality than in non-toxic water. The levels of these were nevertheless low and none could be considered to be present at obviously toxic concentrations (Table 7.19). Only cadmium was present in excess of its water quality criterion; however it also exceeded the criterion in non-toxic water samples. The diluted (5%) GW-101 sample did not contain any of these metals at levels exceeding those in non-toxic Bear Creek water, but Ba, Ca, Mg, and Sr were higher in it than in nontoxic water from Bear Creek. Thus, while the toxicity of Bear Creek and S-3 plume water was clear, it was not possible to associate toxicity with any specific substance.

Aluminum concentrations in uppermost Bear Creek exceeded 4 ppm on numerous occasions in 1983 and 1984 following neutralization of the S-3 ponds (HSEAD 1984a,b; HSEAD 1985). These levels exceed the solubility of aluminum at pH 6-7 (Burrows 1977). Precipitates rich in $Al(OH)_3$ coat the stream bottom in the upper reaches of Bear Creek. Aluminum concentrations in natural waters at pH 7 commonly exceed the levels predicted by mineral equilibria, due to the formation of micro-colloids (Altshuller and Linthurst 1983). Groundwater in the vicinity of upper Bear Creek contains more than 10 ppm "dissolved" aluminum (HSEAD 1984a, b; HSEAD 1985). Thus, it appears as though groundwater containing high levels of aluminum is migrating into the upper reaches of Bear Creek, where the pH

Table 7.18. Maximum concentrations (mg/L), acute toxicty ranges, and water quality criteria for inorganic ions found at elevated levels in Bear Creek

| | Grassy Creek | Bear Creek | Acute toxicity ($LC_{50}$) | Water quality criterion |
|---|---|---|---|---|
| Aluminum | 0.6 | 5.8 | 0.2-38 | --- |
| Ammonia | 0.04 | 0.39 | --- | 3.5[1] |
| Barium | 0.044 | 1.2 | 13.5-105 | --- |
| Boron | 0.01 | 1.1 | 900 | --- |
| Cadmium | 0.004 | 0.16 | 0.09-7.2 | 0.0011 |
| Calcium | 42 | 600 | --- | --- |
| Chloride | 7.4 | 230 | --- | --- |
| Copper | 0.02 | 0.04 | 0.014-1 | 0.012 |
| Fluoride | 0.3 | 2.0 | --- | --- |
| Lead | 0.1 | 0.4 | 1-482 | 0.0032 |
| Lithium | 0.1 | 0.8 | --- | --- |
| Magnesium | 17 | 82 | --- | --- |
| Manganese | 0.087 | 8.8 | 1.5-1000 | --- |
| Nickel | 0.01 | 0.08 | 1.8-188 | 0.160 |
| Nitrate | 0.6 | 440 | --- | --- |
| Potassium | 0.9 | 14 | --- | --- |
| Silver | 0.03 | 0.12 | 0.02-1.0 | 0.120 |
| Sodium | 8.2 | 67 | --- | --- |
| Strontium | <0.5 | 1.5 | 86-10000 | --- |
| Sulfate | 2 | 109 | --- | --- |
| Uranium | 2 | 2 | 2.8-5 | --- |
| Zinc | 0.014 | 0.022 | 0.78-14.3 | 0.110 |

[1]pH 7, 25° C.

Sources: Cushman et al. 1977; EAP 1976; Altshuler and Linthurst 1983; McCauley 1985e; Y-12 HSEAD unpublished (Roy F. Weston, Inc. data).

Table 7.19. Concentrations of metals (mg/L) in water from Bear Creek and the S-3 plume associated with toxicity to Ceriodaphnia. Data are from 3/16/88, when dissolved metal concentrations in creek were highest. Analyses by ICP except where noted. Data from Southworth et al. (1988).

| Metal | Max. Toxic[1] | Min. Toxic[2] | Max. Non-toxic[3] | GW-101[4] | Control[5] |
|---|---|---|---|---|---|
| Ag | 0.008 | 0.003 | 0.009 | <0.006 | <0.006 |
| Al[6,7] | 1.1 | 0.09 | 0.14 | 0.02 | <0.06 |
| As | <0.06 | <0.06 | <0.06 | <0.06 | <0.06 |
| B | <0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| Ba | 0.76 | 0.28 | 0.20 | 1.0 | <0.002 |
| Be | 0.00077 | 0.00031 | 0.00036 | 0.00039 | <0.0003 |
| Ca | 260 | 138 | 100 | 300 | 15 |
| Cd[7] | 0.014 | 0.0035 | 0.0021 | 0.0003 | <0.0001 |
| Co | 0.0062 | 0.0024 | <0.003 | <0.003 | <0.003 |
| Cr | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 |
| Cu | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Fe | 0.090 | 0.036 | 0.13 | 0.048 | <0.02 |
| Ga | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| K | 5.0 | 2.1 | 3.0 | 1.0 | <0.1 |
| Li | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| Mg | 32 | 16 | 16 | 29 | 0.4 |
| Mn | 3.4 | 0.8 | 0.45 | 0.20 | 0.006 |
| Mo | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Na | 13 | 5.2 | 15 | 14 | 1.4 |

Table 7.19. (continued)

| Metal | Max. Toxic[1] | Min. Toxic[2] | Max. Non-toxic[3] | GW-101[4] | Control[5] |
|---|---|---|---|---|---|
| Ni | 0.074 | 0.018 | <0.006 | <0.006 | <0.006 |
| Pb | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Sb | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Se | <0.06 | <0.06 | <0.06 | <0.06 | <0.06 |
| Sn | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Sr | 0.67 | 0.27 | 0.30 | 1.3 | 0.05 |
| Ti | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| U[7] | 0.21 | 0.08 | 0.32 | 0.0034 | 0.0006 |
| V | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| Zn | 0.020 | <0.003 | 0.015 | <0.003 | <0.003 |

[1]Highest concentration in a water sample in which Ceriodaphnia mortality was significantly higher than controls.

[2]Lowest concentration in a water sample in which Ceriodaphnia mortality was significantly higher than controls. Minimum toxic concentrations were estimated by multiplying the greatest dilution associated with toxicity by the metal concentration in the undiluted water sample.

[3]Highest concentration in a water sample in which Ceriodaphnia mortality was not significantly different from controls.

[4]S-3 plume water from well GW101, diluted to 5%. No Ceriodaphnia mortality was associated with these concentrations; however, reduced fecundity was observed at 1/10 these concentrations.

[5]Control water was a synthetic mixture used for toxicity tests, not uncontaminated stream or ground water.

[6]Higher levels of Al were observed on previous dates in association with turbid samples.

[7]Al and Cd were analyzed by graphite furnace atomic absorption spectrophotometry; U by chemical separation and alpha spectrometry.

rises and aluminum hydroxide polymerizes and precipitates. The toxicity of aluminum in uppermost Bear Creek is difficult to evaluate. Most studies have focused on the toxicity of aluminum in acidic waters, where it is highly toxic. At pH 6-7, while measured concentrations of aluminum may be high, much of it may be present as relatively inert particles. However, a study in which rainbow trout were exposed for 45 days to aluminum at 5.2 mg/L at pH 7 (conditions under which most of the aluminum was present as suspended particulates) resulted in high mortality and reduced growth (Burrows 1977). Exposure conditions in that study approximate conditions in the uppermost reaches of Bear Creek, suggesting that aluminum may be having a toxic effect on the stream biota. The relatively high levels of aluminum measured in Grassy Creek (approximately 0.5 mg/L) suggest that suspended clay minerals may also be contributing to the observed aluminum concentrations in Bear Creek and Grassy Creek. Daily aluminum measurements of Bear Creek water for one week following a storm in March 1988 suggested a positive correlation between high suspended solids and measured aluminum concentrations. In August 1984, the maximum aluminum levels observed subsequent to neutralization of the S-3 ponds occurred in Bear Creek. Concentrations decreased from 5.8 mg/L at BCK 12.36 to 1.2 mg/L at BCK 11.59. Concentrations remained about 1 mg/L downstream to BCK 5.15. While not a precipitous drop in concentration, the combination of dilution and conversion of aluminum to less toxic aluminum hydroxide polymers and aggregates would have reduced the toxicity, if any, present in the uppermost reaches.

Little pertinent toxicity data were found for manganese. Cited values in Table 7.18 refer to permanganate, a form not likely to be found in natural waters. Manganese is generally viewed as having low toxicity in aquatic systems (Altshuller and Linthurst 1983).

Potentially, the most highly toxic constituents of Bear Creek surface waters are cadmium, copper, lead, nickel, silver, and zinc. These substances are elevated in upper Bear Creek sediments, and are found at levels close to detection limits in surface water. They presumably enter the stream in contaminated ground water, and are sequestered by sediments and flocculated aluminum hydroxide upon dilution with stream water. As

shown in Table 7.18, cadmium, copper, lead, and silver were found in upper Bear Creek at levels in excess of the EPA water quality criteria for the protection of aquatic life (see also Appendix F). The toxicity of these metals varies widely with species and water chemistry, and it is likely that the observed levels in Bear Creek are nontoxic to the biota inhabiting it. On the other hand, concentrations of cadmium, copper, lead and silver are close enough to levels which reduce toxicity to be possible causes of the toxicity seen in Bear Creek bioassays. The rapid downstream decrease in aqueous concentrations of these metals coincides with the decreased toxicity seen in bioassays. Arguing against this explanation, however, is the possible presence of suspended aluminum hydroxide, which is a highly effective sorbent for cations such as cadmium and copper. If the elevated levels of toxic cations are sequestered by colloids, they would be far less toxic.

Uranium is elevated in Bear Creek, but is less than 2 mg/L at all sites. Uranium exhibits acute toxicity at approximately 3 ppm in very soft water, but is far less toxic (LC50 ca. 140 mg/L) in hard water such as is typical of Bear Creek. Levels of uranium toxic to Ceriodaphnia and fathead minnows in tests run at ORNL ranged from about 0.5 to 3.0 mg/L (A. J. Stewart, ORNL ESD, unpublished data).

The large spring (SS-5) at BCK 9.41 is contaminated with the same inorganics as Bear Creek, and this spring appears from dye tracer studies to be fed by. Levels of elevated metals and anions are about 1/6 to 1/3 the levels seen in uppermost Bear Creek, with the exception of the sediment-accumulating metals such as cadmium, copper, nickel, lead, silver, and zinc. These metals are all below detection limits in the spring water. Spring SS-5 water was non-toxic in bioassays. The reduction in toxicity in comparison with upper Bear Creek water could be due to removal of toxic metal ions during subsurface transport, or simply dilution with additional ground water.

Chemical analyses again prove inadequate to assess the toxicity of Bear Creek water. Depending on the toxicity criteria utilized, Bear Creek surface water can be estimated to be safe for aquatic life or toxic. The bioassays and instream faunal surveys provide a much better indication of

the toxicity of Bear Creek water and can be a gauge for measuring improvement. Initial investigative studies, using bioassays, were not able to determine specific toxicants responsible for the observed bioassay toxicity.

7.4.4 Conclusions and Recommendations

Surface water in Bear Creek and those tributaries located in the Y-12 waste disposal areas have been sampled extensively, and in some cases, intensively, since 1983. Virtually all sampling has been conducted under non-storm flow conditions. The analyses performed have included both inorganic and organic contaminants and typically been fairly comprehensive, including in one case EPA Appendix IX contaminants. Results of these analyses suggest that total dissolved solids, nitrate, uranium, aluminum and cadmium are the chief contaminants warranting human health and ecological concern. The concentrations of all these contaminants decrease downstream from the headwaters near the S-3 Ponds suggesting that the primary release to surface water is related to this SWMU. The occurrence of these contaminants in several springs, which seem to sustain flow in parts of Bear Creek during dry periods, appears to result from recharge of shallow groundwater by Bear Creek upstream of these springs and the subsequent discharge of this shallow groundwater back into Bear Creek. If this interpretation is correct, corrective measures being applied at the S-3 Ponds, if effective, should dramatically reduce both surface water and shallow groundwater contamination in upper Bear Creek.

Given the extensive previous characterization of Bear Creek surface water by several agencies (Y-12 Plant, USGS, Roy F. Weston, Inc., Bechtel National, Inc. and TVA) and the general concordance of results, it seems likely that all contaminants of concern have been identified. No further immediate characterization seems necessary. Extensive corrective measures are in progress, or planned for the near future which may substantially improve the quality of Bear Creek surface water, especially in the headwaters where ecological impacts appear to be greatest. Thus, it would be prudent not to undertake further characterization until all, or most, of these corrective measures have been fully implemented. At that time a

comprehensive sampling program should be initiated to detect and evaluate any changes since the 1983-1986 campaigns.

Previous work has not addressed storm flow transport of contaminants, either from the SWMUs or from historic deposits in the Bear Creek floodplain. Thus, the RFI should include characterization of storm flow.

## 7.5 AIR DATA

### 7.5.1 Introduction

Several air monitoring sites (see Figure 5.9) have been operated in or near Bear Creek watershed as part of larger perimeter and local air monitoring networks. The sites monitor any contaminant releases from the DOE plants as well as regional and global air pollutants.

### 7.5.2 Results

The DOE Oak Ridge Reservation air monitoring network includes one perimeter area monitoring (PAM) station near Bear Creek at BCK-11.09 (Figure 5.9). This station (PAM # 46) monitors only radionuclides in air, including gross alpha, gross beta, iodine-131, cobalt-60, cesium-137, plutonium-238, plutonium-239, thorium-228, thorium-230, thorium-232, total strontium, uranium-234, uranium-235 and uranium-238. Annual data summaries for this site are given in the Environmental Surveillance Reports (MMES 1986 1987 1988) and compared with data for other Reservation perimeter and remote sites. Although this air monitoring site often shows higher activities of uranium isotopes compared with other perimeter and remote sites, the activities have not exceeded the criteria established by the DOE to protect human health.

The Y-12 Plant air monitoring network includes two stations within, or adjacent to Bear Creek watershed. Local air monitoring (LAM) Station # 8 is situated immediately east of the eastern margin of the watershed (Figure 5.9). This site monitors air concentrations of gross alpha, gross beta, sulfur dioxide, uranium, fluoride and mercury. Annual data summaries for this site have been given in the Environmental Surveillance Reports (MMES 1986 1987 1988). Ambient air concentrations of the measured constituents at this site have generally been low and within applicable

criteria. The Y-12 Plant also monitors TSP (total suspended particulates) at a site adjacent to Bear Creek near BCK 12.40 (Figure 5.9). TSP concentrations at this site have been generally within the Tennessee standard, with the few exceptions being attributable to road dust. ORNL staff conducted a preliminary evaluation of airborne volatile organic ehcmicals in the Bear Creek valley waste disposal area and detected only trace levels of these compounds (Jenkins et al. 1986).

### 7.5.3 Conclusions and Recommendations

It is unlikely that air is presently an important pathway for contaminant release in relation to the SWMUs in Bear Creek Valley, the contaminated sediments and floodplain soils of Bear Creek, or Bear Creek itself. Potential sources of air pollutants include the volatile organic compounds historically disposed of in the SWMUs and uranium chip fires which have been relatively common in the past. Historical releases of these substances via the air pathway are assumed to have dissipated long ago. Current releases of volatile organic compounds to Bear Creek should be detected by the proposed surface water monitoring plan, and a decision can be made in later phases as to whether air sampling is needed. Therefore, an air sampling plan is not being recommended at this time.

## 7.6 SUBSURFACE GAS DATA

There are no existing data for subsurface gas, which is a problem unique to landfill situations. One of the SWMUs in Bear Creek watershed consists of a closed sanitary landfill. However, because of the minor amount of putrescible waste disposed of at this landfill, any subsurface gas generated would be of such low volume that the potential for human exposure to such gases is low. Therefore, this RFI Plan does not include a proposal to investigate subsurface gas.

## 7.7 BIOTA DATA

Ecological studies of the Bear Creek watershed were initiated in May 1984 and are continuing at the present time (Southworth et al. 1988). These studies consisted of an initial detailed characterization of the

benthic invertebrate and fish communities in Bear Creek, followed by an ongoing monitoring phase (Figure 7.19) with reduced sampling intensities. The characterization phase utilized two approaches: (1) instream sampling of benthic invertebrate and fish communities in Bear Creek to identify spatial and temporal patterns in distribution and abundance, and (2) laboratory bioassays of water samples from Bear Creek and selected tributaries to identify potential sources of toxicity to biota. The monitoring phase of the ecological program relates to the long term goal of identifying and prioritizing contaminant sources and assessing the effectiveness of remedial actions. It continues activities of the characterization phase at less frequent intervals.

### 7.7.2 Flora

Plant communities in Bear Creek Valley are depicted in Fig. 7.20 as components of the seven general plant communities found on the Oak Ridge Reservation (Welch 1987a). A description of these communities and list of component species is found in Welch (1987a).

Vegetation in the Bear Creek Watershed is predominantly oak, oak-hickory associations on the upper slopes and ridgetops and planted pine along the creek and floodplain area.

Pine Ridge is generally an oak, oak-hickory association with chestnut oak, red oak, tulip poplar, white oak, and hickory as the dominant species. The lower areas along Bear Creek and Bear Creek Road are mainly planted loblolly pine with some scattered areas of planted shortleaf, natural pine, and oak-hickory communities. Also of interest, is a large area of big bluestem which grows along Bear Creek Road. Large stands of this species are uncommon in east Tennessee. This site is currently under consideration to be included as a National Environmental Research Park (NERP) Reference Area. More detailed information is available for portions of the Bear Creek Watershed area in forest compartment maps and various documents (Bradburn and Rosenbalm 1984; Cunningham et al. 1988; Parr and Pounds 1987; Southworth et al. 1988).

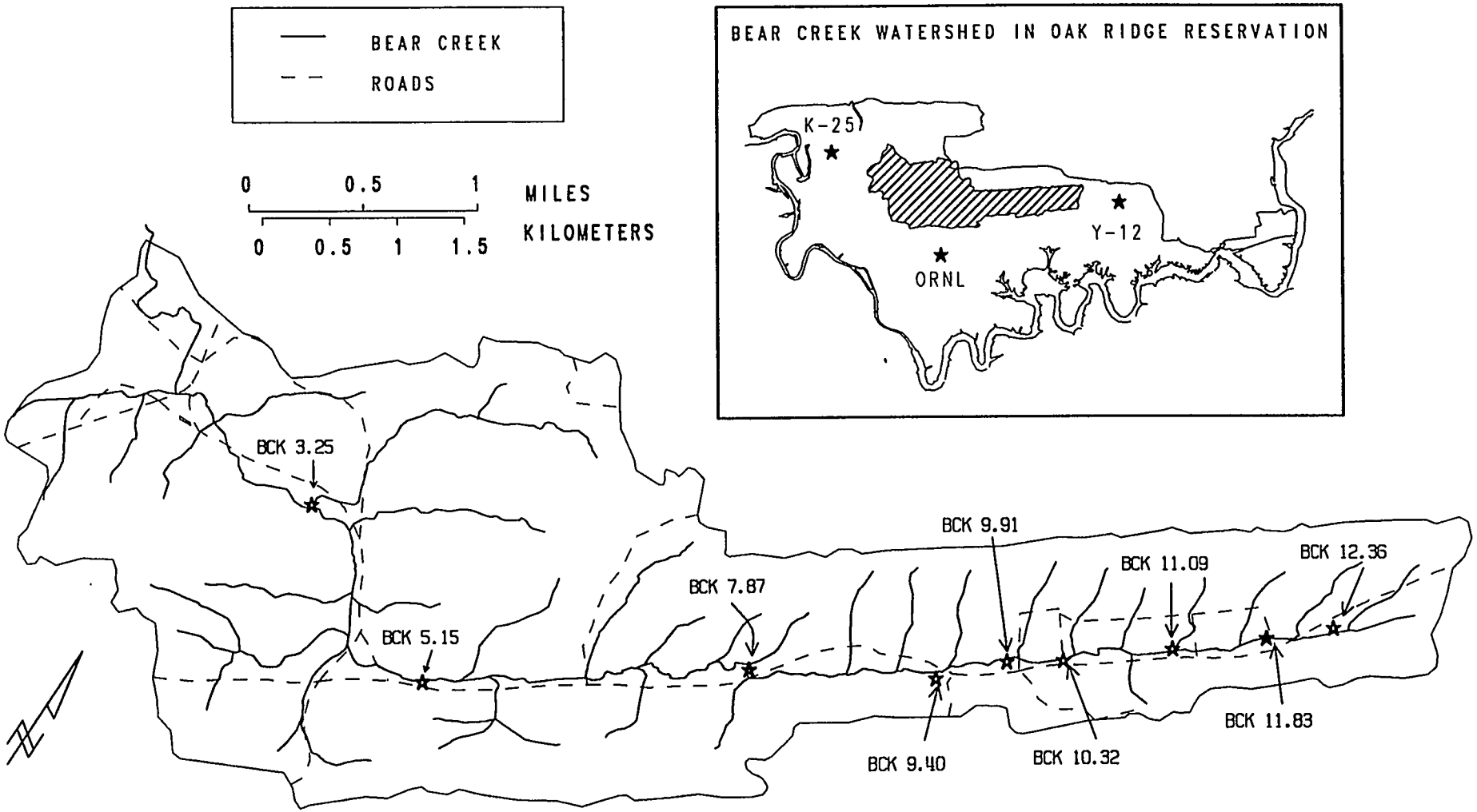


Fig. 7.19. Location of Bear Creek biological monitoring sites.

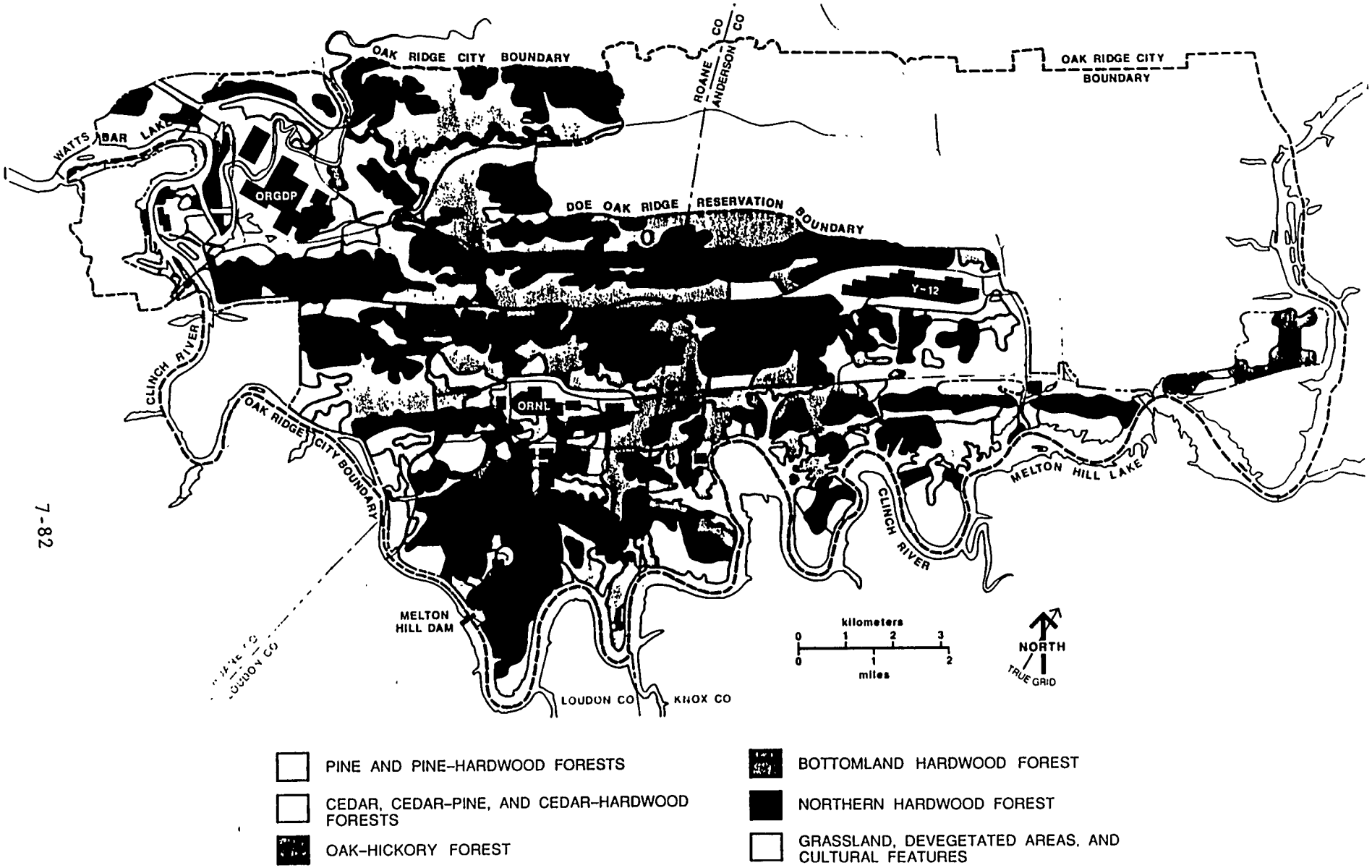


Fig. 7.20. General vegetation cover types on the Oak Ridge Reservation (from USDOE/ORO 1980).

7.7.2.1 Rare Plant Species

Two rare plant populations are known to occur in the area, and these have been designated National Environmental Research Park (NERP) Natural Areas. The Canada lily, *Lilium canadense*, occurs in NERP Natural Area #13 at the base of Pine Ridge. It grows along the forested edges of the powerline right-of-way in the drainage areas. This plant species is state-listed as Threatened. The other site, NERP Natural Area #4 contains the southern rein orchid, *Platanthera flava*. This is a forested area with numerous wetlands around seeps and contains old stream or flood channels. An uncommon aquatic plant, *Orontium aquaticum*, occurs here also. The southern rein orchid is state-listed as a species of special concern. The site has, also, been registered as a State Natural Area in an agreement between DOE and the Tennessee Department of Conservation (Howell 1986).

Most of the Bear Creek Watershed area has not been surveyed to determine the occurrence of rare plant species. A close survey of this watershed for rare plants is recommended.

7.7.3 Fish and Aquatic Invertebrates

Nineteen species of fish have been found in Bear Creek in recent quantitative monitoring conducted at seven sites along virtually the entire length of Bear Creek (Appendix L). Minnows (blacknose dace, *Rhinichthys atratulus*; mountain redbelly dace, *Phoxinus oreas*; stoneroller, *Campostoma anomalum*; and creek chub, *Semotilus atromaculatus*) were the predominant constituents of the fish fauna upstream from the weir at BCK 4.55. Below the weir, larger species (northern hogsucker, *Hypentelium nigricans*; white sucker, *Catastomus commersoni*; and rockbass (*Amblopities rupestris*) were more common, the diversity of minnow species increased, and darters were found. Conclusions of the recent fish monitoring studies (Southworth et al. 1988, Sect. 4.4) were that much of Bear Creek had a limited fish fauna (low species richness) characterized by robust population parameters (high densities and biomass). The uppermost site (BCK 12.36) did not have a stable, resident fish population. Water from this site was commonly toxic to fathead minnow larvae in toxicity testing (Table 7.20), and contained high levels of dissolved salts as a result of inputs of contaminated

Table 7.20. Percentage survival of fathead minnow larvae tested with water from various sampling sites in Bear Creek on different dates. Tabulated values for each test are means calculated from arc-sine square-root transformed values (n = 4 in each case). The overall untransformed mean survival at each site, based on all tests, is shown in the column on the right. CV = coefficient of variation. Data from Southworth et al. (1988).

| | Test Number[a] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Mean | (CV%) |
| Control[b] | 85.4 | 85.4 | 81.7 | 90.0 | 65.6 | 90.0 | 60.6 | 90.0 | 97.6 | (14.3) |
| BCK 12.36 | 37.8* | 0.0* | 11.3* | 85.4 | 4.6* | 4.6* | 24.2 | 71.6 | 24.9 | (108.9) |
| BCK 11.83 | 63.8 | 57.5* | 73.9 | 90.0 | --- | 90.0 | 56.0 | 80.9 | 91.6 | (19.8) |
| BCK 11.09 | 45.7* | 58.0* | 77.1 | 85.4 | 34.1* | 90.0 | 53.8 | --- | 79.9 | (33.3) |
| BCK 10.75 | 50.2* | 76.0 | --- | 90.0 | 61.2 | 90.0 | 62.9 | 80.9 | 91.5 | (21.0) |
| BCK 9.91 | 50.1* | 59.2* | 90.0 | 80.8 | 51.8 | 76.2 | 70.4 | 80.9 | 88.2 | (21.1) |
| BCK 9.40 | 55.7* | 76.7 | 78.8 | 90.0 | 58.9 | 83.4 | 56.9 | 80.9 | 91.2 | (18.5) |
| BCK 7.87 | --- | 53.1* | 68.8 | 85.4 | --- | 48.6* | 62.1 | 77.1 | 83.3 | (21.4) |
| BCK 5.15 | --- | 45.6* | 85.4 | 69.5[c] | --- | 42.0*[c] | 65.8 | --- | 79.7 | (26.1) |
| BCK 3.25 | --- | --- | 67.4 | 33.7*[c] | --- | 67.5[c] | 59.1 | --- | 70.2 | (28.1) |

[a]Test initiation dates are 6/6/84, 7/11/84, 10/10/84, 4/11/85, 6/26/85, 10/22/85, 4/10/86 and 3/10/88 for test 1 through 8, respectively.

[b]Control water is dechlorinated tapwater except in test 8, which used degassed diluted mineral water.

[c]Within-test variability was high (s.d. $\geq$ 25%, transformed percent survival). Such tests are individually suspect. When survival values for these four tests were excluded from the two-way ANOVA the overall F value increased substantially (from 9.46 to 18.27). F values for site and date factors also increased (from 8.21 and 21.14 for site and date, respectively, to 50.30 and 47.12). P $\leq$0.0001 for all factors, however, whether or not the suspenct tests were used in the analysis.

*Astericks designates tests with survival values that are significantly ($p < 0.05$) lower than the within-test (= column) control based on Dunnett's tests.

groundwater from the S-3 pond site (Southworth et al. 1988, Sect. 2). The next two monitoring sites downstream, BCK 11.83 and BCK 11.09 had low fish density and biomass in 1984-1985, but showed recovery in later sampling. No impacts on the fish fauna of Bear Creek were evident in the vicinity of inputs from the burial grounds (BCK 9.91 and BCK 9.40), despite the fact that qualitative surveys of tributaries (NT-6- 8) draining that site found no fish to be present.

No endangered or threatened fish species have been found in Bear Creek. However, the mountain redbelly dace is a major constituent of the fish population above the weir at BCK 4.55. The dace is listed as a species in need of management, and its habitat is protected by the state of Tennessee (Starnes and Etnier 1980). In Bear Creek, it occurs at every site above the weir and in at least four tributaries (NT 13, NT 14, NT 18, and ST 7).

Quantitative sampling of benthic invertebrates was conducted monthly at nine sites from BCK 12.36 to BCK 3.25 from June 1984 through May 1985 as part of Phase I of the ecological monitoring program for Bear Creek, and at quarterly intervals thereafter (Southworth et al. 1988, Sect. 5). A total of 126 distinguishable taxa were collected in Bear Creek (Appendix L), including crustaceans (Isopoda, Amphipoda, and Decapoda), aquatic worms (Oligochaeta), snails (Gastropoda), mussels (Pelecypoda) and insects (Insecta). Eleven orders of insects were collected in Bear Creek including springtails (Collembola), mayflies (Ephemeroptera), dragonflies and damselflies (Odonata), crickets and grasshoppers (Orthoptera), stoneflies (Plecoptera), true bugs (Hemiptera), alderflies and fishflies (Megaloptera), caddisflies (Tricoptera), butterflies and moths (Lepidoptera), beetles (Coleoptera) and true flies (Diptera).

The invertebrate fauna of Bear Creek showed a pattern of increasing density, biomass, and taxonomic diversity and richness with increasing distance downstream from the uppermost sampling site (BCK 12.36). The paucity of benthic invertebrates found in the upper reaches of Bear Creek contrasted sharply with reference sites (unimpacted streams of similar size), which had relatively diverse and abundant assemblages of macroinvertebrates. Water from BCK 12.36 and BCK 11.83 was toxic to

*Ceriodaphnia*, an invertebrate test species, but not to fathead minnow larvae, in toxicity tests run in March 1988 (Table 7.20, 7.21). At the time of these tests, streamflow in Bear Creek was higher than normal, and inputs of contaminants from the S-3 pond groundwater plume were diluted more than would be the case under baseflow conditions. Under low flow conditions, it is likely that Bear Creek water would be toxic to *Ceriodaphnia* as far downstream as BCK 9.4 (Southworth et al. 1988, Sect. 2). While evidence of adverse effects on the fish communities of Bear Creek was not noted at sites downstream from BCK 11.83, the benthic fauna appeared to be more sensitive, with clear differences in faunal composition from unimpacted reference sites at all sites except BCK 3.25, where complete recovery appears to have occurred. Species intolerant of pollution (mayflies, stoneflies, and caddisflies) were absent in the upper reaches and became more common downstream. Mayflies, which are particularly sensitive to toxic metals, were virtually absent at all sites except BCK 3.25. Unlike the fish data, which provide evidence of ecological recovery in Bear Creek since 1984, the benthic macroinvertebrate fauna does not appear to have changed in a manner indicative of either improving or degrading water quality since 1984.

No threatened or endangered species of aquatic macroinvertebrates have been collected in Bear Creek.

A limited amount of data has been collected on the bioaccumulation of contaminants by aquatic biota in Bear Creek. Fish collected from lower Bear Creek contained elevated levels of mercury (0.2 - 0.5 $\mu$g/g, wet weight) in 1982 (Van Winkle et al. 1984) 1984 (TVA 1985) and 1988 (G.R. Southworth, ORNL ESD, unpublished data) in recent investigations. While well below the FDA action level, these data do indicate the presence of biologically available mercury in the Bear Creek system. Fish from lower Bear Creek were also analyzed for cadmium, chromium, silver, arsenic, and nickel in 1984 (TVA 1985), and levels were found to be typical of fish from uncontaminated environments.

PCB contamination in fish from Bear Creek was evident in 1982, when rockbass collected from the lower reaches of the creek were found to contain 0.65 $\pm$ 0.29 ppm (wet wt) PCBs (McElhaney 1982). TVA analyzed fish

Table 7.21. Number of survivors and their fecundity (mean number of offspring per female, ± 1 s.d.) of *Ceriodaphnia* in water from various Bear Creek sites. Test was conducted during March 10-17, 1988; dilutions were prepared using degassed, diluted mineral water. Controls were reared in 100% degassed diluted mineral water. Data from Southworth et al. (1988).

| Site | concentration | replicates used | mean survival | fecundity |
|---|---|---|---|---|
| BCK 12.36 | 100% | 10 | 0* | -- ± -- |
| BCK 12.36 | 60% | 10 | 0* | -- ± -- |
| BCK 12.36 | 40% | 10 | 2* | 11.5 ± 0.7 |
| BCK 12.36 | 20% | 10 | 7 | 16.0 ± 4.6 |
| BCK 11.83 | 100% | 10 | 2* | 16.0 ± 4.2 |
| BCK 11.83 | 70% | 10 | 3* | 18.3 ± 1.5 |
| BCK 11.83 | 30% | 10 | 8 | 18.8 ± 5.4 |
| BCK 10.75 | 100% | 10 | 7 | 20.4 ± 4.2 |
| BCK 10.75 | 50% | 10 | 10 | 20.9 ± 3.7 |
| BCK 9.91 | 100% | 10 | 6 | 22.7 ± 2.7 |
| BCK 9.40 | 100% | 10 | 8 | 19.8 ± 4.4 |
| BCK 7.87 | 100% | 10 | 8 | 18.8 ± 4.5 |
| CONTROL | 100% | 10 | 9 | 20.2 ± 1.4 |

*Astericks show solutions that significantly lower survival of *Ceriodaphnia* relative to controls, based on Fisher's Exact Test.

from lower Bear Creek for organic priority pollutants including PCBs in 1984; levels of all substances were below detection limits. Fish were collected from lower Bear Creek in 1987 as part of an effort to evaluate the importance (relative to other sources) of the East Fork Poplar Creek discharge at New Hope Pond as a source of PCB contamination to lower Poplar Creek and the Clinch River (G. R. Southworth, ORNL ESD, unpublished data). In this collection, PCBs in rockbass averaged 0.28 ± 0.12 ppm (n=8), a value comparable to the level of contamination found in sunfish in the lower third of East Fork Poplar Creek, and well above the level typical of fish from uncontaminated sites (0.02 ± 0.01 ppm). Clams held in Bear Creek (BCK 4.55) for one month as part of the same study accumulated 1.01 ppm PCBs (vs 0.05 ppm in controls), indicating that Bear Creek contains a source of biologically available PCBs at the present time.

PCB contamination has been observed in fish in East Fork Poplar Creek, Poplar Creek, and the Clinch River/Watts Bar Reservoir downstream from Bear Creek ( Loar et al. 1988b; TVA 1985; Loar et al. 1981). It is unlikely that a substantial fraction of this contamination is attributable to Bear Creek, since sources of PCBs and similar levels of contamination are found in fish from these systems far upstream from the mouth of Bear Creek (Loar et al. 1988b; Loar et al. 1988a; TVA 1985). A similar situation exists for mercury (Loar et al. 1988b; TVA 1985).

### 7.7.4 TERRESTRIAL FAUNA

Bear Creek valley contains elements of all major wildlife habitat types found on the Oak Ridge Reservation (Fig. 7.21), and thus the expected terrestrial fauna is that described for the entire reservation (Welch 1987, Sect. 5.2.2.5). An expansion of list from Welch (1987a) compiled from various sources (Kitchings and Mann 1976; Dahlman et al. 1977; Klein, in press) and personal communication (J. D. Story, ORNL, Environmental Compliance Department 1987) is presented in Table 7.22. Hardwood and mixed hardwood/conifer habitats comprise the most abundant habitat type in Bear Creek watershed, followed by pine plantation and grassland habitats, with considerable riparian habitat along the length of Bear Creek. Species commonly found in these habitats are listed below.

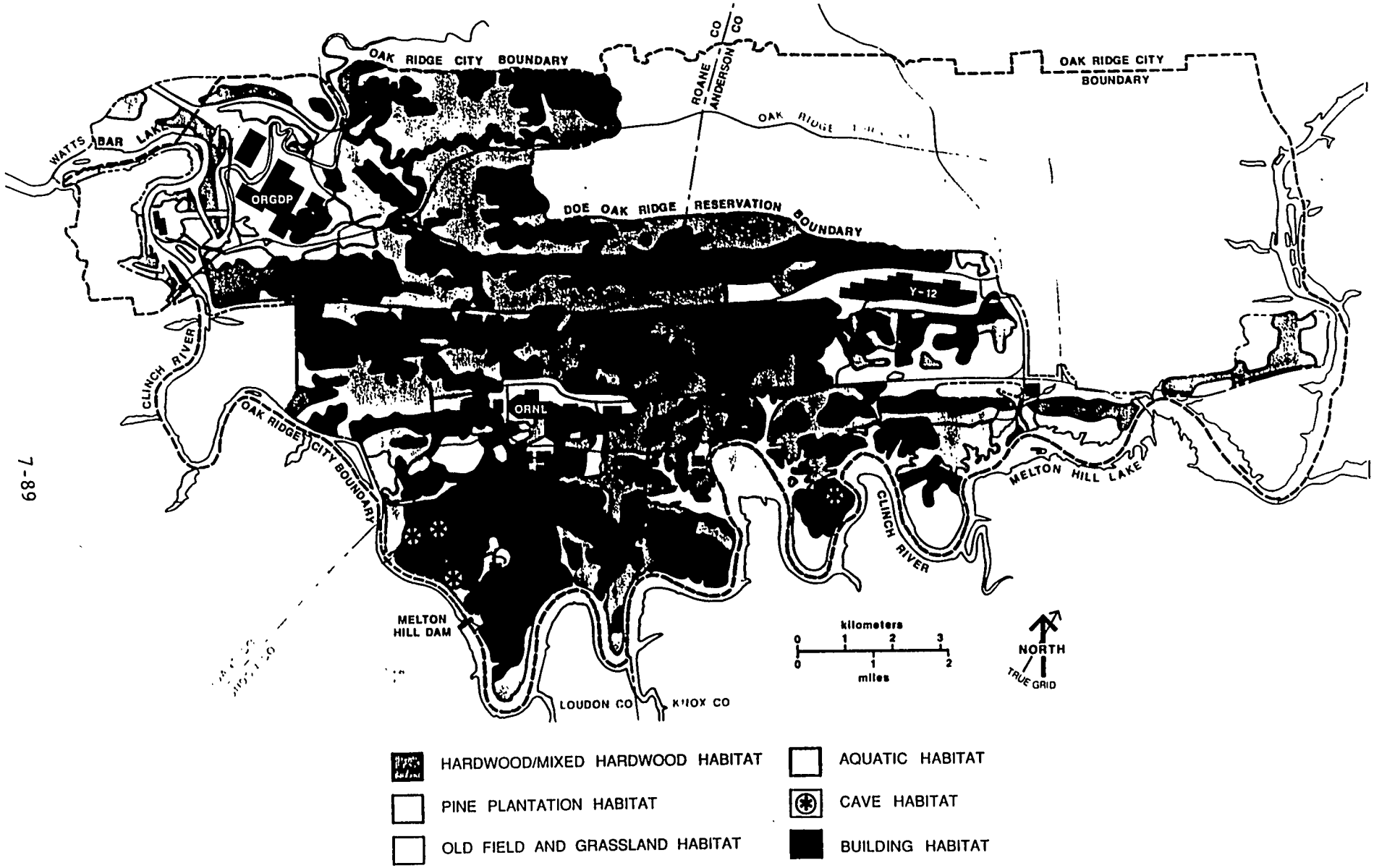


Fig. 7.21. General wildlife habitats on the Oak Ridge Reservation (from USDOE/ORO 1980).

Table 7.22. Extension of list of mammals, reptiles and amphibians found in Bear Creek watershed

| Common Name | Scientific Name |
|---|---|
| Least shrew | Cryptotis parva |
| Eastern mole | Scalopus aquaticus |
| Little brown bat | Myotis lucifugus |
| Keen's bat | Myotis keenii |
| Silver-haired bat | Lasionycteris noctivagans |
| Eastern pipistrelle | Pipistrellus subflavus |
| Big brown bat | Eptesicus fuscus |
| Red bat | Lasiurus borealis |
| Hoary bat | Lasiurus cinereus |
| Groundhog | Marmota marmax |
| Southern flying squirrel | Glaucoys volans |
| Beaver | Castor canadensis |
| Eastern harvest mouse | Reithrodontomys humulis |
| Cotton rat | Sigmodon hispidus |
| Pine vole | Microtus pinetorum |
| Muskrat | Ondatra zibethica |
| Norway rat | Rattus norvegicus |
| House mouse | Mus musculus |
| Coyote | Canis latrans |
| Mink | Mustela vison |
| Striped skunk | Mephitis mephitisemi |
| Eastern spotted skunk | Spilogale putorius |
| Spotted salamander | Ambystoma maculatum |
| Marbled salamander | Ambystoma opacum |
| Two-lined salamander | Eurycea bislineata |
| Spring salamander | Gyrinophilus porphyriticus |
| Mud salamander | Plethodon montanus |
| Eastern narrowmouth toad | Gastrophryne carolinensis |
| Northern cricket frog | Acris cricketans |
| Spring peeper | Hyla crucifer |
| Gray treefrog | Hyla versicolor |
| Upland chorus frog | Pseudacris triseriata |
| Bullfrog | Rana catesbeiana |
| Green frog | Rana clamitans |
| Pickerel frog | Rana palustris |
| Southern leopard frog | Rana sphenocephala |
| Eastern musk turtle | Sternotherus odoratus |
| Stripe-necked musk turtle | Sternotherus minor |
| Spiny softshell turtle | Trionyx spiniferus |
| Ground skink | Scincella lateralis |
| Broadhead skink | Eumeces laticeps |
| Worm snake | Carphophis amonenus |

Table 7.22 (continued)

| Common Name | Scientific Name |
|---|---|
| Scarlet snake | Cemophera coccinea |
| Ringneck snake | Diadophis punctatus |
| Corn snake | Elaphe guttata |
| Mole snake | Lampropeltis calligaster |
| Milk snake | Lampropeltis triangulum |
| Common kingsnake | Lampropeltis getulus |
| Pine snake | Pituophis melanoleucas |
| Common watersnake | Nerodia siprdon |
| Rough green snake | Opheodrys aestivus |
| Queen snake | Regina septemvittata |
| Brown snake | Storeria dekayi |
| Redbelly snake | Storeria occipitomaculata |
| Smooth earth snake | Virginia valeriae |

7.7.4.1 Old-Field and Grassland Habitat

In the grassland/forb stage of vegetation, the principal species of small mammals are the southeastern shrew, least shrew, short-tailed shrew, eastern harvest mouse, hispid cotton rat, pine mouse, and the eastern cottontail rabbit. The yellow-breasted chat is found in the old-fields. The eastern mole occurs in areas of loose soil. Closely mowed or grazed areas and dense kudzu growth is good habitat for the groundhog. Also found there are striped skunks, coyotes, red foxes, and deer. In more brushy vegetation, the white-footed mouse, golden mouse, and opossum may be found. Bird species found in this habitat include bobwhite, re-tailed hawk, field sparrow, towhee, blue grosbeak, meadowlark, and red-winged blackbird. The eastern bluebird population has increased with the establishment of bluebird nesting boxes. Numerous frog, toad, lizard, and snake species are found in the old field areas.

7.7.4.2 Hardwood and Mixed Hardwood/Conifer Habitats

In wooded areas the eastern gray and southern flying squirrels, southeastern shrew, eastern mole, short-tailed shrew, white-footed mouse, white-tailed deer, and eastern chipmunk may be found. Predators such as the bobcat and weasel occur here. Birds commonly found in forest areas (Kroodsma, personal communication, ESD 1987) include the yellow-shafted flicker, red-bellied woodpecker, hairy woodpecker, downy woodpecker, blue jay, Kentucky warbler, pine warbler, ovenbird, Carolina chickadee, tufted titmouse, and scarlet tanager. Hawks (red-shouldered, red-tailed, and broad-winged) are commonly found on the ORR, as are wild turkeys, which have been reintroduced to the area in recent years. Amphibians and reptiles found in the forest habitat include the dusky salamander, American toad, eastern box turtle, ground skink, worm snake, black racer, rat snake, black king snake, milk snake, and copperhead.

7.7.4.3 Pine Plantation Habitat

Very early stages of planted pine areas contain species similar to those in old-field habitats and the small mammals present are much the same

as in the late stages of old fields. The populations tend to be smaller, though, because of less tree diversity. Pine plantations with a dense canopy and no understory are essentially barren of both small and large mammals except around the edges. As plantations are thinned and canopies opened, undergrowth develops and provides habitat for species similar to those found in early to mid-stage hardwood-mixed hardwood/conifer forests. Avian species have a low preference for the pure pine areas bordering the transmission line corridors. Pine warblers and white-throated sparrows are common, but few other species are evident. These habitats are little utilized by reptiles or amphibians (Johnson 1964).

7.7.4.4 Aquatic and Riparian Habitats

Many reptiles and amphibians occur in the various aquatic and wetland areas including turtles, queen snake, water snake, salamanders, and frogs. The muskrat and beaver are bound closely to aquatic habitats. Rice rats, mink, and raccoons are also found in these areas. Many large mammals come frequently to this habitat to drink, and various small species are present at the water's edge. The american bald eagle occurs occasionally as a transient. The Canada goose, great blue herons, and green-backed herons nest on the ORR.

7.7.4.5 Rare and Endangered Species

Three mammal species on the federal list as endangered may occur on the Oak Ridge Reservation, but have not been verified. These are the gray bat (Myotis grisescens), Indiana bat (Myotis sodalis) and eastern cougar (Felis concolor). Only one mammal species listed by the Tennessee Wildlife Resources Agency (TWRA) as in need of management, the southeastern shrew (Sorex longirostris) is known to occur on the reservation (Kroodsma 1987). The pine snake, Pituophis melanoleucas, is listed as threatened by the TWRA, and its presence in the Bear Creek watershed has been verified. The Cooper's hawk (Accipiter striatus) occurs in forests throughout the ORR, and is state-listed as threatened (Kroodsma 1987).

7.7.5 <u>Human Population</u>

There are presently few data relating contaminant releases to Bear Creek and human exposure. The target human population is located well outside (downstream) of the Bear Creek watershed and may also be exposed to contaminants from a multitude of other sources. Exposure assessment conducted by Geraghty & Miller (G & M 1988) for the S-3 Pond ACL Demonstration concluded that Bear Creek is the primary exposure point for human exposure and that personnel studying Bear Creek are the primary exposed population, with dermal contact with the waters or sediments of the creek constituting the highest probability exposure pathway.

### 7.7.6 Conclusions and Recommendations

The continuing biological monitoring and ecological characterization of Bear Creek appears to be adequate for the purpose of defining any ecological and human health effects of current contaminant releases. Results will support the on-going ACL Demonstrations and proposed overall risk assessment. The RFI Plan proposes to continue the close coordination of biota and chemical monitoring and no additional biota monitoring is proposed. As suggested in Section 7.7.2.1, a more complete survey to determine the occurrence of rare plant species in Bear Creek watershed would be prudent, but is not proposed as a part of this RFI Plan.

# 8.0 SURFACE WATER SAMPLING PLAN

## 8.1 OBJECTIVES

Objectives of the surface water sampling program are to evaluate contaminant movement via the surface water pathway and to quantify the volumetric flow in Bear Creek. Contaminant migration within Bear Creek and its associated floodplain is most likely to occur when contaminated sediments are resuspended during flood events. Such migration may impact various receptors, including aquatic and terrestrial biota and downstream human populations. In addition, the flow of surface water over and through areas of contaminated soils and sediments provides a potential for further transportation and redeposition of material within Bear Creek, as well as for direct solubilization of contaminants retained in the soils and sediments by the surface waters themselves. No data are currently available relating contaminant concentration fluctuations in Bear Creek to stream discharge. This sampling program provides strategies for delineating the mechanisms by which contaminant movement occurs within Bear Creek. In addition, the program seeks to confirm and to augment results of past investigations.

## 8.2 TECHNICAL APPROACH

A phased sampling approach will be employed to characterize the nature and extent of hydrologically dependent contaminant transport in Bear Creek. This approach will enable modifications to the sampling program (e.g., addition or relocation of monitoring station locations) during subsequent sampling efforts, if previous data indicate such a need.

Phase Ia is designed to:

- better characterize contaminant transport during low flow periods and during storm water runoff (high flow) to determine whether previously deposited contaminants are continuing to be carried further downstream and, if so, to what extent;
- establish flow and potential contaminant contributions to Bear Creek from selected tributaries in order to identify residual sources following closure of upstream SWMUs.

- develop a flow profile that will assist in verifying gaining and losing reaches within Bear Creek in order to determine if any contaminated areas are located in losing reaches and could, therefore, contribute to groundwater contamination; and
- determine the need for additional sampling stations which would allow gathering of sufficient characterization data to support a decision of whether or not remedial action is needed.

Phase Ib, will investigate stormflow loading of uranium and PCBs from four reaches of Bear Creek. The need to establish additional surface water sampling stations will also be determined in Phase Ib.

### 8.2.1 Monitoring Station Locations

Four long-term monitoring stations (Figure 8.1) on the main stem of Bear Creek, BCK-0.63, BCK-4.55, BCK-9.40 and BCK-11.97, have been selected for collection of surface water samples and for continuous monitoring of flow rates. In addition, eleven tributary and nine spring sites (Figure 8.2) have been selected for collection of surface water samples. The descriptions of these stations are given in Table 8.1.

The four long-term monitoring stations on the main stem of Bear Creek represent critical locations for determining the nature and extent of contaminant contributions from major areas of Bear Creek watershed, historically dedicated to waste disposal/management and from possible historical deposits of contaminants in the downstream floodplains. Station BCK-11.97 includes drainage from all the SWMUs and wastewater treatment facilities located in upper Bear Creek watershed, the area in the triangle formed by Bear Creek Road and old Bear Creek Road. Station BCK-9.40 represents the surface water drainage from all SWMUs related to the Y-12 Plant in Bear Creek watershed. Station BCK-4.55 represents drainage from the BCK-9.40 plus inputs from the tributary area upstream of S.R. 95 where Bear Creek turns northward and flows through Pine Ridge. Station BCK-0.63 represents essentially all the surface water drainage from Bear Creek watershed. This site was chosen over BCK-0.0 mainly because of poor access to BCK-0.0 and the presence of a bridge crossing which can serve as a good hydrological control for discharge monitoring.

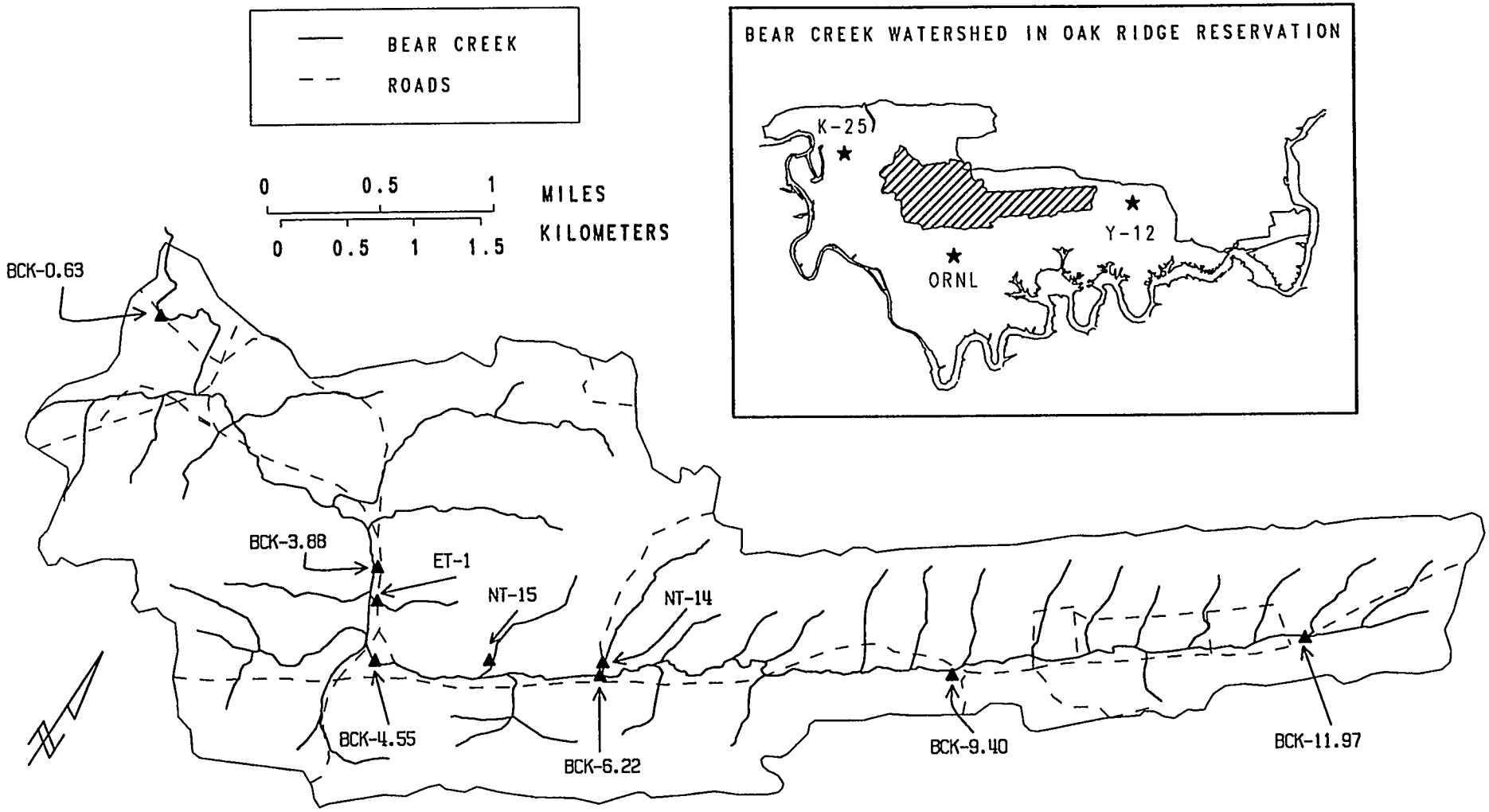


Fig. 8.1. Locations of existing and proposed continuous stream discharge monitoring sites on Bear Creek. Sites BCK-11.97, BCK-9.40 and BCK-0.63 are proposed sites.

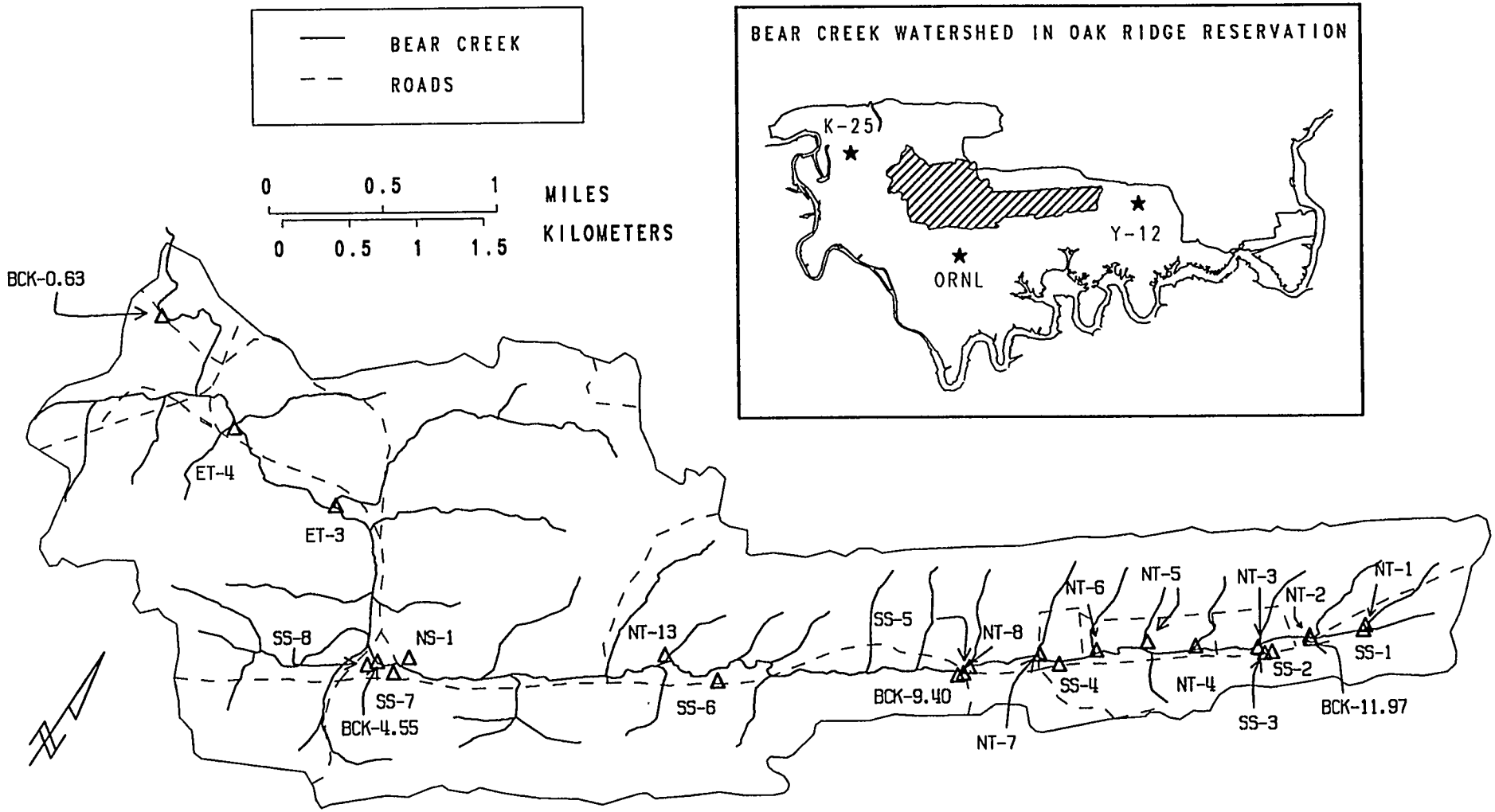


Fig. 8.2. Locations of proposed water sampling sites on Bear Creek.

Table 8.1 (continued)

| Station | Description |
|---|---|
| NT-3 | Tributary which enters Bear Creek between Sanitary Landfill I and Hazardous Chemical Disposal Area-Bone Yard/Burn Yard at BCK-11.59. |
| NT-4 | Tributary which enters Bear Creek downstream of Sanitary Landfill I at BCK-11.15. |
| NT-5 | Tributary which enters Bear Creek at BCK-10.78 between Sanitary Landfill I and the Burial Grounds. Subwatershed is mostly unimpacted by waste disposal activity. |
| NT-6 | Tributary which enters Bear Creek at BCK-10.40 and includes drainage from the eastern edge of Burial Ground A and Oil Retention Pond No. 2. |
| NT-7 | Tributary which enters Bear Creek at BCK-9.99 and includes drainage from the western edge of Burial Ground A and Oil Retention Pond No. 1. Previous studies have shown extensive contamination with PCBs in floodplain deposits. |
| NT-8 | Tributary which enters Bear Creek at BCK-9.45 and includes drainage from the western portions of the Burial Grounds. Previous studies have shown evidence of PCB contamination in sediments. |
| NT-13 | Tributary which enters Bear Creek at BCK-6.76 and represents drainage from a catchment not subject to recent disturbance except powerline maintenance. Will serve as a control or background site. |
| ET-3 | Tributary (McNew Hollow Branch) which enters Bear Creek at BCK-3.30. May include drainage from White Wing Scrap Yard. |
| ET-4 | Tributary which enters Bear Creek at BCK-2.27. May include drainage from White Wing Scrap Yard. |
| <u>SPRING STATIONS</u> | |
| SS-1 | Spring which enters Bear Creek from the south at BCK-12.38 immediately upstream of Rust Spoil Area. Spring has shown evidence of contamination with nitrate and uranium. |

Table 8.1 (continued)

| Station | Description |
|---|---|
| SS-2 | Spring which enters Bear Creek from the south at BCK-11.68 just past the intersection of Bear Creek Road and Old Bear Creek Road. |
| SS-3 | Spring which enters Bear Creek from the south at BCK-11.67 adjacent to spring SS-2. |
| SS-4 | Spring which enters Bear Creek from the south at BCK-10.14. May represent reemergence of Bear Creek surface water which typically disappear in the 'losing reach' of Bear Creek upstream of this spring. Spring has shown evidence of contamination with nitrate and uranium. |
| SS-5 | Spring which enters Bear Creek from the south at BCK-9.41 downstream of Bear Creek Road crossing. Spring has shown evidence of contamination with nitrate and uranium. |
| SS-6 | Spring which enters Bear Creek from the south at BCK-7.11. This spring has not previously been sampled but may represent another location where conduit flow in the Maynardville limestone emerges at the surface. |
| SS-7 | Spring which enters Bear Creek from the south at BCK-4.65 near the junction of Bear Creek Road and S.R. 95. Spring has shown evidence of slight contamination with nitrate and uranium and may represent reemergence of Bear Creek surface waters lost to groundwater upstream. |
| SS-8 | Spring which enters Bear Creek from the south at BCK-4.56 adjacent to and upstream of NPDES monitoring station. Spring has not shown evidence of contamination but contributes considerable flow to Bear Creek. |
| NS-1 | Spring which enters Bear Creek from the north at BCK-4.69 upstream of NPDES monitoring station. Only known spring which enters Bear Creek from the north. |

All but one of the Bear Creek tributary sites represent surface water discharge from subcatchments containing one or more SWMUs. The one tributary site (NT-13) represents a subcatchment with no SWMUs and minimal recent disturbance by man. The NT-13 site is intended as a background or control site.

The nine spring sites represent points of groundwater input to Bear Creek. Previous data have indicated evidence of contamination (i.e., elevated concentrations of nitrate and uranium) in several of these springs. Two springs, SS-6 and NS-1, have not been sampled for water quality previously.

### 8.2.2 Sampling and Analysis Plan

#### 8.2.2.1 Phase Ia

Phase Ia sampling of surface water will not commence until the remedial work on all of the Y-12 SWMUs is completed. During Phase Ia, six sets of flow measurements and water quality samples will be taken at all 24 surface water sites over a period of one year or less, during four high flows representative of erosional events and two low flows representative of depositional events. These events will not necessarily be representative of a water year. The water quality samples will be analyzed for the parameters listed in Table 8.2.

Six synoptic surveys of Bear Creek will also be conducted concurrently with the six sampling events at the stations. These surveys will involve measuring flow, specific conductance, nitrate, and total uranium in each Bear Creek tributary not included above. Specific conductance may be indicative of unknown dissolved contaminants being contributed by the tributaries, whereas nitrate and uranium are specific contaminant known to occur in Bear Creek. Data from the surveys, in combination with flow and water quality data from the Bear Creek stations, will be used to identify any subareas of the watershed for which specific sampling plans need to be developed.

Table 8.2. Proposed analytical parameters for surface water samples during RFI at Bear Creek - Phase Ia

| | Analytical method[a] | Reporting detection limit[b] |
|---|---|---|
| Inorganic Metals (Total and Dissolved) | | |
| Arsenic | 7060[c] | 0.005 mg/L |
| Lead | 7421[c] | 0.005 mg/L |
| Mercury | 7470[d] | 0.002 mg/L |
| Selenium | 7740[c] | 0.005 mg/L |
| ICP Metals Sweep (Total and Dissolved) | 6010 | |
| Aluminum | | 0.2 mg/L[e] |
| Barium | | 0.200 mg/L[e] |
| Beryllium | | 0.005 mg/L[e] |
| Cadmium | | 0.005 mg/L[e] |
| Calcium | | 5.0 mg/L[e] |
| Chromium | | 0.010 mg/L[e] |
| Cobalt | | 0.050 mg/L[e] |
| Copper | | 0.025 mg/L[e] |
| Iron | | 0.100 mg/L[e] |
| Lead | | 0.005 mg/L[e] |
| Magnesium | | 5.0 mg/L[e] |
| Manganese | | 0.015 mg/L[e] |
| Nickel | | 0.040 mg/L[e] |
| Niobium | | 0.01 mg/L[e] |
| Phosphorus | | 0.5 mg/L[e] |
| Potassium | | 5.0 mg/L[e] |
| Silver | | 0.010 mg/L[e] |
| Sodium | | 5.0 mg/L[e] |
| Vanadium | | 0.050 mg/L[e] |
| Zinc | | 0.020 mg/L[e] |
| Other Inorganics | | |
| Chloride | 325.3[f] or 300 | 1.0 mg/L |
| Fluoride | 340.1[f] or 300 | 1.0 mg/L |
| Nitrate | 352.1[f] or 300 | 1.0 mg/L |
| Sulfate | 375.4[f] or 300 | 1.0 mg/L |
| Volatile Organics | 624[g] | |
| Chloromethane | | 10 μg/L |
| Bromomethane | | 10 μg/L |
| Vinyl chloride | | 10 μg/L |
| Chlorethane | | 10 μg/L |
| Methylene chloride | | 5 μg/L |
| Acetone | | 10 μg/L |
| Carbon disulfide | | 5 μg/L |

Table 8.2 (continued)

| | Analytical method[a] | Reporting detection limit[b] |
|---|---|---|
| Volatile Organics (Cont'd) | | |
| 1,1-Dichloroethene | | 5 μg/L |
| 1,1-Dichloroethane | | 5 μg/L |
| Trans-1,2-dichloroethene | | 5 μg/L |
| Chloroform | | 5 μg/L |
| 1,2-Dichloroethane | | 5 μg/L |
| 2-Butanone | | 10 μg/L |
| 1,1,1-Trichloroethane | | 5 μg/L |
| Carbon tetrachloride | | 5 μg/L |
| Vinyl acetate | | 10 μg/L |
| Bromodichloromethane | | 5 μg/L |
| 1,1,2,2-Tetrachloroethane | | 5 μg/L |
| 1,2-Dichloropropane | | 5 μg/L |
| Trans-1,2-dichloropropene | | 5 μg/L |
| Trichloroethene | | 5 μg/L |
| Dibromochloromethane | | 5 μg/L |
| 1,1,2-Trichloroethane | | 5 μg/L |
| Benzene | | 5 μg/L |
| Cis-1,2-dichloropropene | | 5 μg/L |
| 2-Chloroethyl vinyl ether | | 10 μg/L |
| Bromoform | | 5 μg/L |
| 2-Hexanone | | 10 μg/L |
| 4-Methyl-2-pentanone | | 10 μg/L |
| Tetrachloroethene | | 5 μg/L |
| Toluene | | 5 μg/L |
| Chlorobenzene | | 5 μg/L |
| Ethyl benzene | | 5 μg/L |
| Styrene | | 5 μg/L |
| Total Xylenes | | 5 μg/L |
| Total Phenolics | 420.1[f] | 5 μg/L |
| Other Organics | | |
| Total Organic Carbon | 415.1[f] | 1.0 mg/L |
| Total Organic Halogen | 9020 | 5.0 μg/L |
| Dissolved Organic Carbon | 415.1[f] | 1.0 mg/L |
| Radiologicals | | |
| Gross alpha | 900.0[h] | 1.0 pCi/L |
| Gross beta | 900.0[h] | 4.0 pCi/L |
| Radium | 903.0[h] | 1.0 pCi/L |
| Total Uranium | EC-1940[i] | 1 μg/L |
| Isotopic (% U-235) | EC-1940[i] | 0.001 wt/% |
| Gamma spectrometry | EC-370[i] | All Values Reported |
| Polychlorinated Biphenyls | EC-162 | 5 μg/L |

Table 8.2 (continued)

| | Analytical method[a] | Reporting detection limit[b] |
|---|---|---|
| Miscellaneous | | |
| pH | 150.1[g] | NA[j] |
| Specific Conductance | 120.1[g] | NA |
| Total Suspended Solids | 160.2 | 4.0 mg/L |
| Total Dissolved Solids | 160.1 | 10.0 mg/L |
| Alkalinity | 310.1[g] | |

[a]Reference number from Test Methods for Evaluating Solid Waste, (USEPA 1986b) unless noted otherwise.

[b]Specific detection limits are highly matrix dependent; the detection limits provided herein are provided for guidance and may not always be achievable.

[c]Analysis conducted by furnace technique atomic absorption.

[d]Analysis conducted by manual cold vapor technique.

[e]Minimum reporting limits under CLP program.

[f]Reference: Methods for Chemical Analysis of Water and Wastes (USEPA 1983a),

[g]Reference: Guidelines Establishing Test Procedures for the Anaysis of Pollutants under the Clean Water Act, 40 CFR Part 136, 1984.

[h]Prescribed Procedures for Measurement of Radioactivity in Drinking Water (USEPA 1980).

[i]Reference: Martin Marietta Energy Systems Environmental and Effluent Analysis Manual (MMES 1986).

[j]NA = Not applicable.

8.2.2.2 Phase Ib and Later Phases

Data collected from the Bear Creek stations will be evaluated to determine the need for additional long-term EFPC monitoring or tributary stations, which would be installed during Phase Ib. Phase Ib will also entail collecting surface water samples over one or more storm hydrographs at site BCK-11.97, BCK-12.40, BCK-4.55 and BCK-0.63. These samples will be analyzed only for total uranium and PCBs unless Phase Ia results indicate the need to include additional contaminants. The analytical results will be used with storm discharge data to calculate the mass loading and total storm load at each site for uranium and PCBs. The differences in contaminant loads among sites can be used to determine which reaches of Bear Creek are contributing these contaminants from floodplain deposits.

8.2.3 Field Documentation

Field documentation will be in accordance with the RFI Plan-General Document, Volume II: Quality Assurance Project Plan (QAPP) (Wiggins 1988a) and the Environmental Surveillance Procedures Quality Control Program (QC Manual) (Kimbrough et al. 1988).

8.2.4 Sample Collection Methodology

Sample collection methodology will be in accordance with the RFI Plan-General Document, Volume II: QAPP (Wiggins 1988a) and the QC Manual (Kimbrough et al. 1988).

8.2.5 Data Analysis

Data collected during the first sampling phase will be reviewed for values greater than action levels to be determined by the DOE and appropriate regulatory agencies to determine the need for additional sampling phases. Appendixes F and G tabulate possible action levels which may be used for this phase.

8.2.6 Sample Preservation and Handling

Sample containers, preservation methods, and holding times required for each type of chemical analysis are discussed in the RFI Plan-General

Document, Volume II: QAPP (Wiggins 1988a) and the QC Manual (Kimbrough et al. 1988).

8.2.7 Chain-of-Custody Procedures

Chain-of-custody procedures are discussed in the RFI Plan-General Document, Volume II: QAPP (Wiggins 1988a) and the QC Manual (Kimbrough et al. 1988).

8.2.8 Quality Assurance/Quality Control

Quality assurance/quality control procedures are described in the RFI Plan-General Document, Volume II: QAPP (Wiggins 1988a),the QC Manual (Kimbrough et al. 1988), and in Section 14.0 of this RFI Plan.

8.2.9 Sampling Equipment Decontamination Procedures

Decontamination procedures are described in the RFI Plan-General Document, Volume II: QAPP (Wiggins 1988a) and the QC Manual (Kimbrough et al. 1988).

8.2.10 Analytical Procedures

The data quality objective for surface water samples from Bear Creek generally requires Level III analytical levels, i.e., routine analytical services using EPA approved procedures. Analytical procedures will be in accordance with those provided in Test Methods for Evaluating Solid Waste (USEPA 1986), Methods for Chemical Analysis of Waters and Wastes (USEPA 1983c), Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, and Martin Marietta Energy Systems Environmental and Effluent Analysis Manual (MMES 1986). A listing of the methods and detection limits to be used for samples collected in Bear Creek surface water is provided in Tables 8.2.

# 9.0 SEDIMENT AND FLOODPLAIN SOIL SAMPLING PLAN

## 9.1 OBJECTIVES

The objectives of the Bear Creek sediment and floodplain soil sampling program are: (1) to confirm existing data on contaminant levels in sediments and floodplain soils of Bear Creek; (2) to identify tributaries which may be contributing sediment-bound contaminants to Bear Creek; and (3) to define the spatial distribution of selected contaminants in the Bear Creek floodplain, especially uranium and PCBs, which are known to be present in these deposits.

Although the nature and extent of sediment contamination in Bear Creek have been fairly well-characterized, by the time this RFI Plan is implemented these earlier characterizations may be obsolete due to elimination of contaminant sources by closure or remediation of the contributing SWMUs. Thus, the RFI can serve to demonstrate improvement in sediment quality, or at least to establish a baseline against which the success of remedial actions can be assessed.

Previous characterization of floodplain soil contamination has been limited mainly to a preliminary screening for certain contaminants in the floodplain. Thus, a major emphasis of the floodplain soil sampling program will be to better define the full nature and extent of floodplain contamination. Initial efforts will be directed at locating additional depositional areas with high concentrations of uranium and PCBs, and defining the horizontal and vertical extent of these deposits.

## 9.2 TECHNICAL APPROACH

Characterization of contaminants in Bear Creek sediments and floodplain soils will employ a phased approach. For Phase I, a biased, or selective, design will serve to confirm or refute previous data on sediment contamination along the main stem of Bear Creek and at the mouth of those tributaries containing SWMUs. Sediment contamination in drainage swales downstream of SWMUs which discharge storm runoff directly into Bear Creek will also be investigated. The finding of elevated contaminant levels

in tributary or swale sediment will prompt a Phase II investigation of the sources of these contaminants.

Two floodplain areas known from previous work to be contaminated with PCBs and uranium will be further characterized in Phase I to confirm the previously reported levels and to define the lateral and vertical extent of contamination. Using geomorphic indicators and field screening methods developed at these two sites, other floodplain areas will be selected for contaminant screening and full characterization, if warranted. Methods of field detection of contaminants, such as field extraction and gas chromatography, portable gamma spectrometry and X-ray fluorescence spectrometry, will be applied if proven to be of value in locating contaminant hot spots. In Phase II the entire floodplain (flood-of-record) of Bear Creek will be systematically surveyed using a combination of field screening and in-depth sampling to define areas needing remedial action.

### 9.2.1 Sampling Locations

In Phase I the surface water sampling sites described in Section 8.1.2 will also be used for sediment sampling (Figure 9.1). This includes the background tributary site, NT-13. Drainage swales at road crossings at BCK-9.98, BCK-10.27, BCK-11.28 and BCK-11.84 will also be sampled (Figure 9.2). Floodplain soil contamination at sites (Figure 9.3) adjacent to BCK-4.68 and BCK-9.99 will be also be evaluated in detail in Phase I, along with a screening level investigation at five other sites. The latter sites will likely include the floodplain adjacent to the following Bear Creek locations: BCK-0.63, BCK-7.90, BCK-10.27, BCK-11.28 and BCK-11.84. Phase II will involve only floodplain soil sampling and the selection of sites will be guided by the results of Phase I. Phase II could involve intensive sampling of selected areas of the floodplain which are found to be deposition areas for contaminants.

### 9.2.2 Sampling and Analysis Plan

Sediment sampling in Phase I will entail a single round of sampling of all the surface water and drainage swale sampling sites shown in Table 8.1. Sediment samples will generally consist of unconsolidated material

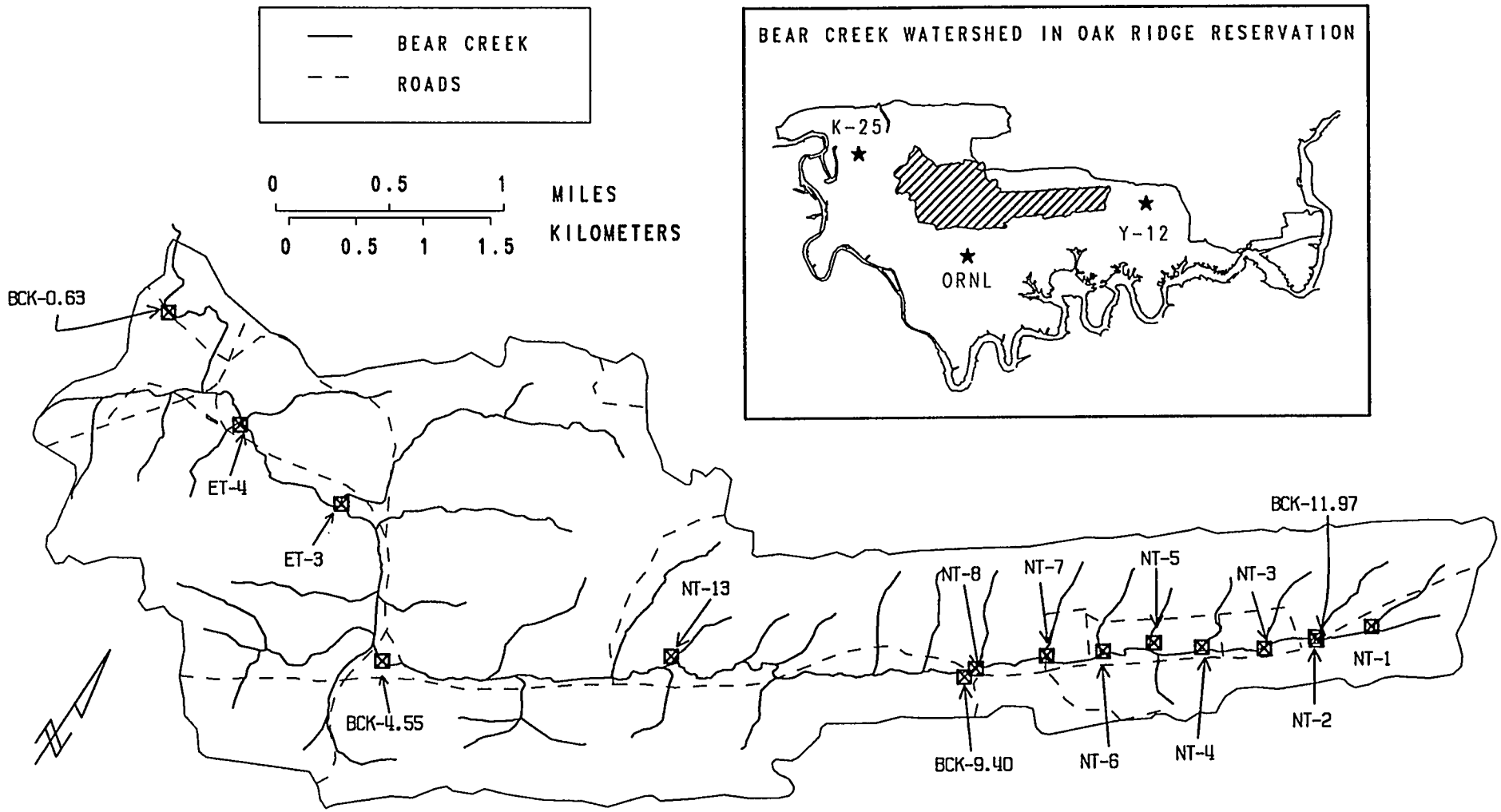


Fig. 9.1. Locations of proposed sediment sampling sites on Bear Creek.

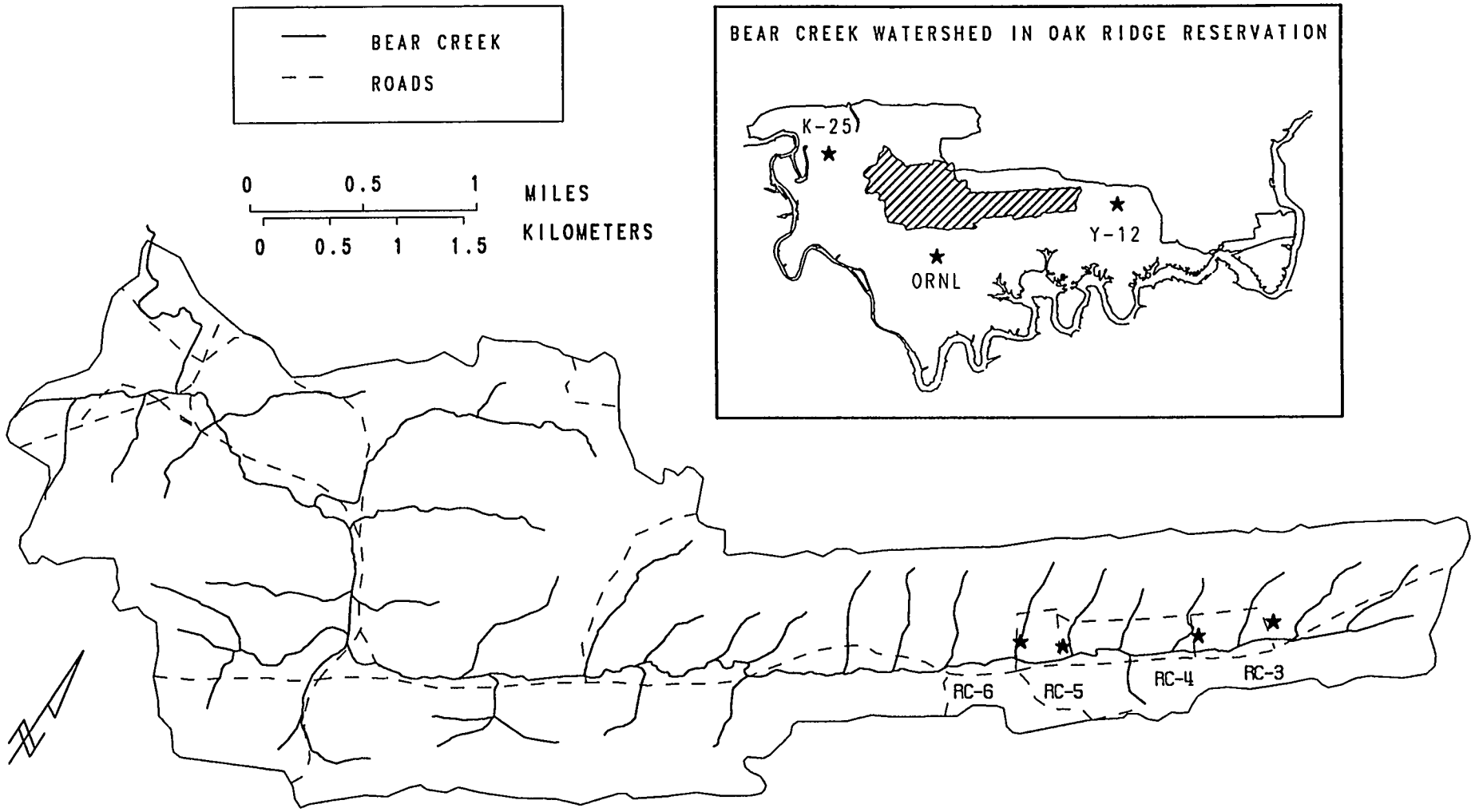


Fig. 9.2. Locations of proposed swale sediment sampling sites near Bear Creek.

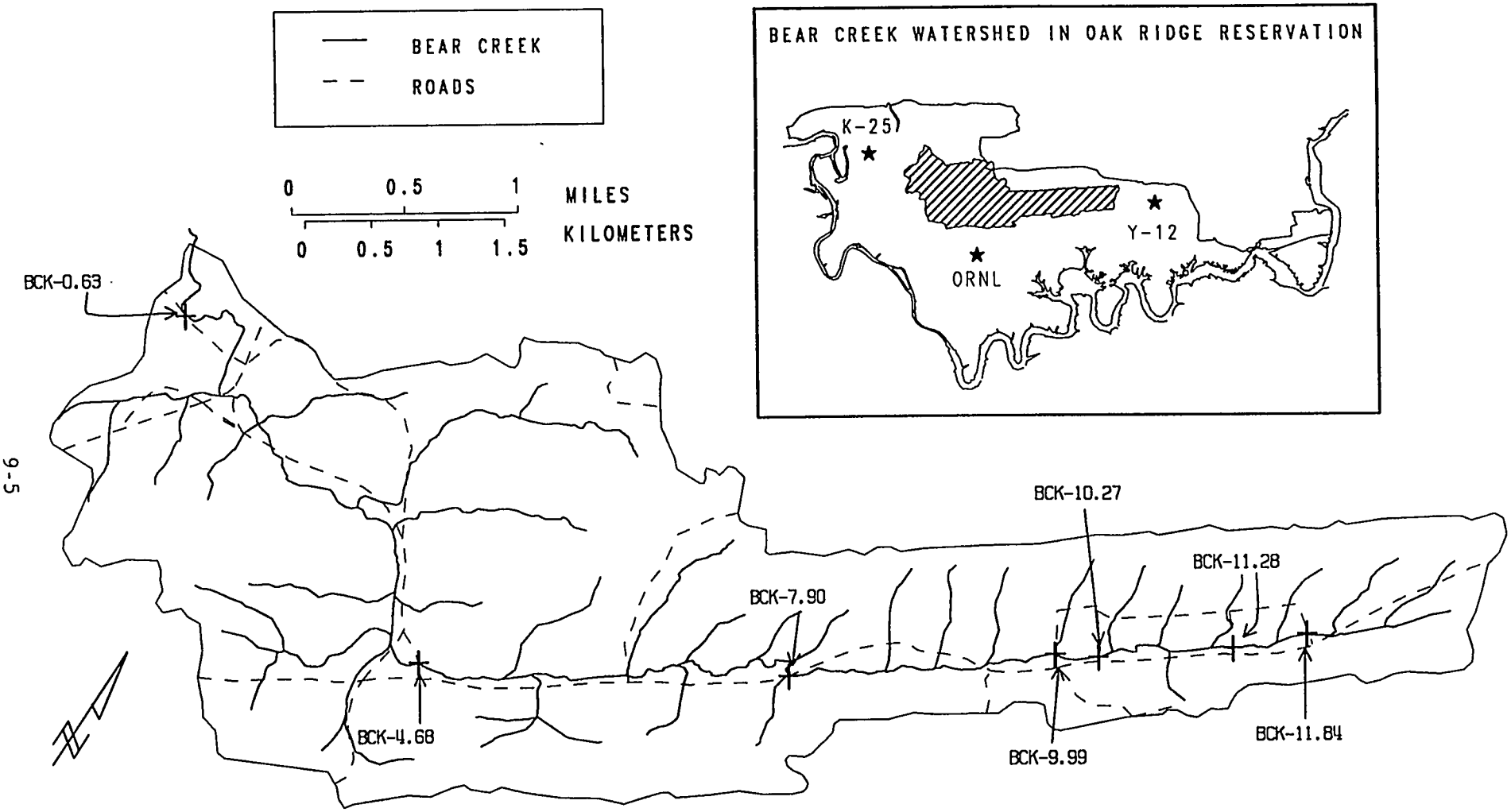


Fig. 9.3. Locations of Phase I floodplain soil sampling sites at Bear Creek.

obviously deposited recently by the action of water and composited from multiple scoops from each locality. The one exception to this is the sediment contained in the weir pool at BCK-4.55, which will be sampled by coring and core compositing. Sediment accumulation in this weir pool is extensive, and contaminant identities and concentrations have not previously been characterized. To provide data for within-site variability in sediment contamination, the sediment at five sites will be sampled in triplicate. Floodplain soil sampling in both Phase I and Phase II will entail coring and sectioning of cores to define the depth limits of contamination. Within a floodplain sampling locality an authoritative process will generally be used to select coring locations within the area bounded by the flood-of-record.

All sediment and soil samples collected in Phase I will be analyzed for the constituents shown in Table 9.1 Phase II samples will only be analyzed for PCBs, total uranium and any contaminants which emerge from Phase I results which justify investigation.

### 9.2.3 Field Documentation

Field documentation is described fully in the RFI Plan-General Document, Volume II: QAPP (Wiggins 1988a) and the QC Manual (Kimbrough et al. 1988). Locations of all sampling points will be surveyed by measuring the distance and bearing to a nearby well-defined and mapped landmark. This information will be recorded in the field notebook. In the case of contaminated floodplain areas which are possible candidates for remedial action, each core location will be temporarily marked with a stake or flagging and then formally surveyed using a transit and steel tape or an electronic distance meter (EDM).

### 9.2.4 Sample Collection Methodology

General procedures of soil and sediment sampling are described fully in the QC Manual (Kimbrough et al. 1988). Sediment samples will be collected by scooping only the upper 1-inch or less of unconsolidated sediment in the streambed. At each site a sample will consist of a well-homogenized composite of material from each side and the center of the

Table 9.1. Proposed analytical parameters for soil and sediment samples during RFI at Bear Creek

| | Analytical method[a] | Reporting detection limit[b] |
|---|---|---|
| % Moisture | | |
| Inorganic Metals | | |
| Arsenic | 3050 (prep), 7060 (analysis) | 0.5 mg/kg |
| Lead | 7421 | 0.5 mg/kg |
| Mercury | 7471 | 0.2 mg/kg |
| Selenium | 3050 (prep), 7740 (analysis) | 0.1 mg/kg |
| ICP Metals Sweep | 6010 | |
| Aluminum | | 12 mg/kg |
| Barium | | 10 mg/kg |
| Beryllium | | 1 mg/kg |
| Cadmium | | 3 mg/kg |
| Calcium | | 100 mg/kg |
| Chromium | | 10 mg/kg |
| Cobalt | | 2 mg/kg |
| Copper | | 2 mg/kg |
| Iron | | 100 mg/kg |
| Lead | | 20 mg/kg |
| Magnesium | | 50 mg/kg |
| Manganese | | 2 mg/kg |
| Nickel | | 10 mg/kg |
| Niobium | | 10 mg/kg |
| Phosphorus | | 50 mg/kg |
| Potassium | | 500 mg/kg |
| Silver | | 4 mg/kg |
| Sodium | | 50 mg/kg |
| Vanadium | | 5 mg/kg |
| Zinc | | 2 mg/kg |
| Volatile Organics | 624[d] | |
| Chloromethane | | 10 μg/kg |
| Bromomethane | | 10 μg/kg |
| Vinyl chloride | | 10 μg/kg |
| Chlorethane | | 10 μg/kg |
| Methylene chloride | | 5 μg/kg |
| Acetone | | 10 μg/kg |
| Carbon disulfide | | 5 μg/kg |
| 1,1-Dichloroethene | | 5 μg/L |

Table 9.1 (continued)

| | Analytical method[a] | Reporting detection limit[b] |
|---|---|---|
| Volatile Organics (Cont'd) | | |
| 1,1-Dichloroethane | | 5 μg/kg |
| Trans-1,2-dichloroethene | | 5 μg/kg |
| Chloroform | | 5 μg/kg |
| 1,2-Dichloroethane | | 5 μg/kg |
| 2-Butanone | | 10 μg/kg |
| 1,1,1-Trichloroethane | | 5 μg/kg |
| Carbon tetrachloride | | 5 μg/kg |
| Vinyl acetate | | 10 μg/kg |
| Bromodichloromethane | | 5 μg/kg |
| 1,1,2,2-Tetrachloroethane | | 5 μg/kg |
| 1,2-Dichloropropane | | 5 μg/kg |
| Trans-1,2-dichloropropene | | 5 μg/kg |
| Trichloroethene | | 5 μg/kg |
| Dibromochloromethane | | 5 μg/kg |
| 1,1,2-Trichloroethane | | 5 μg/kg |
| Benzene | | 5 μg/kg |
| Cis-1,2-dichloropropene | | 5 μg/kg |
| 2-Chloroethyl vinyl ether | | 10 μg/kg |
| Bromoform | | 5 μg/kg |
| 2-Hexanone | | 10 μg/kg |
| 4-Methyl-2-pentanone | | 10 μg/kg |
| Tetrachloroethene | | 5 μg/kg |
| Toluene | | 5 μg/kg |
| Chlorobenzene | | 5 μg/kg |
| Ethyl benzene | | 5 μg/kg |
| Styrene | | 5 μg/kg |
| Total Xylenes | | 5 μg/kg |
| Radiologicals | | |
| Gross alpha | EC-101[c] | All Values Reported |
| Gross beta | EC-101[c] | All Values Reported |
| Gamma Spectrometry | EC-134[c] | All Values Reported |
| Total Uranium | EC-370[c] | 0.2 mg/kg |
| Polychlorinated Biphenyl | EC-340[c] | 0.1 μg/g |

[a]Reference number from Test Methods for Evaluating Solid Waste, (USEPA 1986b) unless noted otherwise.

[b]Specific detection limits are highly matrix dependent; the detection limits provided herein are provided for guidance and may not always be achievable.

[c]Reference: Martin Marietta Energy Systems Environmental and Effluent Analysis Manual (MMES 1986).

[d]Reference: Guidelines Establishing Test Procedures for the Anaysis of Pollutants under the Clean Water Act, 40 CFR Part 136, 1984.

creek or drainage swale, or from several depositional areas within 5 meters of the site. Rocks and coarse organic debris will be excluded from the samples by passing each scoop of the material through a stainless steel sieve with 2 mm openings (10 mesh). Samples for volatile organic compounds will not be sieved.

In the weir pool at BCK-4.55 a stainless steel corer will be used to sample the entire thickness of the sediment (corer will be pushed manually to refusal).

Floodplain soil sampling will employ bucket augers or a vibracorer depending on the moisture content of the soil. The vibracorer will generally yield better undisturbed core sections in saturated soils than bucket augers which may allow the hole to collapse between samples. Floodplain samples will not be screened by sieving, but large rocks and roots will be removed from samples. After subsampling for VOCs floodplain samples will be thoroughly homogenized either in the field or laboratory prior to subsampling for analysis.

### 9.2.5 Data Analysis

Data collected during Phase I will be reviewed for concentrations of contaminants greater than health and environmental criteria given by regulatory agencies. Such criteria include the TSCA and TDHE limit for PCBs in soil (25 $\mu$g/g) and the DOE/NRC/Y-12 Plant policy guideline for uranium in soil (30-35 pCi/g). Contaminants approaching or exceeding these criteria or occurring at concentrations more than twice the local expected background will be included in Phase II chemical analysis.

### 9.2.6 Sample Preservation and Handling

Procedures for sample preservation and handling are fully described in the QC Manual (Kimbrough et al. 1988). Aliquots of all soil and sediment samples collected for the RFI will be air-dried and archived for at least one year following completion of sampling.

### 9.2.7 Chain-of Custody Procedures

Procedures for chain-of-custody are fully described in the QC Manual (Kimbrough et al. 1988)

### 9.2.8 Quality Assurance/Quality Control

Quality assurance/quality control procedures are fully described in the QC Manual (Kimbrough et al. 1988), the RFI Plan-General Document, Volume II: QAPP (Wiggins 1988a), and Section 14.0 of this RFI Plan.

### 9.2.9 Sampling Equipment Decontamination Procedures

Sampling equipment decontamination procedures are fully described in the QC Manual (Kimbrough et al. 1988)

### 9.2.10 Analytical Procedures

The data quality objective for soil and sediment samples from Bear Creek generally requires Level III analytical levels, i.e., routine analytical services using EPA-approved procedures. Field screening for the presence of certain contaminants, such as PCBs and uranium may entail Level II analytical levels with confirmation by Level III. Analytical procedures will be in accordance with those provided in Test Methods for Evaluating Solid Waste (USEPA 1986b), Methods for Chemical Analysis of Waters and Wastes (USEPA 1983a), Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, and Martin Marietta Energy Systems Environmental and Effluent Analysis Manual (MMES 1986). A listing of the methods and detection limits to be used for soil and sediment samples collected at Bear Creek is provided in Table 9.1.

# 10.0 GROUNDWATER MONITORING PLAN

## 10.1 OBJECTIVES

The objective of the groundwater monitoring effort is to determine if floodplain deposits contaminated with uranium and PCBs are releasing these, or other, contaminants into very shallow groundwater near Bear Creek. Previous work has suggested that these deposits are shallow (<2 ft) and more likely to be physically redistributed by streamflow than by groundwater movement. The issue of groundwater contamination via recharge of the shallow Maynardville Limestone aquifer by Bear Creek along hydrologically "losing" reaches is not addressed in this RFI Plan. This is a complex issue being addressed by special investigations and relates more directly to corrective measures being taken, or contemplated, at the upstream SWMUs than to potential corrective measures which could be reasonably applied to Bear Creek and its floodplain.

A series of shallow wells will be installed in two floodplain areas of Bear Creek where previous studies have shown PCB concentration up to 132 $\mu g/g$ and 240 $\mu g/g$ total uranium in floodplain soils. The presence of these contaminants in close proximity to Bear Creek surface water indicates the need to evaluate all transport routes, including groundwater migration.

## 10.2 TECHNICAL APPROACH

### 10.2.1 Sampling Locations

Two floodplain localities with high reported concentrations of PCBs and uranium in shallow floodplain soils are BCK-4.68 and BCK-9.99. The site at BCK-4.68 has been described in Section 7.3.2 and consists of a flood levee immediately adjacent to Bear Creek near the intersection of Bear Creek Road and S.R. 95 (Fig. 10.1). The site at BCK-9.99 is located near the confluence of Bear Creek with NT-7, the tributary which has received drainage from Oil Pond No. 1. As discussed in Section 4.7 floodplain soils downstream of Oil Pond No. 1 contain total PCB concentrations up to 574 $\mu g/g$.

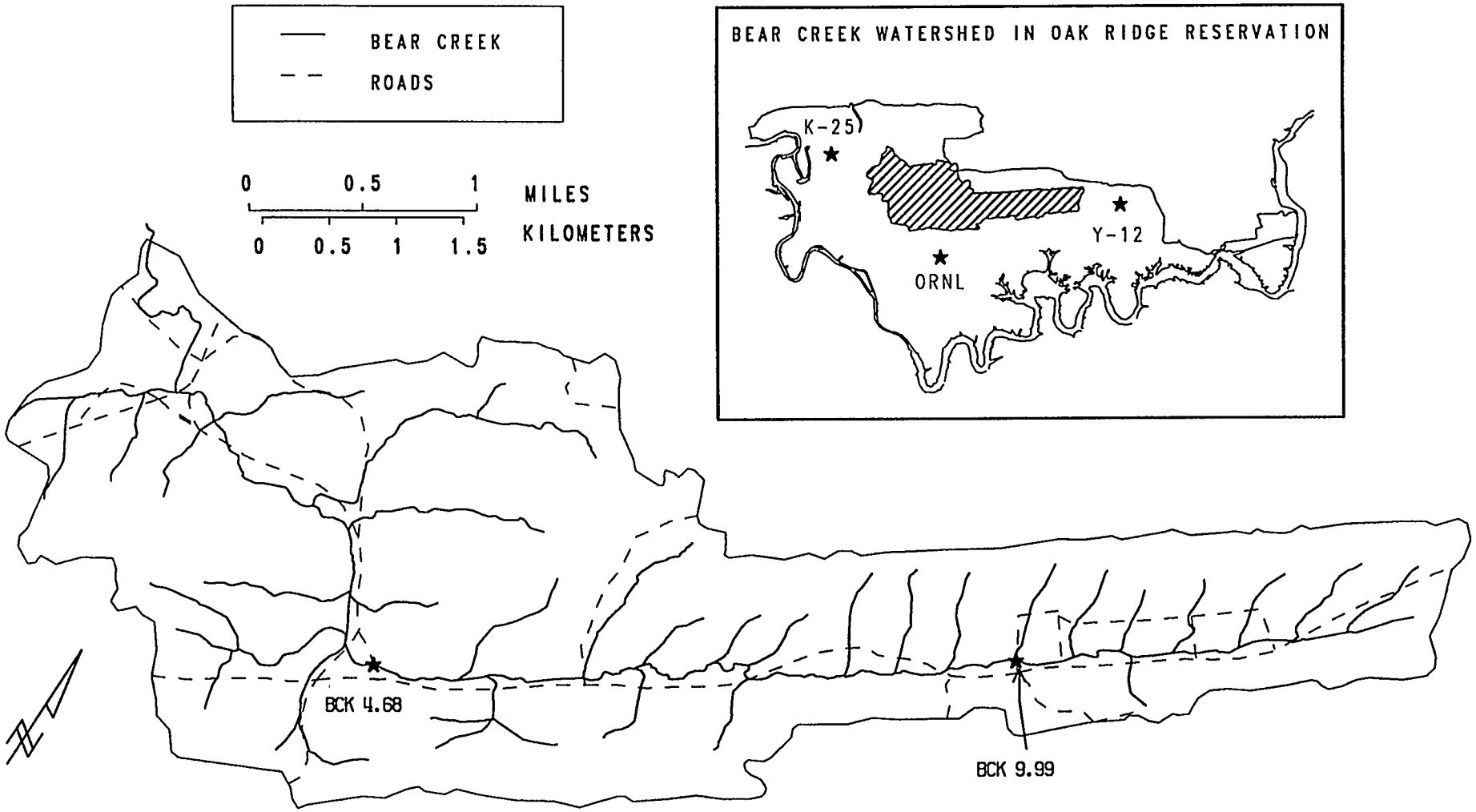


Fig. 10.1. Locations of proposed groundwater sampling sites near Bear Creek.

### 10.2.2 Sampling and Analysis Plan

Three very shallow (< 6 ft) wells for vadose zone monitoring will be installed in the floodplain at BCK-4.68 and BCK-9.99. Actual locations of each well will be selected after areal and depth distributions of contaminants are mapped for these sites (Section 9.2). These wells will be screened in soil horizons with three concentration levels of PCBs and uranium at each site, i.e., from the highest to the lowest. Piezometers will be installed adjacent to each well to provide for measurement of water level without disturbing the sampling wells. Due to the possibility that the screened intervals may not always be in the saturated zone, a lysimeter-type well design (Fig. 10.2) will be used, with installation and sampling in accordance with procedures given in EPA (1984). A bucket auger will be used to bore each well. Well development will follow the procedures described by Gillis (1988) for a standard well installation.

Each well will be sampled initially four times, representing wet and dry periods, as determined by seasonally high and seasonally low water levels in the piezometers. Well samples will be analyzed for the constituents listed in Table 10.1. Unless these wells yield especially turbid samples, analysis will be limited to unfiltered samples.

Depending on the results of the initial rounds of sampling and analysis, additional wells may be installed to better characterize any apparent migration of contaminants from the floodplain deposits, either into deeper groundwater or directly to the stream.

### 10.2.3 Field Documentation

Field documentation will be in accordance with the RFI Plan-General Document, Volume II: Quality Assurance Project Plan (QAPP) (Wiggins 1988a) and the QC Manual (Kimbrough et al. 1988).

### 10.2.4 Sample Collection Methodology

Sample collection methodology will be in accordance with the RFI Plan-General Document, Volume II: QAPP (Wiggins 1988a) and the QC Manual (Kimbrough et al. 1988).

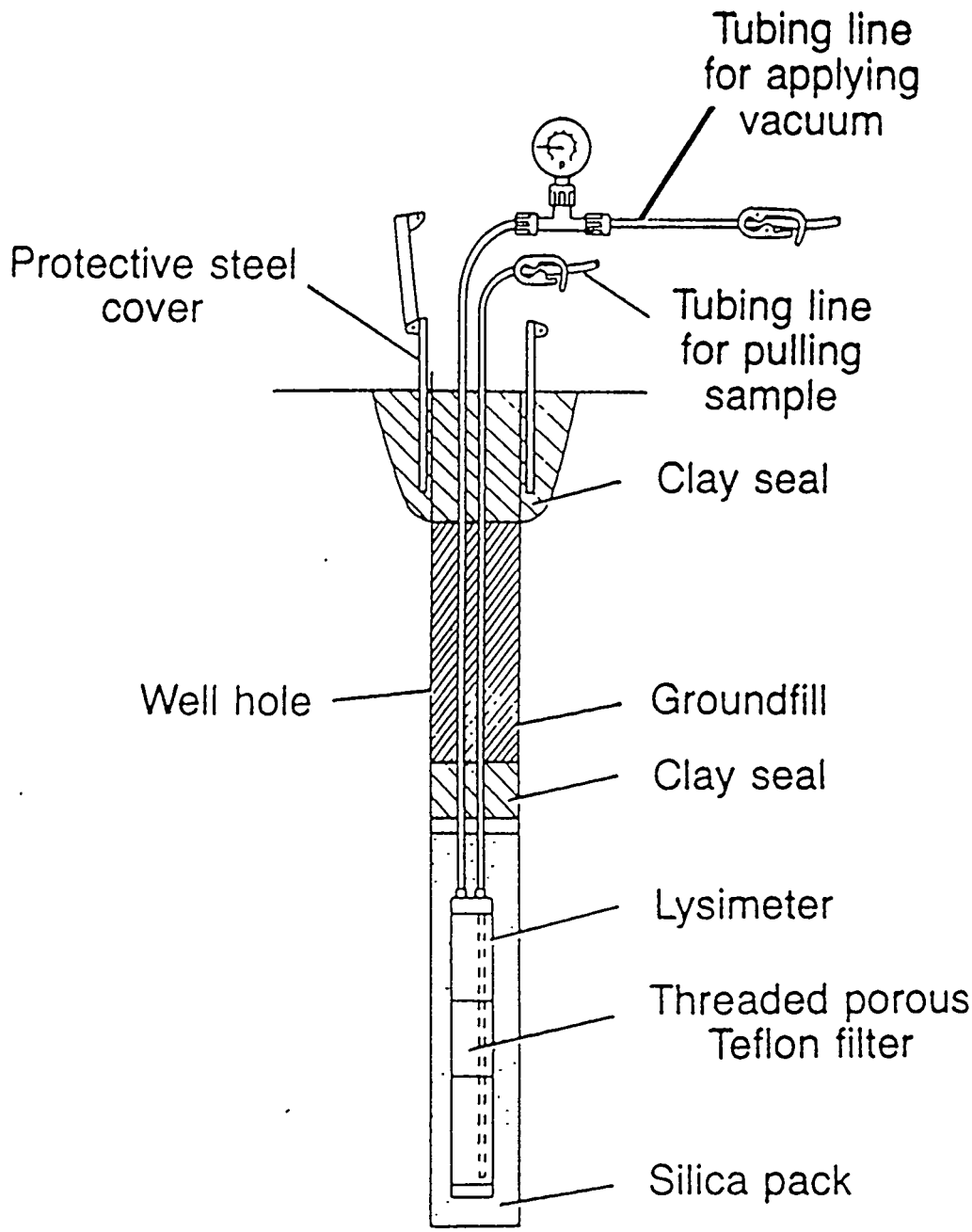


Fig. 10.2. Typical installation of lysimeter for vadose zone sampling

Table 10.1. Proposed analytical parameters for groundwater samples during RFI at Bear Creek

| | Analytical method[a] | Reporting detection limit[b] |
|---|---|---|
| Inorganic Metals | | |
| Arsenic | 7060[c] | 0.005 mg/L |
| Lead | 7421[c] | 0.005 mg/L |
| Mercury | 7470[d] | 0.002 mg/L |
| Selenium | 7740[c] | 0.005 mg/L |
| ICP Metals Sweep | 6010 | |
| Aluminum | | 0.2 mg/L[e] |
| Barium | | 0.200 mg/L[e] |
| Beryllium | | 0.005 mg/L[e] |
| Cadmium | | 0.005 mg/L[e] |
| Calcium | | 5.0 mg/L[e] |
| Chromium | | 0.010 mg/L[e] |
| Cobalt | | 0.050 mg/L[e] |
| Copper | | 0.025 mg/L[e] |
| Iron | | 0.100 mg/L[e] |
| Lead | | 0.005 mg/L[e] |
| Magnesium | | 5.0 mg/L[e] |
| Manganese | | 0.015 mg/L[e] |
| Nickel | | 0.040 mg/L[e] |
| Niobium | | 0.01 mg/L[e] |
| Phosphorus | | 0.5 mg/L[e] |
| Potassium | | 5.0 mg/L[e] |
| Silver | | 0.010 mg/L[e] |
| Sodium | | 5.0 mg/L[e] |
| Vanadium | | 0.050 mg/L[e] |
| Zinc | | 0.020 mg/L[e] |
| Other Inorganics | | |
| Chloride | 325.3[f] or 300 | 1.0 mg/L |
| Fluoride | 340.1[f] or 300 | 1.0 mg/L |
| Nitrate | 352.1[f] or 300 | 1.0 mg/L |
| Sulfate | 375.4[f] or 300 | 1.0 mg/L |
| Volatile Organics | 624[g] | |
| Chloromethane | | 10 μg/L |
| Bromomethane | | 10 μg/L |
| Vinyl chloride | | 10 μg/L |
| Chlorethane | | 10 μg/L |
| Methylene chloride | | 5 μg/L |
| Acetone | | 10 μg/L |
| Carbon disulfide | | 5 μg/L |

Table 10.1 (continued)

| | Analytical method[a] | Reporting detection limit[b] |
|---|---|---|
| Volatile Organics (Cont'd) | | |
| 1,1-Dichloroethene | | 5 μg/L |
| 1,1-Dichloroethane | | 5 μg/L |
| Trans-1,2-dichloroethene | | 5 μg/L |
| Chloroform | | 5 μg/L |
| 1,2-Dichloroethane | | 5 μg/L |
| 2-Butanone | | 10 μg/L |
| 1,1,1-Trichloroethane | | 5 μg/L |
| Carbon tetrachloride | | 5 μg/L |
| Vinyl acetate | | 10 μg/L |
| Bromodichloromethane | | 5 μg/L |
| 1,1,2,2-Tetrachloroethane | | 5 μg/L |
| 1,2-Dichloropropane | | 5 μg/L |
| Trans-1,2-dichloropropene | | 5 μg/L |
| Trichloroethene | | 5 μg/L |
| Dibromochloromethane | | 5 μg/L |
| 1,1,2-Trichloroethane | | 5 μg/L |
| Benzene | | 5 μg/L |
| Cis-1,2-dichloropropene | | 5 μg/L |
| 2-Chloroethyl vinyl ether | | 10 μg/L |
| Bromoform | | 5 μg/L |
| 2-Hexanone | | 10 μg/L |
| 4-Methyl-2-pentanone | | 10 μg/L |
| Tetrachloroethene | | 5 μg/L |
| Toluene | | 5 μg/L |
| Chlorobenzene | | 5 μg/L |
| Ethyl benzene | | 5 μg/L |
| Styrene | | 5 μg/L |
| Total Xylenes | | 5 μg/L |
| Total Phenolics | 420.1[f] | 5 μg/L |
| Other Organics | | |
| Total Organic Carbon | 415.1[f] | 1.0 mg/L |
| Total Organic Halogen | 9020 | 5.0 μg/L |
| Dissolved Organic Carbon | 415.1[f] | 1.0 mg/L |
| Radiologicals | | |
| Gross alpha | 900.0[h] | 1.0 pCi/L |
| Gross beta | 900.0[h] | 4.0 pCi/L |
| Radium | 903.0[h] | 1.0 pCi/L |
| Total Uranium | EC-1940[i] | 1 μg/L |
| Isotopic (% U-235) | EC-1940[i] | 0.001 wt/% |
| Gamma spectrometry | EC-370[i] | All Values Reported |
| Polychlorinated Biphenyls | EC-162 | 5 μg/L |

Table 10.1 (continued)

| | Analytical method[a] | Reporting detection limit[b] |
|---|---|---|
| Miscellaneous | | |
| pH | 150.1[g] | NA[j] |
| Specific Conductance | 120.1[g] | NA |
| Total Suspended Solids | 160.2 | 4.0 mg/L |
| Total Dissolved Solids | 160.1 | 10.0 mg/L |
| Alkalinity | 310.1[g] | |

[a]Reference number from Test Methods for Evaluating Solid Waste, (USEPA 1986b) unless noted otherwise.

[b]Specific detection limits are highly matrix dependent; the detection limits provided herein are provided for guidance and may not always be achievable.

[c]Analysis conducted by furnace technique atomic absorption.

[d]Analysis conducted by manual cold vapor technique.

[e]Minimum reporting limits under CLP program.

[f]Reference: Methods for Chemical Analysis of Water and Wastes (USEPA 1983a),

[g]Reference: Guidelines Establishing Test Procedures for the Anaysis of Pollutants under the Clean Water Act, 40 CFR Part 136, 1984.

[h]Prescribed Procedures for Measurement of Radioactivity in Drinking Water (USEPA 1980).

[i]Reference: Martin Marietta Energy Systems Environmental and Effluent Analysis Manual (MMES 1986).

[j]NA = Not applicable.

10.2.5 Data Analysis

Data collected during the first sampling phase will be reviewed for values greater than action levels to be determined by the DOE and appropriate regulatory agencies to determine the need for additional sampling phases.

10.2.6 Sample Preservation and Handling

Sample containers, preservation methods, and holding times required for each type of chemical analysis are discussed in the RFI Plan-General Document, Volume II: QAPP (Wiggins 1988a) and the QC Manual (Kimbrough et al. 1988).

10.2.7 Chain-of-Custody Procedures

Chain-of-custody procedures are discussed in the RFI Plan-General Document, Volume II: QAPP (Wiggins 1988a) and the QC Manual (Kimbrough et al. 1988).

10.2.8 Quality Assurance/Quality Control

Quality assurance/quality control procedures are described in the RFI Plan-General Document, Volume II: QAPP (Wiggins 1988a) and the QC Manual (Kimbrough et al. 1988), and Section 14.0 of this RFI Plan.

10.2.9 Sampling Equipment Decontamination Procedures

Decontamination procedures are described in the RFI Plan-General Document, Volume II: QAPP (Wiggins 1988a) and the QC Manual (Kimbrough et al. 1988).

10.2.10 Analytical Procedures

The data quality objective for shallow groundwater samples from the Bear Creek floodplain generally requires Level III analytical services, i.e., routine analytical services using EPA approved procedures. Analytical procedures will be in accordance with those provided in Test Methods for Evaluating Solid Waste (USEPA 1986b), Methods for Chemical Analysis of Waters and Wastes (USEPA 1983a), Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, and Martin Marietta Energy Systems Environmental and Effluent Analysis Manual (MMES 1986). A listing of the methods and detection limits to be used for groundwater samples collected at the Bear Creek floodplain is provided in Table 10.1.

# 11.0 BIOTA MONITORING PLAN

Ecological studies of the Bear Creek watershed were initiated by staff in the ORNL Environmental Sciences Division in May 1984, and are continuing at present. The study plan consisted of an initial, detailed characterization of the benthic invertebrate and fish communities in Bear Creek in the first year followed by a subsequent reduction in sampling intensity during the monitoring phase of the study. The results of sampling conducted from May 1984 through early 1988 were recently presented in an interpretative report (Southworth 1988).

The objectives of the ecological studies on Bear Creek have initially been to characterize the ecological condition of Bear Creek and then to monitor any ecological recovery associated with various remedial actions to be taken in the watershed. To accomplish the first objective the existing environment in Bear Creek was characterized utilizing two approaches: (1) instream sampling of the benthic invertebrate and fish communities to identify spatial and temporal patterns in distribution and abundance and, (2) laboratory bioassays on water samples from Bear Creek and selected tributaries to identify potential sources of toxicity to biota. Following completion of the initial characterization studies in July 1985, periodic monitoring was conducted over several years and is continuing.

Because of the existence of an established biological monitoring program which is highly directed towards monitoring recovery of Bear Creek, biological monitoring is not addressed in this RFI Plan. However, it should be noted that selection of surface water monitoring locations for the RFI Plan considered the locations (Fig. 11.1) of the biological sites.

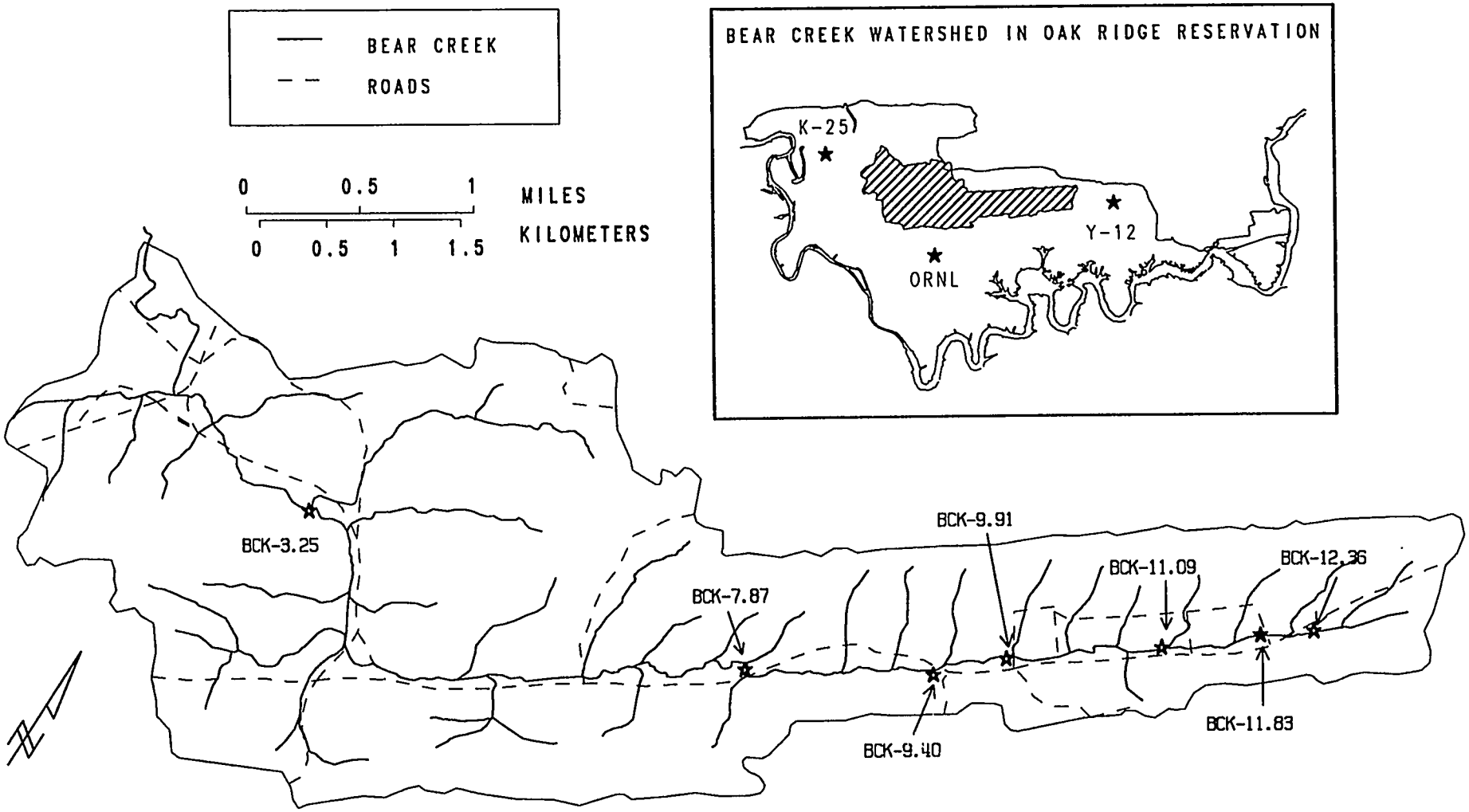


Fig. 11.1. Locations of existing biological monitoring sites which will continue to be monitored during RFI.

# 12.0 DATA MANAGEMENT PROCEDURES

Characterization of contaminant releases from a solid waste management unit may produce significant amounts of data, including sampling data and results of chemical, physical, and biological analyses. Data management procedures have been established to effectively process these data so that relevant data descriptions such as sample numbers, locations, methods, analytical results, etc. are accurately maintained and readily accessible. The RFI Plan-General Document, Volume III: Data Management Plan (Wiggins 1988) establishes the procedures that will be used to evaluate the data generated during the RCRA Facility Investigations at the Y-12 Plant.

Foundations for a data management plant were developed in the RFI Plan-General Document, Volume II: Quality Assurance Project Plan (QAPP) (Wiggins 1988), which will be implemented to document and track investigation data and results. Among the documents that are controlled in accordance with the QAPP are the RFI sampling and analysis plan, project and field logbooks, chain of custody records, audit and evaluation reports, analytical data, RFI sampling and analyses reports, RFI training records, and other miscellaneous information and documentation. Primary records will be maintained by the laboratories, drillers, field geologists, etc. Copies of the records will be available to the Y-12 Document Custodian for the permanent Y-12 project record.

Data reporting and review will be conducted according to quality assurance procedures discussed in the QAPP (Wiggins 1988a) and the Environmental Surveillance Procedures-Quality Control Program (Kimbrough et al. 1988). After being received, reviewed, and evaluated by the Environmental Management Department Assessment Group at the Y-12 Plant, all data will be reported to the RFI Project Manager, who will be responsible for the preparation of the RFI Report.

For statistical analysis, reported levels will be compared to typical levels found within the Oak Ridge Reservation. For example, surface water analytical results will be compared to waters of similar natural chemistry based on cation and on ion levels. Groundwater analytical results will be compared to results of waters from similar geologic formations.

Comparisons of data will be made using statistical methods such as can be found in Test Methods for Evaluating Solid Waste (SW-846) (USEPA 1986a).

# 13.0 HEALTH AND SAFETY PROCEDURES

## 13.1 INTRODUCTION

Specific requirements and procedures to protect the health and safety of the investigating team, the Y-12 Plant personnel, and the general public during the RCRA Facility Investigation (RFI) of Bear Creek are addressed in this section.

The RFI Plan - General Document, Volume I (Welch 1987a) describes the Health, Safety, Environmental, Security, Plant Protection, and Emergency Response organizations at the Y-12 Plant. These organizations provide support to the Y-12 Plant line organization to meet the requirements for health and safety during the RFIs. They provide 1) communications, response, and reporting for any plant emergency; 2) on-site medical facilities with medical surveillance, treatment, monitoring, and periodic physical examinations; 3) health physics and industrial hygiene surveillance; 4) hazard evaluation and control; 5) operational safety accident prevention and control; and 6) plant security and visitor control. A Site Health and Safety Officer (SHSO), who will be present during the on-site RFI activities, will be responsible for determining the level of protection required for sampling personnel. The SHSO also will be responsible for implementing the Health and Safety Plan onsite and for providing site-specific health and safety training.

The General Document also identifies the organizational responsibilities for health and safety at the Solid Waste Management Unit (SWMU) sites during RFIs. The document details the potential hazards that may be encountered, the methodology for establishing the work zones of each SWMU, the level of personal protection required, decontamination procedures, personnel exposure limits, monitoring requirements, and site emergency procedures.

## 13.2 KNOWN HAZARDS AND RISKS

### 13.2.1 Bear Creek Watershed

The Bear Creek Watershed has been used for disposal of a wide variety of liquid and solid wastes. Potential hazards at the disposal facilities

are primarily the special wastes, which may include asbestos, uranium metal, and beryllium oxide (BeO). However, these hazards have been minimized through use of specified disposal procedures developed for each type of waste. Additional hazards may exist for other metals, PCBs, and organic solvents.

### 13.2.2 Substance Summary List

The following list identifies hazardous contaminants found previously at elevated concentrations in Bear Creek surface water, sediments, floodplain deposits and in nearby groundwater:

| | |
|---|---|
| Uranium | Volatile Organics |
| Beryllium | PCBs |
| Cadmium | |
| Mercury | |
| Nitrate | |

## 13.3 LEVEL OF PROTECTION

The level of personnel protection required for RFI sampling activities at Bear Creek will be dictated by the location and type of sampling to be conducted. The activities planned consist of soil sampling, sediment sampling, well construction, groundwater sampling, and surface water sampling in Bear Creek, its tributaries and floodplain. Sampling activities will not penetrate waste deposits in any SWMUs but may penetrate historical deposits of contaminant releases in the floodplain of the creek. The personnel protection level recommended is Level D, which is defined in Welch (1987a). Well installation will entail the use of only hand tools, such as bucket augers; thus, no heavy equipment will be present. Workers will be required to wear steel-toed boots and safety glasses for foot and eye protection.

During sampling activities, the work areas will be monitored for organic airborne pollutants and total particulates. Monitoring for radiation will also be done as a precaution, although a radiation hazard is not expected to occur at Bear Creek sites. All monitoring will be

conducted in accordance with procedures described in the Martin Marietta Energy Systems QC Manual (Kimbrough et al. 1988).

If there is a need for increased protection, the protection level can be upgraded as described by Welch (1987a).

LEVEL OF PROTECTION

| Level Designation | | Monitoring Parameters | |
|---|---|---|---|
| A | | Organic Airborne Pollutants | |
| B | | Explosion Potential | |
| C | | Radiation | X |
| D | X | Total Particulates | X |

## 13.4 DESIGNATION OF WORK AREA ZONES

Because contamination which would pose a health hazard is not expected and the protection level is Level D, establishment of work area zones to control contamination is not required. If, however, the protection level is upgraded, three work area zones (Exclusion, Contamination Reduction, and Support) will be established in accordance with the methodology developed by Welch (1987a).

## 13.5 EXPOSURE LIMITS

If any of the following conditions occur, the SHSO will upgrade the protection level as described in Welch (1987a):

- Organic vapor levels exceeded background conditions for more than 1 min.

- Significant dusting ($\geq$ 5 mg/m$^3$, which is 1/2 of the TLV for nuisance dust) occurs anywhere in the immediate sampling location.

## 13.6 DECONTAMINATION PROCEDURES

There are no specific decontamination procedures required for Level D protection. However, workers should follow the standard safety practice of washing hands and face upon leaving the work area and before eating or drinking.

## 13.7 TRAINING REQUIRED

The OSHA basic 40-hr health and safety course will be provided for all field personnel prior to going onsite during the field investigation as required by OSHA for all employees engaged in hazardous waste activities (29 CFR Part 1910).

Because radiation is known to occur at low levels at Bear Creek, the field team will be given radiation safety training (including such topics as radiological hazards, appropriate protective clothing, operation and use of field survey instruments, and decontamination procedures) to ensure their safety in the event that radiation is detected.

## 13.8 PROCEDURES FOR WEATHER-RELATED PROBLEMS

Depending on the time of year, the SHSO must monitor all field team members for symptoms of heat stress or cold exposure. Procedures to minimize weather-related problems are discussed by Welch (1987a).

## 13.9 SITE EMERGENCY PROCEDURES

In the event of an emergency at Bear Creek the SHSO must immediately contact the Plant Shift Superintendent (PSS). At that time, all directives for safety and well-being will be initiated by the PSS. A form providing other important emergency information and contacts will be completed and made available to the field team. Table 13.1 is the emergency reference form.

Table 13.1. Emergency reference form

SITE: _____ PROJ. NO. _____

Emergency Information:

Local Resources: _____

Ambulance (Name): _____

Hospital (Name): _____

Police (Local or State): _____

Fire Department (Name): _____

Radio Channel: _____

Nearest Phone: _____

Project Manager: _____

Site Health and
Safety Officer: _____

Emergency Contacts (Medical and Health):

- 
- 
- 
- Poison Information Center:
- National Response Center
  (FOR ENVIRONMENTAL EMERGENCY ONLY) - 1-800-424-8802
- Office

Directions to Hospital:

# 14.0 SITE-SPECIFIC QUALITY ASSURANCE PROCEDURES

Strict quality assurance/quality control (QA/QC) procedures will be adhered to during the RCRA Facility Investigation for Bear Creek. General QA/QC requirements have been specified in the RCRA Facility Investigation Plan - General Document, Volume II: Quality Assurance Project Plan (QAPP) (Wiggins 1988a), the Environmental Surveillance Procedures, Quality Control Program (QC Manual) (Kimbrough et al. 1988), and the RCRA Facility Investigation Plan - General Document, Volume III: Data Management Plan (Wiggins et al. 1988b). Additional requirements are outlined below.

As a means to organize this section of the RFI Plan for Bear Creek the sixteen point outline for quality assurance project plans specified in the Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans (USEPA 1983) has been used. Of those sixteen elements, two have been omitted (Title Page/Introduction, Table of Contents) from this RFI Plan.

## 14.1 PROJECT DESCRIPTION

Because of the many activities that make up the 3004(u) RFI Program and the impact the sites could have on human health and the environment, it is necessary that a QA/QC program be established for the overall 3004(u) Program as well as the individual site-specific RFI projects. The QC Manual (Kimbrough et al. 1988) has been developed for use by all three DOE-Oak Ridge Operations (ORO) facilities. Outlined therein are the proper procedures for sampling methods, chain-of-custody, and other activities that are common to the Remedial Action Programs at the three facilities. The RFI QAPP (Wiggins 1988a) and RFI Data Management Plan (Wiggins et al. 1988) are companion documents that set forth QA and data management requirements specific to the Y-12 3004(u) Program. Finally, additional QA/QC procedures are included in the site-specific RFI plans. These four documents, the QC Manual, RFI QAPP, RFI Data Management Plan, and the site-specific RFI plan, comprise the QA/QC Program for each RFI Project.

The development of the four QA/QC documents is based on the USEPA document Draft RCRA Facility Investigation Guidance, Development of an RFI

Work Plan and General Considerations for RCRA Facility Investigations, Volumes I, II, III, and IV (USEPA 1987a).

## 14.2 PROJECT ORGANIZATION

The combined and organized efforts of several organizations within the Y-12 Plant are necessary for a successful RCRA 3004(u) Facility Investigation Program. The organizational structures for the RFI Program and for Facilities Quality Assurance are shown in Section 1.0 of the RFI QAPP (Wiggins 1988a).

## 14.3 QUALITY ASSURANCE OBJECTIVES FOR DATA MEASUREMENT

The quality of data necessary to fulfill the requirements of this investigation will follow guidance suggested in Data Quality Objectives for Remedial Response Activities (USEPA 1987b). The Data Quality Objectives (DQOs) set forth for Bear Creek will provide for the collection of field and analytical data, of known quality, that can be used for the phased site characterization and for risk assessment, if necessary. A risk assessment will be conducted only if the presence of environmental contamination poses a threat to public health and the environment.

### 14.3.1 Data Quality Levels

Data of two different quality levels will be generated during field investigations at Bear Creek. Data quality Levels I and III, as defined in Data Quality Objectives for Remedial Response Activities (USEPA 1987b), will be used. Field data, such as those data collected during organic vapor and radiation monitoring, will meet the requirements for Level I data quality. Analytical laboratory data generated from the analysis of surface and groundwater samples will meet the requirements for Level III data quality. The elements of Level I and Level III data quality are discussed below.

Level I requirements for field screening are designed to provide real-time data that may be used to refine sampling plans and to determine the extent of contamination at the site. Level I field analytical techniques will provide the following information during field

investigations at Bear Creek:

- Identification of soil which has a high likelihood of showing contamination through subsequent analysis.
- Real-time data to be used for health and safety considerations during site investigations.
- Quantitative data of total contaminants detected. Identification of contaminants at this site are unlikely.
- The presence or absence of contamination.

There are no data quality criteria specified for Level I because this level is characterized by the use of hand-held instruments and is not conducive to the generation of quantitative data. Documentation for field screening will be recorded in a field logbook. Information recorded should include sample identification, location, instrument reading, and calibration and blanks information.

Level III requirements for analytical laboratory support are designed to provide laboratory analysis using standard USEPA approved procedures. Specific laboratory QA/QC protocols are derived by the EPA approved methods. Analysis procedures for metals and organics may be similar to Contract Lab Program (CLP) procedures, but usually do not include the extent of validation and documentation required by CLP. Analyses conducted on samples collected from Bear Creek are designed to provide qualitative and quantitative data for organic and inorganic compounds in the surface water, sediment, floodplain soil, and groundwater at Bear Creek. Level III provides data of adequate quality for site characterizations and confirmation of field data, and can also provide data for risk assessment requirements. Level III laboratory analyses provide the following information from samples collected at Bear Creek:

- Data for use in evaluating the site for further action; and
- Data for use in risk assessments.

Data quality criteria specified for Level III are as follows:

- Detection limits for each analytical method will be consistent with USEPA approved methods. Table 14.2

lists the analytical procedures, suggested analytical methods, and reporting detection limits that will be used at Bear Creek.

- Laboratory QA/QC procedures will follow method specific requirements.
- Field QA/QC procedures will be assessed by reviewing data generated from the analysis of trip blanks, equipment blanks, and duplicate samples.

The type and amount of documentation for laboratory analysis will be determined by the requirements of each analytical procedure. Documentation for both analytical and field procedures are discussed in the RFI QAPP (Wiggins 1988a) and the Martin Marietta Energy Systems QC Manual (Kimbrough et al. 1988).

## 14.4 SAMPLING PROCEDURES

Sampling and analysis activities provide quantitative and qualitative data that will be used to determine the nature and extent of contaminant releases to Bear Creek and its floodplain. Sampling data generated by this investigation must be of acceptable quality and must be comparable to other data. To ensure the quality and consistency of data, specific sampling procedures should be followed. These procedures can be found in the ESP-300 series methods of the QC Manual (Kimbrough et al. 1988).

### 14.4.1 Location, Types, and Numbers of Samples

Samples collected at Bear Creek for the RFI investigation will include samples from surface water, groundwater, sediment and soil locations, as discussed in Chapters 8, 9, and 10 of this plan. Table 14.1 summarizes the sampling/monitoring locations and media. The numbers of samples collected and number of analyses estimated to be conducted are shown in Tables 14.2 and 14.3. In addition, field quality control samples will be collected and sent to the analytical laboratory.

Table 14.1. Proposed RFI Monitoring Sites and Media for Bear Creek. Hydrological and Biological Monitoring by Others Is Also Indicated.

| ite | Stream Discharge | Surface Water Sampling | Sediment Sampling | Floodplain Soil Sampling | Swale Soil Sampling | Shallow Groundwater Sampling | Biota Monitoring |
|---|---|---|---|---|---|---|---|
| BCK-0.63 | RFI | RFI | RFI | RFI | | | |
| ET-4 | | RFI | RFI | | | | |
| ET-3 | | RFI | RFI | | | | |
| BCK-2.88 | USGS[a] | | | | | | |
| ET-1 | USGS | | | | | | |
| BCK-3.28 | | | | | | | ORNL[b] |
| BCK-4.55 | USGS | RFI | RFI | | | | |
| SS-8 | | RFI | | | | | |
| SS-7 | | RFI | | | | | |
| BCK-4.68 | | | | RFI | | RFI | |
| NS-1 | | RFI | | | | | |
| NT-15 | USGS | | | | | | |
| BCK-6.22 | USGS | | | | | | |
| NT-14 | USGS | | | | | | |
| NT-13 | | RFI | RFI | | | | |
| BCK-7.87 | | | | | | | ORNL |
| BCK-7.90 | | | | RFI | | | |
| SS-6 | | RFI | | | | | |
| BCK-9.40 | RFI | RFI | RFI | | | | ORNL |
| SS-5 | | RFI | | | | | |
| NT-8 | | RFI | RFI | | | | |
| RC-6 | | | | | RFI | | |
| BCK-9.91 | | | | | | | ORNL |
| CK-9.99 | | | | RFI | RFI | RFI | |
| NT-7 | | RFI | RFI | | | | |
| SS-4 | | RFI | | | | | |
| RC-5 | | | | | RFI | | |
| BCK-10.27 | | | | RFI | | | |
| NT-6 | | RFI | RFI | | | | |
| NT-5 | | RFI | RFI | | | | |
| BCK-11.09 | | | | | | | ORNL |
| NT-4 | | RFI | RFI | | | | |
| RC-4 | | | | | RFI | | |
| BCK-11.28 | | | | RFI | | | |
| NT-3 | | RFI | RFI | | | | |
| SS-3 | | RFI | | | | | |
| SS-2 | | RFI | | | | | |
| RC-3 | | | | | RFI | | |
| BCK-11.83 | | | | | | | ORNL |
| BCK-11.84 | | | | RFI | | | |
| NT-2 | | RFI | RFI | | | | |
| BCK-11.97 | RFI | RFI | RFI | | | | |
| BCK-12.36 | | | | | | | ORNL |
| NT-1 | | RFI | RFI | | | | |
| SS-1 | | RFI | | | | | |

[a]USGS U. S. Geological Survey

[b]ORNL Oak Ridge National Laboratory

Table 14.2. Numbers of Samples and Quality Control for Water Samples

| Medium | Parameter | Number of Sites | Number of Sampling Events | Number of Samples | Duplicates[c] | QC Samples: Tri p Blanks[d] | QC Samples: Field Blanks[d] | QC Samples: Equipment Rinsate Blanks[d] | Total Samples |
|---|---|---|---|---|---|---|---|---|---|
| Surface Water[a] | Drinking Water Metals[f]<br>Arsenic<br>Barium<br>Cadmium<br>Chromium<br>Lead<br>Mercury<br>Selenium<br>Silver | 24 | 6 | 288 | 30 | | | | 318 |
| | Metals-ICP Scan[f] | 24 | 6 | 288 | 30 | | | | 318 |
| | Radiologicals<br>Radium<br>Gross Alpha<br>Gross Beta<br>Total Uranium<br>% Uranium-235<br>Gamma Spectrometry | | | | | | | | |
| | Volatile Organics | 24 | 6 | 144 | 15 | 8 | 8 | | 175 |
| | Base/Neutral Organics<br>PCBs | 24 | 6 | 144 | 15 | | | | 159 |
| | Inorganics<br>Sulfate<br>Fluoride<br>Nitrate<br>Chloride | 24 | 6 | 144 | 15 | | | | 159 |
| | Others<br>Alkalinity<br>Total Organic Carbon<br>Total Organic Halogen<br>Total Suspended Solids<br>Phenols<br>pH<br>Specific Conductance<br>Dissolved Oxygen | 24 | 6 | 144 | 15 | | | | 159 |

Table 14.2 (continued)

| Medium | Parameter | Number of Sites | Number of Sampling Events | Number of Samples | QC Samples: Duplicates[c] | Trip Blanks[d] | Field Blanks[d] | Equipment Rinsate Blanks[d] | Total Samples |
|---|---|---|---|---|---|---|---|---|---|
| Groundwater[a] (Vadose Zone) | Drinking Water Metals<br>Arsenic<br>Barium<br>Cadmium<br>Chronium<br>Lead<br>Mercury<br>Selenium<br>Silver | 2 | 4 | 24[g] | 2 | | | 1 | 27 |
| | Metals-ICP Scan | 2 | 4 | 24[g] | 2 | | | | 26 |
| | Radiologicals<br>Radium<br>Gross Alpha<br>Gross Beta<br>Gamma Spectrometry<br>Total Uranium<br>% Uranium-235 | 2 | 4 | 24[g] | 2 | | | 1 | 27 |
| | Volatile Organics | 2 | 4 | 24[g] | 2 | 1 | 1 | 1 | 29 |
| | Base/Neutral Organics<br>PCBS | 2 | 4 | 24[g] | 2 | | | 1 | 27 |
| | Inorganics<br>Sulfate<br>Fluoride<br>Nitrate<br>Chloride | 2 | 4 | 24[g] | 2 | | | 1 | 27 |
| | Others<br>Alkalinity<br>Total Organic Carbon<br>Total Organic Halogen<br>Total Suspended Solids<br>Phenols<br>pH<br>Specific Conductance | 2 | 4 | 24[g] | 2 | | | | 26 |

[a]See Tables 8.1 and 10.1 for analytical methods and reporting detection limits.
[b]Includes collection of 2 wet weather and 2 dry weather samples.
[c]Minimum 10% of field samples.
[d]One trip blank per cooler, one set of samples per cooler.
[e]One per piece of equipment used.
[f]Both filtered and unfiltered samples for metals analysis will be collected
[g]Three wells per site.

Table 14.3. Numbers of Samples and Quality Control for Sediment and Floodplain Soil Sampling

| Medium | Parameter | Number of Sites | Number of Sampling Events | Number of Samples | QC Samples: Duplicates[c] | QC Samples: Trip Blanks[d] | QC Samples: Field Blanks[d] | QC Samples: Equipment Rinsate Blanks[d] | Total Samples |
|---|---|---|---|---|---|---|---|---|---|
| Sediment[a] | Drinking Water Metals<br>Arsenic<br>Barium<br>Cadmium<br>Chromium<br>Lead<br>Mercury<br>Selenium<br>Silver | 15 | 1 | 15 | 3 | | | 1 | 19 |
| | Metals-ICP Scan | 15 | 1 | 15 | 3 | | | | 18 |
| | Radiologicals<br>Gross Alpha<br>Gross Beta<br>Gamma Spectrometry<br>Total Uranium<br>% Uranium-235 | | | | | | | | |
| | Volatile Organics | 15 | 1 | 15 | 3 | 2 | 2 | 2 | 24 |
| | PCBs | 15 | 1 | 15 | 3 | | | 2 | 20 |
| Sediment[a] | Others<br>Moisture Content<br>Total Organic Carbon | 15 | 1 | 15 | 3 | | | | 18 |
| Floodplain Soil[a] | Metals-ICP Scan | 7 | 1 | 105[e] | 10 | | 5 | | 120 |
| | Radiologicals<br>Gross Alpha<br>Gross Beta<br>Gamma Spectrometry<br>Total Uranium<br>% Uranium-235 | 7 | 1 | 105[e] | 10 | | 5 | | 120 |
| | PCBs | 7 | 1 | 105[e] | 10 | | 5 | | 120 |
| | Others<br>Moisture Content<br>Total Organic Carbon | 7 | 1 | 105[e] | 10 | | | | 120 |

Table 14.3 (continued)

| Medium | Parameter | Number of Sites | Number of Sampling Events | Number of Samples | QC Samples: Duplicates[c] | Trip Blanks[d] | Field Blanks[d] | Equipment Rinsate Blanks[d] | Total Samples |
|---|---|---|---|---|---|---|---|---|---|
| Swale Soil | Drinking Water Metals<br>Arsenic<br>Barium<br>Cadmium<br>Chromium<br>Lead<br>Mercury<br>Selenium<br>Silver | 5 | 1 | 5 | 1 | | 1 | | 7 |
| | Metals-ICP Scan | 5 | 1 | 5 | 1 | | | | 6 |
| | Radiologicals<br>Gross Alpha<br>Gross Beta<br>Gamma Spectrometry<br>Total Uranium<br>% Uranium-235 | 5 | 1 | 5 | 1 | | 1 | | 7 |
| | PCBs | 5 | 1 | 5 | 1 | | 1 | | 7 |

[a]See Table 9.1 for analytical methods and reporting detection limits.

[b]Minimum of 10% of field samples.

[c]One trip blank per cooler, one set of samples per cooler.

[d]One per piece of equipment used.

[e]Assumes an average of 3 cores per site and 5 depth intervals per core.

### 14.4.2 Sample Preservation

Appropriate sample preservatives, sample containers, and analytical holding times are found in Method ESP-701 of the QC Manual (Kimbrough et al. 1988). Preservatives specific to analytical procedures selected for use at Bear Creek will be added to the sample containers by a laboratory technician before the containers are provided to the field sampling team.

## 14.5 SAMPLE AND DOCUMENT CUSTODY PROCEDURES

An essential part of any program that requires sampling and analysis is ensuring the sample integrity from collection to data reporting. This includes the ability to trace the possession and handling of samples from the time of collection through analysis and final disposition. This documentation of the history of the sample is referred to as chain-of-custody. Specific chain-of-custody procedures for the RFI Program can be found in Method No. ESP-500 in the QC Manual (Kimbrough et al. 1988) and in Section 8.5 of the RFI QAPP (Wiggins 1988a).

## 14.6 CALIBRATION PROCEDURES AND FREQUENCY

An important consideration in any environmental measurement is the calibration of the measurement system. An improperly and/or infrequently calibrated system may have a serious negative impact on the precision and accuracy of the determinations. The result will be erroneous data and the need to repeat measurements (USEPA 1987a). Field instrumentation will be calibrated according to the frequencies specified in Table 14.4 and according to the procedures specified in the manufacturer's operating manual for the particular instrument. Laboratory analysis instrumentation will be calibrated according to the procedures specified in the analytical methods and operating manual for the particular instrument and will be fully documented in the laboratory's specific quality control manual.

Table 14.4. Quality Assurance Procedures for Field Analysis and Equipment

| Instrument | General | Daily | Quarterly |
|---|---|---|---|
| 1. pH | | | |
| Electrode Method | Enter the make, model serial and/or identification (ID) number for each in a logbook. | 1. Calibrate the system against standard buffer solution of known pH value at the start of a sampling run.<br>2. Periodically check the buffers during the sample run and record the data in the log sheet or book.<br>3. Be on the alert for erratic meter response arising from weak batteries, cracked electrode, and fouling, etc. | Take all meters to laboratory for for maintenance, calibration and quality control checks. |
| 2. Conductivity | Enter the make, model, serial and/or ID number for each meter in a logbook. | 1. Standardize with potassium chloride standards having similar specific conductance values to those anticipated in the samples. Calculate the cell constant using two different standards. | Take all meters to lab for maintenance, calibration and quality control checks. |
| and replatinize if necessary. | | | Check date of last platinizing |
| | | Cell Constant = Standard Value<br>Actual Value<br>Specific Conductance = Reading multiplied by Cell Constant | Analyze National Bureau of Standards or USEPA reference standard and record actual vs. observed readings in the log. |
| | | Rinse cell after each sample to prevent carryover. | |
| 3. Organic Vapor Analyzer | For operational check, take background and felt tip marker readings. | Conduct operational check. | |
| 4. Toxic gases and vapors--Photoionization detector. | For operational check, take background and felt tip marker readings. | Conduct operational check. | |
| 5. Measuring Devices | Enter model and serial or ID number in log book. | | |

Source: Taken from White Oak Dam Project Quality Assurance Project Plan (ORNL 1988).

## 14.7 ANALYTICAL PROCEDURES

Analytical procedures will be in accordance with those provided in Test Methods for Evaluating Solid Waste (USEPA 1986a), Methods for Chemical Analysis of Waters and Wastes (USEPA 1983a), Guidelines Establishing Test Procedures for the Analysis of Pollutants under the Clean Water Act, USEPA 40 CFR Part 136, and Martin Marietta Energy Systems Environmental and Effluent Analysis Manual (MMES 1986). A listing of the recommended methods and detection limits to be used for samples collected at Bear Creek is provided in Tables 14.2 and 14.3.

## 14.8 DATA REDUCTION, VALIDATION, AND REPORTING

Data reduction, validation and reporting applies to all measurements performed in support of the RFI. Data reduction methods will be identified early in the investigation and will include all equations used to calculate the concentration or value of the measured parameter and the reporting units. Data validation is the process of reviewing data and accepting or rejecting it based on sound criteria. These criteria must be appropriate for each type of data and for the purpose of the measurement. Records of all data should be maintained. Specific data management procedures and criteria to address these issues can be found in the RFI Data Management Plan (Wiggins et al. 1988b).

## 14.9 INTERNAL QUALITY CONTROL CHECKS

Several quality control checks will be utilized during this investigation. These will help to insure that the data collected during this investigation is as complete, accurate,and precise as possible. Quality control checks will be conducted to assess both field and laboratory procedures.

### 14.9.1 Field Quality Control Checks

Three types of field blanks will be collected, each measuring the quality of different phases of sampling. The three types include:

### 14.9.2 Trip Blanks

Trip blanks are used predominantly during the analysis of volatile organic compounds (VOCs). Trip blanks will be carried along with the sample containers throughout the entire sample preparation and analytical process. Each trip blank will consist of two septum vials which will be filled with deionized water of known purity. No headspace will be left in the vials. The vials will be sealed in a ziploc bag with other VOC samples and transported to the laboratory. A trip blank will be placed in each sample transportation container (cooler, ice chest, etc.), and will be analyzed by the laboratory for the appropriate constituents. Trip blanks are useful in determining if cross contamination has occurred during sample collection or while in transport to the field or to the laboratory. As a minimum, one trip blank will be prepared and transported with every packed cooler containing VOC samples.

### 14.9.3 Field Blanks

If on-site monitoring indicates the presence of organic vapors, a field blank may be taken at the discretion of the field supervisor or project manager. Field blanks are prepared using the same procedure as preparing trip blanks but will be prepared at the sampling site. Field blanks are taken by filing two 50 ml septum vials with deionized water while in the field. The vials will then be sealed in a ziploc bag, placed on ice, and transported to the laboratory with the other collected samples. The field blanks will be analyzed by the laboratory for the appropriate constituents. Field blanks are used to measure the influence of ambient conditions at a particular sampling location or site. One field blank may be collected for VOCs at a particular sampling location.

### 14.9.4 Equipment Rinsate Blanks

Equipment rinsate blanks will be utilized during the investigation to determine the effectiveness of decontamination procedures and to insure that samples are not being biased in any way by the equipment used to collect them. One equipment blank will be taken from each type of equipment used per sampling event or one blank for every 20 field samples collected. Deionized water will be used to rinse decontaminated field equipment. The rinsate will be collected into sample containers and preserved and handled in the same manner as the

environmental samples. The field supervisor or project manager will determine which particular piece of equipment from each equipment type will require rinse blanks. Cleaning and decontamination procedures for sample containers, sampling devices, and other equipment can be found in Procedures ESP-900 and ESP-901 in the Energy Systems QC Manual (Kimbrough et al. 1988).

### 14.9.5 Duplicate Samples

Duplicate samples will be utilized to determine the variability in sampling technique or method. Duplicate samples are co-located samples taken in the same manner at the same time. The sample load will dictate the frequency of samples to be duplicated. A minimum of 10 percent of the samples taken will be duplicates per sampling event and per sample matrix (soil, surface water, etc.). When groundwater is being sampled, one well will be duplicated per sampling event. The field supervisor or project manager will determine the sampling location that is to be duplicated.

### 14.9.6 Field Calibration

To insure the accuracy of field measurements such as pH, temperature, conductivity, etc., field instruments will be calibrated according to the guidelines in Table 14.5. Actual calibration procedures will follow those in the manufacture's operating manual for a particular instrument. The concentration of all standards used in calibration should be verified against samples of known concentration which are obtained from a laboratory or other outside source. If the instrument's response varies by more than 10 percent from the predicted response from that parameter, the measurement will be repeated using a fresh calibration standard. A logbook of all calibration data for field instruments will be kept up to date at all times.

## 14.10 LABORATORY QUALITY CONTROL CHECKS

Laboratory accuracy and precision can be assessed by utilizing laboratory quality control checks. Analytical instrument performance and analytical technique must be monitored on a routine basis. Since laboratory quality control checks are in many cases method specific, such procedures to be used by the laboratory must be documented in the analytical Laboratory QA/QC Manual. These procedures must be consistent with protocol suggested in appropriate USEPA methodologies and guidance documents.

## 14.11 PERFORMANCE AND SYSTEMS AUDITS

Systems audits are qualitative evaluations of all components of measurement systems to determine their proper selection and use. These audits include a careful review of all data gathering activities and their appropriate quality control procedures. These are normally performed prior to, or shortly after, systems are operational. The primary objective of systems audits is to ensure that QA/QC procedures are being adhered to (USEPA 1987a).

After systems are operational and generating data, performance audits are conducted periodically to determine the accuracy of the total measurement system or component parts thereof. Performance audits are quantitative evaluations of the measurement parameter where all measurement systems are included (USEPA 1987a).

Audits should be performed by personnel who have no direct responsibility for the activities being audited. They should be performed in accordance with written procedures or checklists. Results of audits should be reported to, and reviewed by, the management responsible for the program. If follow up activities are indicated, they shall be taken.

Specific auditing procedures are specified in Section 18.0 of the RFI QAPP (Wiggins 1988a).

## 14.12 PREVENTATIVE MAINTENANCE

Preventative maintenance schedules assure the maximum amount of active time for analytical and field instruments and computer hardware over the course of the RFI program. A schedule will be made of important preventative maintenance tasks that will be carried out to minimize downtime of all

measurement systems. Also, a critical spare parts inventory will be maintained to minimize downtime. Manufacturer's operating manuals will be used to establish schedules for preventative maintenance on instruments and other equipment. The manuals will also be used to provide specifications for ordering critical spare parts.

## 14.13 DATA MEASUREMENT ASSESSMENT PROCEDURES

Quality assurance objectives for measurement data are expressed in terms of accuracy, precision, completeness, representativeness, and comparability. QA objectives provide the mechanism for ongoing control and assessment of data throughout the RFI project and will be used to define data quality of the measured parameters.

Accuracy is a measure of bias in a system. Accuracy values include components of both random error and systematic error. Both components may reflect the total error for a given measurement, expressed as a percentage of the true value. Precision is a measure of mutual agreement among individual measurements of the same property. Precision is best described as standard deviation and can be used to measure variability of replicate measurements. Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount expected to be obtained under ideal conditions. Representativeness is the degree to which data accurately and precisely represents variations at a sampling point. Representativeness is best evaluated by ensuring acceptable precision and accuracy as measured by analysis of field QC samples. Finally, comparability is the confidence with which one data set can be compared to another. The use of standard units for reporting data will achieve the comparability goal. Each of these quality assurance objectives and their uses are further defined in the RFI Plan - General Document, Volume III: Data Management Plan (Wiggins et al. 1988b).

## 14.14 CORRECTIVE ACTION

Corrective actions are those measures taken to rectify a measurement system that is out of control that may adversely impact either the reliability of the RFI project data or the environment, safety, or health. Procedures for corrective action are detailed in Section 16.0 of the RFI QAPP (Wiggins 1988a).

## 14.15 QUALITY ASSURANCE REPORTS TO MANAGEMENT

Communication between the Y-12 Facilities Quality Assurance and the RCRA 3004(u) management organization will always be maintained. Regular appraisal by the RFI management of the quality aspects related to the ongoing data gathering efforts provides the mechanism whereby the established objectives may be met. Reports to management should include: periodic assessment of measurement data accuracy, precision, and completeness; results of performance audits; results of systems audits; significant QA/QC problems and recommended solutions; and, resolutions of previously stated problems (USEPA 1987a).

Further information on reporting of quality assurance data to management can be found in Section 2.4 of the RFI QAPP (Wiggins 1988a).

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# APPENDIX A. CHARACTERISTICS OF WATER AND SLUDGES FROM THE S-3 PONDS AND UPPER BEAR CREEK (BLUE LAGOON)

Table A.1. Ranges[a] of S-3 pond water and sludge characteristics prior to neutralization and denitrification

| | Water (mg/L) | Sludge (μg/g) |
|---|---|---|
| pH | 0.9-2.4 | --- |
| Specific Gravity | 1.0000-1.0191 | --- |
| Nitrate | 6700-85,000 | --- |
| Chloride | 190-1000 | --- |
| Perchloroethylene | ND-21 | --- |
| PCBs | <0.0005-0.017 | --- |
| Uranium | 26-600 | 280-620 |
| Silver | <0.02-0.08 | 2.1-17 |
| Aluminum | 288-1653 | 21640-59000 |
| Arsenic | <0.3 | 15-32 |
| Boron | 3.8-16.7 | 56-139 |
| Barium | 0.26-5.7 | 286-429 |
| Beryllium | 0.03-0.11 | 1.3-16.4 |
| Calcium | 395-3059 | 894-3960 |
| Cadmium | 0.19-1.1 | <0.6 |
| Cerium | <0.15 | 46-73 |
| Cobalt | 0.12-0.85 | <0.01-3.3 |
| Chromium | 2.5-24 | 48-163 |
| Copper | 2.6-39 | 111-145 |
| Fe | 24-662 | 8230-92,000 |
| Gallium | <0.1 | 1.6-34 |
| Hafnium | <0.1-0.5 | 4.9-19 |
| Mercury | <0.001-0.62 | 0.21-12 |
| Potassium | 38-322 | 8000-23800 |
| Lanthanum | <0.001-0.04 | 25-46 |
| Lithium | 4.5-34 | 29-47 |
| Magnesium | 87-335 | 1600-4400 |
| Manganese | 3.0-17.7 | 46-112 |
| Molybdenum | 0.25-1.7 | 30-192 |
| Sodium | 519-1960 | 1430-2040 |
| Niobium | 0.007-0.82 | 31-137 |
| Nickel | 22-72 | 61-99 |
| Phosphorus | 5.2-86 | 1330-6900 |
| Lead | 0.53-14.5 | 120-207 |
| Scandium | <0.003-0.15 | 4.6-8.4 |
| Selenium | <0.002 | <0.2 |
| Silica | <0.01-7.0 | 23-666 |
| Strontium | 0.70-4.1 | 40-66 |
| Thorium | 0.01-12.2 | 150-529 |
| Titanium | 0.04-3.9 | 3630-5210 |
| Vanadium | <0.02-0.18 | 26-65 |
| Yttrium | 0.07-0.32 | 8.4-12.5 |
| Zinc | 3.2-14.1 | 34-95 |
| Zirconium | 0.08-33 | 818-3370 |

Table A.1. (continued)

| | Water (mg/L) | Sludge (μg/g) |
|---|---|---|
| $^{241}Am$ (pCi) | <0.2-1.0 | <1.7 |
| $^{238}Pu$ (pCi) | 0.04-3.42 | 39-174 |
| $^{239,240}Pu$ (pCi) | 0.07-1.60 | 18-65 |
| $^{237}Np$ (pCi) | 0.74-6.6 | 2.0-5.1 |
| Gross Alpha (pCi) | 29-590 | 795-3260 |
| $^{99}Tc$ (pCi) | 20-134 | 73-6390 |
| Gross Beta (pCi) | 58-840 | 466-7890 |
| $^{137}Cs$ (pCi) | <1 | <1 |
| $^{95}Zr$-Nb (pCi) | <1 | <1 |
| $^{106}Ru$ (pCi) | <1 | <1 |
| $^{235}U$ (%) | 0.30-0.43 | 0.37-0.62 |
| $^{238}U$ (%) | 99.50-99.70 | 99.40-99.60 |

[a]Data summarized from Y-12 Report Y/MA-6400 "The Chemical and Radiological Characterization of the S-3 Ponds" July 14, 1983.

Table A.2. Composition of S-3 pond sludges following neutralization and denitrification of pond water

| Analytes | Cells Sampled SW* | NW | NE | SE | Average | Quality Assurance Duplicate SW |
|---|---|---|---|---|---|---|
| % Moisture | 81.8 | 80.1 | 78 | 80 | 80.2 | 81.7, 81.8 |
| Ave Depth (ft) | 2.0 | 3.17 | 4.58 | 4.50 | 3.1 | |
| Density (g/ml) | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | |
| **Analyses (μg/g wet weight)** | | | | | | |
| Oil & Grease | 2400 | 1000 | 1000 | 3300 | 1925 | - - |
| TOC | 1300 | 220 | 440 | 760 | 680 | 1280; 1320 |
| Total C (%) | 1.72 | 1.25 | 0.90 | 1.20 | 1.27 | 1.74; 1.70 |
| CN | 3 | 2 | 4 | 8 | 4.3 | 3; 3 |
| $NO_3$ as $NO_3$ | 88 | 4030 | 6100 | 1950 | 3067 | |
| $NO_3$-N | 20 | 910 | 1400 | 440 | 682 | 20; 19 |
| TKN-N | 420 | 260 | 260 | 460 | 350 | 420; 420 |
| Total N-N | 440 | 1200 | 1700 | 900 | 1060 | 440; 440 |
| $SO_4$ | 900 | 2200 | 2000 | 2200 | 1825 | 900; 900 |
| Dates Sampled | 11/28/84 | 11/28/84 | 11/29/84 | 11/29/84 | | |

*Average of duplicate quality assurance data.

Table A.2 (continued)

| Analytes | Cells Sampled SW* | NW | NE | SE | Average | Quality Assurance Duplicate SW |
|---|---|---|---|---|---|---|
| **Analyses, Total (µg/g wet wt)** | | | | | | |
| Ag | 0.3 | 0.3 | 3 | 0.6 | 4.20 | <1; <0.6; <0.6 |
| Al | 21,100 | 13,000 | 12,400 | 11,400 | 14,500 | 20,600; 21,000; 22,000 |
| As | <0.4 | <0.4 | <0.4 | <0.4 | <0.4 | <0.4; <0.4 |
| B | 27 | 13 | 38 | 43 | 30 | 27; 27; 27 |
| Ba | 130 | 44 | 120 | 39 | 330 | 130; 130; 130 |
| Be | 2.9 | <1 | <1 | 1 | 1.3 | 3; 2.9; 2.7 |
| Ca | 29,200 | 45,000 | 47,000 | 45,000 | 41,500 | 29,500;29,000;29,000 |
| Cd | 2.6 | 4 | 7 | 2 | 3.9 | 2; 2.9; 2.9 |
| Ce | <6 | <6 | <6 | <6 | <6 | <6; <6; <6 |
| Co | 1.8 | 3 | 2 | 2 | 2.2 | 3; 2.7; 2.7 |
| Cr | 140 | 95 | 100 | 100 | 109 | 140; 140; 140 |
| Cr (VI) | <0.1 | <0.1 | 0.2 | 0.2 | 0.1 | - - |
| Cu | 88 | 78 | 100 | 90 | 89 | 88; 87; 89 |
| Fe | 3,000 | 3,100 | 1,300 | 2,100 | 2375 | 3000; 3100; 2,900 |
| Ga | <6 | <6 | <6 | <6 | <6 | <6; <6; <6 |
| Hg | 1.8 | 0.3 | 0.7 | 1.3 | 1.0 | 1.5;2.0 |
| K | 1300 | 540 | 100 | 120 | 515 | 1300; 1300; 1300 |
| La | <0.8 | <2 | <2 | <2 | <2 | <2; <0.2; <0.2 |
| Li | 76 | 36 | 77 | 36 | 56 | 76; 76; 76 |

Table A.2. (continued)

| Analytes | Cells Sampled SW* | NW | NE | SE | Average | ty Assurance Duplicate SW |
|---|---|---|---|---|---|---|
| Mg | 1500 | 1500 | 1700 | 1500 | 1550 | 1500; 1500; 1500 |
| Mn | 68 | 95 | 63 | 62 | 72 | 68; 68; 68 |
| Mo | 13 | 11 | 9 | 19 | 13 | 13; 13; 13 |
| Na | 2900 | 990 | 1300 | 1200 | 1600 | 2900; 2900; 2900 |
| Nb | 15 | 11 | 26 | 21 | 18 | 15; 15; 15 |
| Ni | 570 | 230 | 360 | 360 | 380 | 500; 500; 700 |
| P | 990 | 470 | 750 | 640 | 710 | 990; 990; 990 |
| Pb | 35 | 16 | 36 | 32 | 30 | 35; 35; 33 |
| Sc | 1 | 1 | <1 | <1 | 1 | 1; 0.8; 1 |
| Se | <0.8 | <0.8 | <0.8 | <0.8 | <0.8 | <0.8; <0.8 |
| Sn | 0.6 | 0.8 | 1.6 | 1.8 | 1.2 | 0.4; 0.8 |
| Sr | 35 | 33 | 30 | 18 | 29 | 35; 35; 33 |
| Th | 150 | 270 | 61 | 79 | 140 | 150; 150; 150 |
| Ti | 350 | 190 | 97 | 64 | 175 | 350; 350; 350 |
| Tl | 0.2 | 0.3 | 0.1 | 0.4 | 0.25 | 0.2; 0.2 |
| V | 5.7 | 5 | <1 | 1 | 3.2 | 6; 5.6; 5.4 |
| Y | 3.9 | 2 | 2 | 2 | 2.5 | 4; 3.9; 3.9 |
| Zn | 58 | 35 | 32 | 32 | 39 | 58; 58; 58 |
| Zr | 490 | 170 | 420 | 180 | 315 | 490; 500; 470 |
| U | 769 | 993 | 1040 | 926 | 930 | 740; 798 |
| U-235% | 0.39% | 0.29% | 0.33% | 0.34% | 0.34% | 0.35; 0.42 |
| Dates Sampled | 11/28/84 | 11/28/84 | 11/29/84 | 11/29/84 | | |

*Average of duplicate quality assurance data.

Table A.2 (continued)

| Analytes | Cells Sampled SW* | NW | NE | SE | Average | Quality Assurance Duplicate SW |
|---|---|---|---|---|---|---|
| pCi/g wet wt. | | | | | | |
| Alpha Activity | 895 | 420 | 960 | 870 | 790 | 910; 880 |
| Beta Activity | 1150 | 680 | 1300 | 2100 | 1310 | 1200; 1100 |
| Non-U gamma Act. | | | | | | |
| Cs-137 | <5 | <5 | <5 | <5 | <5 | <5; <5 |
| Ru-106 | 19 | <5 | 43 | 23 | 23 | 20; 18 |
| Np-237 | 7.1 | 5.7 | 12 | 8.0 | 8.2 | 6.5 ;7.6 |
| Pu-238 | 27 | 15 | 3.1 | 5.5 | 12.7 | 29; 25 |
| Pu-239,240 | 2.6 | <1.6 | 2.3 | <1.6 | 2.0 | 2.9; 2.3 |
| Sr-90 | 14 | 4.2 | 5.0 | 10 | 8.3 | 14;13 |
| Tc-99 | 930 | 1200 | 790 | 12,000 | 3730 | 980; 880 |
| Th-228 | 280 | 160 | 270 | 210 | 230 | |
| Th-230 | 520 | 210 | 370 | 570 | 418 | |
| Th-232 | 47 | 100 | 15 | 32 | 49 | |
| Zr-95 | ND | ND | ND | ND | ND | |
| Dates Samples | 11/28/84 | 11/28/84 | 11/29/84 | 11/29/84 | | |

*Average of duplicate quality assurance data.

ND = Not detected

Table A.2 (continued)

| Analytes | Cells Sampled SW* | NW | NE | SE | Average | Quality Assurance Duplicate SW |
|---|---|---|---|---|---|---|
| **Volatile Organic Analysis** (mg/l wet weight) | | | | | Note 2 | |
| Tetrachloroethene | - | 0.0032[1] | 0.0016[1] | | 0.0012 | 0.0036; 0.0037 |
| Freon 113 | 0.0036[1] | - | - | | 0.0009 | |
| All others total | 0.0085 | <0.01 | <0.01 | <0.01 | <0.01 | 0.0098; 0.0072 |
| **PCB Analyses** (ug/g wet weight) | | | | | | |
| Total PCB | 0.88 | 0.4 | 6 | 4 | 2.8 | |
| Aroclor 1248 | 0.88 | 0.4 | 6 | 4 | 2.8 | |
| **Acid Base/Neutral Fraction Analyses** (ug/g wet weight) | | | | | | |
| Tetrachloroethene | 6.6 | 1.2 | 14 | 4.1 | 6.5 | 6.2; 6.9 |
| Phenol | 76 | 4.8 | 72 | 7.0 | 40 | 77; 74 |
| Hydrocarbon (C11-C18) | 1.6 | - | - | - | 0.4 | 1.8; 1.3 |
| 3(1,1-Dimethylethyl)-Phenol | 67 | 1.7 | 24 | 4.9 | 24 | 70; 63 |
| Hydrocarbon (C9-C13) | 1.6 | - | - | - | 0.4 | -; 1.6 |
| Hydrocarbon (C10-C21) | 2.4 | - | - | - | 0.6 | 2.5; 2.2 |
| Hydrocarbon (C12-C26) | 2.6 | - | - | - | 0.6 | 2.7; 2.4 |
| Hydrocarbon (C16-C26) | 3.0 | - | - | - | 0.7 | 3.3; 2.6 |
| Hydrocarbon (C17-C25) | 3.5 | - | - | - | 0.9 | 4.2; 2.7 |
| Hydrocarbon (C17-C26) | 2.8 | - | - | - | 0.7 | 3.5; 2.0 |
| Hydrocarbon (C18-C26) | 1.7 | - | - | - | 0.4 | 1.3; 2.0 |
| Hydrocarbon (C19-C25) | 2.4 | - | - | - | 0.6 | 2.7; 2.0 |
| Hydrocarbon (C20-C25) | 1.4 | - | - | - | 0.4 | 1.6; 1.2 |
| Diethyl Phthalate | 3.6 | 3.4 | 5.5 | 5.6 | 4.5 | 4.2; 2.9 |
| Triphenyl Ester Phosphoric Acid | - 7.8 | 1.5 - | - - | 1.6 - | 0.8 1.9 | 7.5; 8.1 |

Table A.2. (continued)

| Analytes | Cells Sampled SW* | NW | NE | SE | Average | Quality Assurance Duplicate SW |
|---|---|---|---|---|---|---|
| Unidentified (possible silane) | 175 | 15 | 15; 3.1 | 14 | 55 | 166; 183 |
| Unidentified methylester | 161 | 9.7 | | 13 | 45 | 143; 179 |
| 1,1,2,2-Tetrachloroethane | 3 | 1.2 | 5.5 | 2.0 | 2.9 | 1.6; 0.64 |
| A Dimethylphenol | 0.87[3] | - | - | - | 0.2 | 1.0; 0.73 |
| A Dimethylphenol | 0.92[3] | - | - | - | 0.2 | 1.2; 0.64 |
| Hydrocarbon (C15-C27) | 1.06[3] | - | - | - | 0.3 | 1.2; 0.91 |
| Hydrocarbon (C25-C43) | 0.78[3] | - | - | - | 0.2 | 1.0; 0.55 |
| 2 Butoxylethanol | - | 1.1 | 24 | 2.8 | 7 | |
| 2(2-Butoxyethoxy)-Ethanol | - | 1.4 | 20 | 3.1 | 6.1 | |
| Hydrocarbon (C12-C14) | - | - | - | 1.7 | 0.4 | |
| Hydrocarbon (C10-C15) | - | - | - | 2.4 | 0.6 | |
| Hydrocarbon (C10-C12) | - | - | - | 2.1 | 0.5 | |
| Hydrocarbon (C10-C14) | - | - | - | 2.1 | 0.5 | |
| 1-(2-Butoxythoxy)-ethanol | - | 2.5 | - | 11 | 3.4 | |
| Octamethyl-Cyclotetrasiloxane | - | - | 130 | 10 | 35 | |
| 1,1,2-Trichloroethane | - | - | - | 0.79[3] | 0.2 | |
| Hydrocarbon (C11-C13) | - | - | - | 0.39[3] | 0.2 | |
| Hydrocarbon (C10-C16) | - | - | - | 0.66[3] | 0.2 | |
| Hydrocarbon (C11-C14) | - | - | - | 0.79[3] | 0.2 | |
| 2-Hexanol | - | 3.1 | - | - | 0.8 | |
| A Methyl Phenol | - | 3.5 | - | - | 0.9 | |
| Dates Sampled | 11/28/84 | 11/28/84 | 11/29/84 | 11/29/84 | | |

[1]By GC.

[2]Sample contained a heavy surfactant.

[3]Detected but below recommended detection limit.

Table A.3. Composition of sludges in UBC lagoons near BCK 12.46. Sampled March 1984 (see Turner and Kamp 1984)

| | Western Lagoon | Eastern Lagoon |
|---|---|---|
| Major Constituents[a] (%, dry weight) | | |
| Calcium | 0.24 | 0.52 |
| Magnesium | 0.43 | 0.46 |
| Sodium | 0.15 | 0.21 |
| Potassium | 1.3 | 1.1 |
| Iron | 2.7 | 2.4 |
| Aluminum | 9.6 | 15.0 |
| Trace Constituents[a] (μg/g, dry weight) | | |
| Barium | 310 | 200 |
| Beryllium | 6 | 10 |
| Boron | 43 | 46 |
| Cadmium | <5 | <5 |
| Cerium | 91 | 190 |
| Cobalt | 30 | 19 |
| Chromium | 86 | 100 |
| Copper | 100 | 140 |
| Gallium | <30 | <31 |
| Lanthanum | 40 | 56 |
| Lithium | 95 | 100 |
| Manganese | 340 | 330 |
| Molybdenum | <8 | <8 |
| Niobium | 9 | <5 |
| Nickel | 71 | 69 |
| Phosphorus | 450 | 530 |
| Lead | 47 | 66 |
| Scandium | 7 | 8 |
| Strontium | 56 | 47 |
| Thorium | 35 | 43 |
| Titanium | 3500 | 2600 |
| Uranium | 1600 | 4900 |
| Vanadium | 57 | 45 |
| Yttrium | 43 | 96 |
| Zinc | 160 | 180 |
| Zirconium | 130 | 75 |
| Radionuclides (pCi/g) | | |
| Gross Alpha | 770 | 1500 |
| Gross Beta | 1200 | 2600 |
| Technetium-99 | 56 | 91 |
| Uranium-238 | 880 | 2675 |
| Uranium-234 | 246 | 755 |

Table A.3. (continued)

| | Western Lagoon | Eastern Lagoon |
|---|---|---|
| Uranium-235 (%) | 0.32 | 0.34 |
| Plutonium-238 | <1 | <1 |
| Plutonium-239 & 240 | <1 | 1.3 |
| Neptunium-237 | 2.5 | 1.5 |
| Cobalt-60 | <1 | <1 |
| Cesium-137 | <1 | <1 |
| Lead-212 | 3.8 | 7.5 |
| Thallium-208 | 9 | --- |
| Zirconium-95 + Niobium-95 | 2.3 | 20 |
| Organic Constituents[b] (μg/g) | | |
| 1,1,2,2-Tetrachloroethylene | <0.01 | 0.089 |
| 4-Nitrophenol | <0.5 | 1.4 |
| Naphthalene | <0.2 | 0.22 |
| Phenanthrene | <0.2 | 0.36 |
| Fluoranthene | 0.3 | 0.46 |
| Pyrene | 0.28 | 0.36 |
| Bis(Z)-ethyhexylphthalate | <0.2 | 0.46 |
| Benzo(b)fluoranthene | 0.34 | 0.28 |
| Benzo(k)fluoranthene | 0.34 | 0.28 |
| Chrysene | 0.32 | <0.2 |
| Benzo(A)pyrene | 0.32 | <0.2 |
| Cyanide | 2.0 | 1.5 |
| Priority Pollutant Metals[c] (μg/g) | | |
| Antimony | <0.04 | <0.05 |
| Arsenic | 155 | 210 |
| Beryllium | 2.2 | 3.4 |
| Cadmium | 2.2 | <0.2 |
| Chromium | 33 | 37 |
| Copper | 77 | 99 |
| Lead | 127 | 220 |
| Mercury | 16 | 20 |
| Nickel | 49 | 41 |
| Selenium | 4.4 | <0.5 |
| Silver | <0.4 | <0.6 |
| Thallium | 15 | 0.5 |
| Zinc | 33 | <0.2 |

[a]Digestion by hydrofluoric/nitric acid-ICP emission spectroscopy.
[b]Only compounds which occurred above detection limits are shown.
[c]Digestion by nitric acid/hydrogen peroxide (EPA Method 3050)-ICP emission spectroscopy.

# APPENDIX B. COMPOSITION OF WASTE OILS, OILY WASTE AND MACHINE COLLANTS GENERATED AT THE Y-12 PLANT

Table B.1. Typical composition of oily wastes generated at the Y-12 Plant[a]

| Description | Density (lb/gal) | Density ($g/cm^3$) | Carbon (%) | Hydrogen (%) | Uranium ($\mu g/g$) |
|---|---|---|---|---|---|
| Waste Oil Composite | 7.41 | 0.9 | 73.10 | 11.73 | 4 |
| Machine Coolant Composite | 8.15 | 1.0 | 12.40 | 7.43 | 23 |
| Machine Coolant and Mop Water Mixed | 8.26 | 1.0 | 3.30 | 7.41 | 35 |
| Waste Oil fromn Ponds | 7.40 | 0.9 | 83.01 | 12.79 | 49 |

[a]From UCC-ND Report Y-1934, "Disposal of Oily Wastes by Microbial Assimilation," May 16, 1974.

Table B.2. Spectrographic analyses of samples of oily wastes generated at the Y-12 Plant[a]

| Element | Waste Oil Composite (ppm) | Machine Coolant Composite (ppm) | Mixture Machine Coolant and Mop Water (ppm) | Waste Oil from Ponds (ppm) |
|---|---|---|---|---|
| Ag | <0.01 | <0.1 | <0.2 | <20.0 |
| Al | 2. | 8. | 10. | 50. |
| Au | - | 0.4 | <0.8 | <10. |
| B | 0.2 | 0.8 | 10. | 5. |
| Ba | 0.4 | 20. | 0.8 | 2. |
| Be | 12. | 0.4 | 0.04 | <0.5 |
| Bi | - | <0.2 | 0.4 | <5. |
| Ca | 25. | 40. | 200. | 80. |
| Cd | 0.2 | <0.4 | <2. | <20. |
| Co | <0.2 | 0.2 | <0.2 | <20. |
| Cr | 2. | 1. | 2. | <5. |
| Cs | - | 10. | <20. | <300. |
| Cu | 0.5 | 2. | 3. | <2. |
| Fe | 9. | 20. | 70. | 300. |
| Ge | - | - | - | - |
| Hf | - | <0.4 | <0.8 | <10. |
| K | 50. | <400. | 800. | <20. |
| Li | 4.5 | 1. | 2. | <10. |
| Mg | 4.5 | 6. | 20. | 10. |
| Mn | 0.5 | 0.4 | 0.8 | 10. |
| Mo | 0.01 | 0.2 | 2. | <1. |
| Na | >200. | >400. | 800. | 10. |
| Nb | - | 0.4 | 3. | <10. |
| Ni | <0.04 | <0.2 | 0.8 | <5. |
| P | <1. | 200. | <40. | 500. |
| Pb | 0.4 | 3. | 3. | <5. |
| Pd | - | 0.04 | - | - |
| Rb | - | 3. | <60. | <80. |
| Sb | - | <0.8 | <2. | <20. |
| Si | 4.5 | 10. | 50. | 100. |
| Sn | <0.01 | 10. | <0.2 | <2. |
| Ta | - | <3. | 60. | <80. |
| Th | - | <0.8 | <2. | <20. |
| Ti | 0.2 | 0.8 | 2. | <5. |
| U | 60. | 20. | 80. | <200. |
| V | <0.01 | 0.1 | 0.2 | <2. |
| W | <0.01 | 3. | 6. | <40. |
| Zn | 2. | <2. | <3. | <40. |
| Zr | 1.5 | 0.2 | 2. | 1. |

[a]From UCC-ND Report Y-1934, "Disposal of Oily Wastes by Microbial Assimilation," May 16, 1974.

Table B.3. Analyses of waste oils generated at the Y-12 Plant[a]

| Element | Concentration (μg/ml) Vacuum Pump Oil Filtered | Vacuum Pump Oil Unfiltered | Crankcase Oil Unfiltered | Surface Oil-Field Pond 2 Filtered | Surface Oil-Field Pond 2 Unfiltered |
|---|---|---|---|---|---|
| Be | <0.005 | <0.01 | <0.01 | <0.01 | <0.01 |
| B | 0.02 | 0.03 | 6.0 | 0.3 | 0.2 |
| F | 0.09 | 0.3 | 0.3 | 0.3 | 0.3 |
| Na | 100.0 | 20.0 | 500.0 | 50.0 | 20.0 |
| Mg | 0.3 | 11.0 | 10.0 | 1.0 | 1.0 |
| Al | 4.0 | 4.0 | 4.0 | 20.0 | 1.0 |
| Si | 10.0 | 10.0 | 80.0 | 80.0 | 1500.0 |
| P | 0.2 | 0.7 | 1500.0 | 6000.0 | 14500.0 |
| S | 2.0 | 10.0 | 40.0 | 20.0 | 7.0 |
| Cl | 200.0 | 650.0 | 1000.0 | 1000.0 | 2000.0 |
| K | 2.0 | 2.0 | 20.0 | 20.0 | 2.0 |
| Ca | 3.0 | 9.0 | 3000.0 | 9.0 | 3.0 |
| Sc | 0.6 | <0.06 | 0.2 | <0.06 | <0.06 |
| Cr | 0.1 | <0.09 | 0.9 | <0.09 | <0.09 |
| Mn | 0.1 | 0.1 | 0.8 | <0.08 | <0.08 |
| Fe | 80.0 | 40.0 | 80.0 | 10.0 | 30.0 |
| Co | 0.08 | <0.08 | <0.08 | <0.08 | <0.08 |
| Ni | 0.2 | 0.2 | 0.2 | <0.1 | <0.1 |
| Cu | 0.4 | 0.6 | 0.2 | <0.1 | <0.1 |
| Zn | 2.0 | 6.0 | 300.0 | 6.0 | 2.0 |
| Cd | 0.3 | <0.5 | <0.5 | <0.5 | <0.5 |
| Sn | <0.2 | <0.5 | <0.5 | <0.5 | <0.5 |
| Ba | 0.3 | <0.3 | 150.0 | 1.0 | <0.3 |
| Ta | 0.8 | <0.8 | <0.3 | <0.3 | <0.3 |
| W | 0.4 | <0.8 | <0.8 | <0.8 | <0.8 |
| Hg | <0.3 | <0.9 | <0.9 | <0.9 | <0.9 |
| Pb | <0.2 | <0.6 | 200.0 | <0.6 | <0.6 |
| Bi | <0.1 | <0.3 | <0.3 | <0.3 | <0.3 |
| Th | 0.5 | 0.5 | <0.3 | <0.3 | <0.3 |
| U | <0.1 | <0.3 | <0.3 | <0.3 | <0.3 |
| Mo | <0.6 | <0.6 | 20.0 | <0.6 | <0.6 |

[a]From UCC-ND Report Y-1934, "Disposal of Oily Wastes by Microbial Assimilation," May 16, 1974.

APPENDIX C. RESULTS OF EPA APPENDIX IX ANALYSES PERFORMED BY ROY F. WESTON, INC., ON SAMPLES COLLECTED NOVEMBER 1987

**KEY TO SPECIAL MISSING VALUES**
**ROY F. WESTON ANALYTICS**
**APPENDIX 9 SAMPLING DATA**

Compound analyzed for but not detected. The minimum attainable detection limit is:

Volatile and Semi-Volatile Compounds (Water samples)

| | | |
|---|---|---|
| G | 5 | µg/l |
| N | 10 | |
| V | 20 | |
| Z | 25 | |
| M | 50 | |
| X | 80 | |
| Y | 90 | |
| K | 100 | |
| R | 200 | |
| T | 250 | |
| F | 350 | |
| W | 500 | |
| L | 1000 | |
| P | 2000 | |
| H | 4000 | |
| J | 5000 | |
| D | 7500 | |
| S | 10000 | |
| U | 20000 | |

Volatile and Semi-Volatile Compounds (Sediment samples)

N Detection limit sample dependent (ug/kg)

**KEY TO SPECIAL MISSING VALUES**
**ROY F. WESTON ANALYTICS**
**APPENDIX 9 SAMPLING DATA**

Compound analyzed for but not detected. The minimum attainable detection limit is:

Herbicides, Pesticides & PCB's (Water samples)

| | | |
|---|---|---|
| G | 0.02 | ug/l |
| U | 0.03 | |
| R | 0.04 | |
| H | 0.05 | |
| J | 0.1 | |
| Q | 0.15 | |
| I | 0.17 | |
| A | 0.2 | |
| S | 0.25 | |
| T | 0.3 | |
| V | 0.33 | |
| P | 0.4 | |
| B | 0.5 | |
| C | 1 | |
| X | 1.5 | |
| D | 2 | |
| Y | 3 | |
| Z | 4 | |
| E | 5 | |
| F | 10 | |
| M | 50 | |
| K | 100 | |
| W | 500 | |
| L | 1000 | |

Volatile and Semi-Volatile Compounds (Sediment samples)

N Detection limit sample dependent (ug/kg)

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB

BEAR CREEK VALLEY
INORGANIC ANALYSES
GROUND WATER - DISSOLVED ELEMENTS
UNITS ARE MG/L

| | | GW-103 | GW-225 |
|---|---|---|---|
| SILVER | (ICAP) | 0.0207 | <0.01 |
| ALUMINUM | (ICAP) | 691 | <0.2 |
| ARSENIC | (AAS ) | <0.01 | <0.01 |
| BARIUM | (ICAP) | 0.212 | <0.2 |
| BERYLLIUM | (ICAP) | 0.0899 | <0.005 |
| CALCIUM | (ICAP) | 1490 | 135 |
| CADMIUM | (ICAP) | 0.475 | <0.005 |
| COBALT | (ICAP) | 2.56 | <0.05 |
| CHROMIUM | (ICAP) | 0.42 | <0.01 |
| COPPER | (ICAP) | 2.73 | <0.025 |
| IRON | (ICAP) | <0.1 | 0.102 |
| MERCURY | (AAS) | 0.0166 | <0.0002 |
| POTASSIUM | (AAS) | 52.3 | <5 |
| MAGNESIUM | (ICAP) | 277 | 47.2 |
| MANGANESE | (ICAP) | 117 | <0.015 |
| SODIUM | (AAS ) | 596 | 12.7 |
| NICKEL | (ICAP) | 17.8 | <0.04 |
| LEAD | (AAS ) | 0.161 | <0.005 |
| ANTIMONY | (AAS ) | <0.06 | <0.06 |
| SELENIUM | (AAS ) | <0.005 | <0.005 |
| TIN | (ICAP) | 0.457 | <0.1 |
| THALLIUM | (AAS ) | <0.01 | <0.01 |
| VANADIUM | (ICAP) | <0.05 | <0.05 |
| ZINC | (ICAP) | 3.31 | <0.02 |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB

BEAR CREEK VALLEY
INORGANIC ANALYSES
GROUND WATER - TOTAL ELEMENTS
UNITS ARE MG/L

| | | GW-103 | GW-225 |
|---|---|---|---|
| SILVER | (ICAP) | 0.0177 | <0.01 |
| ALUMINUM | (ICAP) | 624 | <0.2 |
| ARSENIC | (AAS ) | <0.01 | <0.01 |
| BARIUM | (ICAP) | <0.2 | <0.2 |
| BERYLLIUM | (ICAP) | 0.0852 | <0.005 |
| CALCIUM | (ICAP) | 1130 | 117 |
| CADMIUM | (ICAP) | 0.45 | <0.005 |
| COBALT | (ICAP) | 2.49 | <0.05 |
| CHROMIUM | (ICAP) | 0.405 | <0.01 |
| COPPER | (ICAP) | 2.54 | 0.104 |
| IRON | (ICAP) | <0.1 | 1.01 |
| MERCURY | (AAS) | 0.0082 | <0.0002 |
| POTASSIUM | (AAS) | 50 | <5 |
| MAGNESIUM | (ICAP) | 257 | 42 |
| MANGANESE | (ICAP) | 111 | <0.015 |
| SODIUM | (AAS ) | 567 | 11.3 |
| NICKEL | (ICAP) | 17.3 | <0.04 |
| LEAD | (AAS ) | 0.176 | <0.005 |
| ANTIMONY | (AAS ) | <0.06 | <0.06 |
| SELENIUM | (AAS ) | <0.005 | <0.005 |
| TIN | (ICAP) | 0.402 | <0.1 |
| THALLIUM | (AAS ) | <0.01 | <0.01 |
| VANADIUM | (ICAP) | <0.05 | <0.05 |
| ZINC | (ICAP) | 3.17 | 0.0344 |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB

BEAR CREEK VALLEY
INORGANIC ANALYSES
SPRING WATER - TOTAL ELEMENTS
UNITS ARE MG/L

| | | SS-1 | SS-2 | SS-3 | SS-4 |
|---|---|---|---|---|---|
| SILVER | (ICAP) | <0.01 | <0.01 | <0.01 | <0.01 |
| ALUMINUM | (ICAP) | <0.2 | <0.2 | <0.2 | 0.278 |
| ARSENIC | (AAS ) | <0.01 | <0.01 | <0.01 | <0.01 |
| BARIUM | (ICAP) | <0.2 | <0.2 | <0.2 | 0.259 |
| BERYLLIUM | (ICAP) | <0.005 | <0.005 | <0.005 | <0.005 |
| CALCIUM | (ICAP) | 270 | 36.3 | 37.2 | 203 |
| CADMIUM | (ICAP) | <0.005 | <0.005 | <0.005 | <0.005 |
| COBALT | (ICAP) | <0.05 | <0.05 | <0.05 | <0.05 |
| CHROMIUM | (ICAP) | <0.01 | <0.01 | <0.01 | <0.01 |
| COPPER | (ICAP) | <0.025 | <0.025 | <0.025 | 0.0281 |
| IRON | (ICAP) | <0.1 | <0.1 | <0.1 | <0.1 |
| MERCURY | (AAS) | <0.0002 | <0.0002 | <0.0002 | <0.0002 |
| POTASSIUM | (AAS) | <5 | <5 | <5 | <5 |
| MAGNESIUM | (ICAP) | 29.3 | 21.3 | 22 | 39 |
| MANGANESE | (ICAP) | 0.0157 | <0.015 | <0.015 | <0.015 |
| SODIUM | (AAS ) | 35.8 | <5 | <5 | 26.1 |
| NICKEL | (ICAP) | <0.04 | <0.04 | <0.04 | <0.04 |
| LEAD | (AAS ) | <0.005 | <0.005 | <0.005 | <0.005 |
| ANTIMONY | (AAS ) | <0.06 | <0.06 | <0.06 | <0.06 |
| SELENIUM | (AAS ) | <0.005 | <0.005 | <0.005 | <0.005 |
| TIN | (ICAP) | <0.1 | <0.1 | <0.1 | <0.1 |
| THALLIUM | (AAS ) | <0.01 | <0.01 | <0.01 | <0.01 |
| VANADIUM | (ICAP) | <0.05 | <0.05 | <0.05 | <0.05 |
| ZINC | (ICAP) | <0.02 | <0.02 | <0.02 | <0.02 |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB

BEAR CREEK VALLEY
INORGANIC ANALYSES
SPRING WATER - TOTAL ELEMENTS
UNITS ARE MG/L

| | | SS-5 | SS-7 | SS-8 |
|---|---|---|---|---|
| SILVER | (ICAP) | <0.01 | <0.01 | <0.01 |
| ALUMINUM | (ICAP) | <0.2 | <0.2 | <0.2 |
| ARSENIC | (AAS ) | <0.01 | <0.01 | <0.01 |
| BARIUM | (ICAP) | 0.21 | <0.2 | <0.2 |
| BERYLLIUM | (ICAP) | <0.005 | <0.005 | <0.005 |
| CALCIUM | (ICAP) | 158 | 68 | 37.8 |
| CADMIUM | (ICAP) | <0.005 | <0.005 | <0.005 |
| COBALT | (ICAP) | <0.05 | <0.05 | <0.05 |
| CHROMIUM | (ICAP) | <0.01 | <0.01 | <0.01 |
| COPPER | (ICAP) | <0.025 | <0.025 | <0.025 |
| IRON | (ICAP) | <0.1 | <0.1 | <0.1 |
| MERCURY | (AAS) | <0.0002 | <0.0002 | <0.0002 |
| POTASSIUM | (AAS) | <5 | <5 | <5 |
| MAGNESIUM | (ICAP) | 29.8 | 23.2 | 16.2 |
| MANGANESE | (ICAP) | <0.015 | <0.015 | <0.015 |
| SODIUM | (AAS ) | 19.2 | 7.38 | <5 |
| NICKEL | (ICAP) | <0.04 | <0.04 | <0.04 |
| LEAD | (AAS ) | <0.005 | <0.005 | <0.005 |
| ANTIMONY | (AAS ) | <0.06 | <0.06 | <0.06 |
| SELENIUM | (AAS ) | <0.005 | <0.005 | <0.005 |
| TIN | (ICAP) | <0.1 | <0.1 | <0.1 |
| THALLIUM | (AAS ) | <0.01 | <0.01 | <0.01 |
| VANADIUM | (ICAP) | <0.05 | <0.05 | <0.05 |
| ZINC | (ICAP) | <0.02 | 0.032 | 0.0222 |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB

BEAR CREEK VALLEY
INORGANIC ANALYSES
SURFACE WATER - TOTAL ELEMENTS
UNITS ARE MG/L

| | | BCK-05.15 | BCK-09.43 | BCK-12.46 | TRIB.07-3 |
|---|---|---|---|---|---|
| SILVER | (ICAP) | <0.01 | <0.01 | <0.01 | <0.01 |
| ALUMINUM | (ICAP) | <0.2 | <0.2 | 0.327 | <0.2 |
| ARSENIC | (AAS ) | <0.01 | <0.01 | <0.01 | <0.01 |
| BARIUM | (ICAP) | <0.2 | <0.2 | <0.2 | <0.2 |
| BERYLLIUM | (ICAP) | <0.005 | <0.005 | <0.005 | <0.005 |
| CALCIUM | (ICAP) | 87.7 | 86.1 | 460 | 128 |
| CADMIUM | (ICAP) | <0.005 | <0.005 | <0.005 | <0.005 |
| COBALT | (ICAP) | <0.05 | <0.05 | <0.05 | <0.05 |
| CHROMIUM | (ICAP) | <0.01 | <0.01 | <0.01 | <0.01 |
| COPPER | (ICAP) | <0.025 | <0.025 | <0.025 | <0.025 |
| IRON | (ICAP) | <0.1 | 0.167 | <0.1 | 0.718 |
| MERCURY | (AAS) | <0.0002 | <0.0002 | <0.0002 | <0.0002 |
| POTASSIUM | (AAS) | <5 | <5 | 10 | <5 |
| MAGNESIUM | (ICAP) | 23.1 | 13.8 | 83.3 | 15.8 |
| MANGANESE | (ICAP) | <0.015 | 0.262 | 1.47 | 2.22 |
| SODIUM | (AAS ) | 9.99 | 13.7 | 91.9 | 30.4 |
| NICKEL | (ICAP) | <0.04 | <0.04 | <0.04 | 0.0619 |
| LEAD | (AAS ) | <0.005 | <0.005 | <0.005 | <0.005 |
| ANTIMONY | (AAS ) | <0.06 | <0.06 | <0.06 | <0.06 |
| SELENIUM | (AAS ) | <0.005 | <0.005 | <0.005 | <0.005 |
| TIN | (ICAP) | <0.1 | <0.1 | <0.1 | <0.1 |
| THALLIUM | (AAS ) | <0.01 | <0.01 | <0.01 | <0.01 |
| VANADIUM | (ICAP) | <0.05 | <0.05 | <0.05 | <0.05 |
| ZINC | (ICAP) | <0.02 | <0.02 | <0.02 | <0.02 |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB

BEAR CREEK VALLEY
INORGANIC ANALYSES
GROUND WATER - FIELD MMTS. & INORGANICS
UNITS ARE MG/L UNLESS OTHERWISE STATED

| | GW-103 | GW-225 |
|---|---|---|
| DATE SAMPLED | 11/19/87 | 11/13/87 |
| DATE STATIC WATER LEVEL MEASURED | 11/18/87 | 11/13/87 |
| STATIC WATER LEVEL (IN FT. +/- GRADE) | -13.48 | -18.3 |
| WATER TEMP. (IN DEGREES CENTIGRADE) | 18 | 16.5 |
| DISSOLVED OXYGEN (PPM) | 1.1 | 9.5 |
| FIELD CONDUCTIVITY (UMHOS/CM), REP. 1 | 145000 | 800 |
| FIELD CONDUCTIVITY (UMHOS/CM), REP. 2 | 145000 | 800 |
| FIELD CONDUCTIVITY (UMHOS/CM), REP. 3 | 145000 | 800 |
| FIELD PH (PH UNIT), REP. 1 | 3.9 | 7.3 |
| FIELD PH (PH UNIT), REP. 2 | 3.9 | 7.3 |
| FIELD PH (PH UNIT), REP. 3 | 3.9 | 7.3 |
| FIELD REDOX (MV), REP. 1 | 340 | -50 |
| FIELD REDOX (MV), REP. 2 | 350 | -30 |
| FIELD REDOX (MV), REP. 3 | 350 | -30 |
| CYANIDE | <0.01 | <0.0111 |
| CORROSIVITY (PH UNIT) | . | . |
| FLUORIDE | 0.42 | 0.17 |
| SULFIDE | <0.1 | <0.1 |
| IGNITABILITY (DEG. F) | . | . |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB

BEAR CREEK VALLEY
INORGANIC ANALYSES
SPRING WATER - FIELD MMTS. & INORGANICS
UNITS ARE MG/L UNLESS OTHERWISE STATED

| | SS-1 | SS-2 | SS-3 | SS-4 |
|---|---|---|---|---|
| DATE SAMPLED | 12/08/87 | 12/07/87 | 12/07/87 | 12/08/87 |
| DATE STATIC WATER LEVEL MEASURED | . | . | . | . |
| STATIC WATER LEVEL (IN FT. +/- GRADE) | . | . | . | . |
| WATER TEMP. (IN DEGREES CENTIGRADE) | 11 | 12 | 10 | 12 |
| DISSOLVED OXYGEN (PPM) | 11.8 | 12 | 10.9 | 10.9 |
| FIELD CONDUCTIVITY (UMHOS/CM), REP. 1 | 1250 | 210 | 200 | 1050 |
| FIELD CONDUCTIVITY (UMHOS/CM), REP. 2 | 1250 | 190 | 205 | 1000 |
| FIELD CONDUCTIVITY (UMHOS/CM), REP. 3 | 1250 | 210 | 200 | 1000 |
| FIELD PH (PH UNIT), REP. 1 | . | 8.4 | 7.9 | 7.8 |
| FIELD PH (PH UNIT), REP. 2 | . | 8.5 | 8.3 | 8 |
| FIELD PH (PH UNIT), REP. 3 | . | 8.5 | 8.4 | 8 |
| FIELD REDOX (MV), REP. 1 | 130 | 160 | 240 | 130 |
| FIELD REDOX (MV), REP. 2 | 120 | 150 | 230 | 140 |
| FIELD REDOX (MV), REP. 3 | 120 | 150 | 230 | 130 |
| CYANIDE | <0.01 | <0.01 | <0.01 | <0.01 |
| CORROSIVITY (PH UNIT) | . | . | . | . |
| FLUORIDE | 0.18 | 0.1 | <0.1 | 0.32 |
| SULFIDE | <0.1 | <0.1 | <0.1 | <0.1 |
| IGNITABILITY (DEG. F) | . | . | . | . |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB

BEAR CREEK VALLEY
INORGANIC ANALYSES
SPRING WATER - FIELD MMTS. & INORGANICS
UNITS ARE MG/L UNLESS OTHERWISE STATED

| | SS-5 | SS-7 | SS-8 |
|---|---|---|---|
| DATE SAMPLED | 12/07/87 | 12/08/87 | 12/08/87 |
| DATE STATIC WATER LEVEL MEASURED | . | . | . |
| STATIC WATER LEVEL (IN FT. +/- GRADE) | . | . | . |
| WATER TEMP. (IN DEGREES CENTIGRADE) | 13 | 13 | 13 |
| DISSOLVED OXYGEN (PPM) | 6.1 | 7.6 | 8.1 |
| FIELD CONDUCTIVITY (UMHOS/CM), REP. 1 | 775 | 370 | 225 |
| FIELD CONDUCTIVITY (UMHOS/CM), REP. 2 | 750 | 390 | 230 |
| FIELD CONDUCTIVITY (UMHOS/CM), REP. 3 | 780 | 390 | 220 |
| FIELD PH (PH UNIT), REP. 1 | 3.3 | 7.1 | 6 |
| FIELD PH (PH UNIT), REP. 2 | 3.3 | 7.1 | 5.9 |
| FIELD PH (PH UNIT), REP. 3 | 3.5 | 7.2 | 5.9 |
| FIELD REDOX (MV), REP. 1 | 150 | 250 | 150 |
| FIELD REDOX (MV), REP. 2 | 150 | 250 | 140 |
| FIELD REDOX (MV), REP. 3 | 150 | 250 | 140 |
| CYANIDE | <0.01 | <0.01 | <0.01 |
| CORROSIVITY (PH UNIT) | . | . | . |
| FLUORIDE | 0.3 | 0.11 | <0.1 |
| SULFIDE | <0.1 | <0.1 | <0.1 |
| IGNITABILITY (DEG. F) | . | . | . |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB

BEAR CREEK VALLEY
INORGANIC ANALYSES
SURFACE WATER - FIELD MMTS. & INORGANICS
UNITS ARE MG/L UNLESS OTHERWISE STATED

| | BCK-05.15 | BCK-09.43 | BCK-12.46 | TRIB.07-3 |
|---|---|---|---|---|
| DATE SAMPLED | 12/08/87 | 12/08/87 | 12/07/87 | 12/08/87 |
| DATE STATIC WATER LEVEL MEASURED | . | . | . | . |
| STATIC WATER LEVEL (IN FT. +/- GRADE) | . | . | . | . |
| WATER TEMP. (IN DEGREES CENTIGRADE) | 11 | 10 | 17 | 10 |
| DISSOLVED OXYGEN (PPM) | 9.3 | 7.8 | 16.6 | 9.2 |
| FIELD CONDUCTIVITY (UMHOS/CM), REP. 1 | 380 | 425 | 1975 | 700 |
| FIELD CONDUCTIVITY (UMHOS/CM), REP. 2 | 410 | 390 | 2050 | 650 |
| FIELD CONDUCTIVITY (UMHOS/CM), REP. 3 | 400 | 700 | 2090 | 700 |
| FIELD PH (PH UNIT), REP. 1 | 7.5 | 5.8 | 7.3 | 6.1 |
| FIELD PH (PH UNIT), REP. 2 | 7.6 | 5.8 | 7.4 | 6.1 |
| FIELD PH (PH UNIT), REP. 3 | 7.5 | 5.7 | 7.4 | 6.2 |
| FIELD REDOX (MV), REP. 1 | 200 | 160 | 145 | 250 |
| FIELD REDOX (MV), REP. 2 | 190 | 140 | 130 | 240 |
| FIELD REDOX (MV), REP. 3 | 190 | 140 | 140 | 240 |
| CYANIDE | <0.01 | <0.0167 | <0.01 | <0.01 |
| CORROSIVITY (PH UNIT) | . | . | . | . |
| FLUORIDE | 0.16 | 0.26 | 0.63 | 0.11 |
| SULFIDE | <0.1 | <0.1 | <0.1 | <0.1 |
| IGNITABILITY (DEG. F) | . | . | . | . |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
GROUND WATER - VOLATILE ORGANICS - HSL
UNITS ARE UG/L

| | GW-103 | GW-225 |
|---|---|---|
| CHLOROMETHANE | K | N |
| BROMOMETHANE | K | N |
| VINYL CHLORIDE | K | N |
| CHLOROETHANE | K | N |
| METHYLENE CHLORIDE | 50 | 3 |
| ACETONE | 240 | 9 |
| CARBON DISULFIDE | M | G |
| 1,1-DICHLOROETHENE | M | G |
| 1,1-DICHLOROETHANE | M | 1 |
| TRANS-1,2-DICHLOROETHENE | M | 3 |
| CHLOROFORM | 12 | 2 |
| 1,2-DICHLOROETHANE | M | G |
| 2-BUTANONE | 39 | N |
| 1,1,1-TRICHLOROETHANE | M | 5 |
| CARBON TETRACHLORIDE | M | 10 |
| VINYL ACETATE | K | N |
| BROMODICHLOROMETHANE | M | G |
| 1,2-DICHLOROPROPANE | M | G |
| TRANS-1,3-DICHLOROPROPENE | M | G |
| TRICHLOROETHENE | M | 420 |
| CHLORODIBROMOMETHANE | M | G |
| 1,1,2-TRICHLOROETHANE | M | G |
| BENZENE | M | G |
| CIS-1,3-DICHLOROPROPENE | M | G |
| 2-CHLOROETHYLVINYL ETHER | K | N |
| BROMOFORM | M | G |
| 4-METHYL-2-PENTANONE | K | N |
| 2-HEXANONE | K | N |
| TETRACHLOROETHENE | 400 | 5 |
| 1,1,2,2-TETRACHLOROETHANE | M | G |
| TOLUENE | M | G |
| CHLOROBENZENE | M | G |
| ETHYLBENZENE | M | G |
| STYRENE | M | G |
| XYLENES | M | G |
| ACROLEIN | K | N |
| ACRYLONITRILE | K | N |
| FLUOROTRICHLOROMETHANE | M | G |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SPRING WATER - VOLATILE ORGANICS - HSL
UNITS ARE UG/L

| | SS-1 | SS-2 | SS-3 | SS-4 |
|---|---|---|---|---|
| CHLOROMETHANE | N | N | N | N |
| BROMOMETHANE | N | N | N | N |
| VINYL CHLORIDE | N | N | N | N |
| CHLOROETHANE | N | N | N | 6 |
| METHYLENE CHLORIDE | 33 | 33 | 31 | 5 |
| ACETONE | 19 | 2 | 3 | G |
| CARBON DISULFIDE | G | G | G | G |
| 1,1-DICHLOROETHENE | G | G | G | G |
| 1,1-DICHLOROETHANE | G | G | G | G |
| TRANS-1,2-DICHLOROETHENE | G | G | G | G |
| CHLOROFORM | G | G | G | G |
| 1,2-DICHLOROETHANE | G | G | G | G |
| 2-BUTANONE | 9 | N | N | N |
| 1,1,1-TRICHLOROETHANE | G | G | G | G |
| CARBON TETRACHLORIDE | G | G | G | G |
| VINYL ACETATE | N | N | N | N |
| BROMODICHLOROMETHANE | G | G | G | G |
| 1,2-DICHLOROPROPANE | G | G | G | G |
| TRANS-1,3-DICHLOROPROPENE | G | G | G | G |
| TRICHLOROETHENE | G | G | G | G |
| CHLORODIBROMOMETHANE | G | G | G | G |
| 1,1,2-TRICHLOROETHANE | G | G | G | G |
| BENZENE | G | G | G | G |
| CIS-1,3-DICHLOROPROPENE | G | G | G | G |
| 2-CHLOROETHYLVINYL ETHER | N | N | N | N |
| BROMOFORM | G | G | G | G |
| 4-METHYL-2-PENTANONE | N | N | N | N |
| 2-HEXANONE | N | N | N | N |
| TETRACHLOROETHENE | G | G | G | G |
| 1,1,2,2-TETRACHLOROETHANE | G | G | G | G |
| TOLUENE | 2 | G | 1 | 2 |
| CHLOROBENZENE | G | G | G | G |
| ETHYLBENZENE | G | G | G | G |
| STYRENE | G | G | G | G |
| XYLENES | G | G | G | G |
| ACROLEIN | N | N | N | N |
| ACRYLONITRILE | N | N | N | N |
| FLUOROTRICHLOROMETHANE | 5 | 5 | 5 | 2 |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SPRING WATER - VOLATILE ORGANICS - HSL
UNITS ARE UG/L

| | SS-5 | SS-7 | SS-8 |
|---|---|---|---|
| CHLOROMETHANE | N | N | N |
| BROMOMETHANE | N | N | N |
| VINYL CHLORIDE | N | N | N |
| CHLOROETHANE | N | N | N |
| METHYLENE CHLORIDE | 7 | 6 | 7 |
| ACETONE | 4 | N | 9 |
| CARBON DISULFIDE | G | G | G |
| 1,1-DICHLOROETHENE | 1 | G | G |
| 1,1-DICHLOROETHANE | 2 | G | 2 |
| TRANS-1,2-DICHLOROETHENE | 23 | G | G |
| CHLOROFORM | G | G | G |
| 1,2-DICHLOROETHANE | G | G | G |
| 2-BUTANONE | N | N | N |
| 1,1,1-TRICHLOROETHANE | 3 | G | G |
| CARBON TETRACHLORIDE | G | G | G |
| VINYL ACETATE | N | N | N |
| BROMODICHLOROMETHANE | G | G | G |
| 1,2-DICHLOROPROPANE | G | G | G |
| TRANS-1,3-DICHLOROPROPENE | G | G | G |
| TRICHLOROETHENE | 12 | G | G |
| CHLORODIBROMOMETHANE | G | G | G |
| 1,1,2-TRICHLOROETHANE | G | G | G |
| BENZENE | G | G | G |
| CIS-1,3-DICHLOROPROPENE | G | G | G |
| 2-CHLOROETHYLVINYL ETHER | N | N | N |
| BROMOFORM | G | G | G |
| 4-METHYL-2-PENTANONE | N | N | N |
| 2-HEXANONE | N | N | N |
| TETRACHLOROETHENE | 3 | G | G |
| 1,1,2,2-TETRACHLOROETHANE | G | G | G |
| TOLUENE | 2 | 2 | 2 |
| CHLOROBENZENE | G | G | G |
| ETHYLBENZENE | G | G | G |
| STYRENE | G | G | G |
| XYLENES | G | G | G |
| ACROLEIN | N | N | N |
| ACRYLONITRILE | N | N | N |
| FLUOROTRICHLOROMETHANE | 3 | 3 | 3 |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SURFACE WATER - VOLATILE ORGANICS - HSL
UNITS ARE UG/L

| | BCK-05.15 | BCK-09.43 | BCK-12.46 | TRIB.07-3 |
|---|---|---|---|---|
| CHLOROMETHANE | N | N | N | N |
| BROMOMETHANE | N | N | N | N |
| VINYL CHLORIDE | N | N | N | N |
| CHLOROETHANE | N | N | N | 11 |
| METHYLENE CHLORIDE | 30 | 6 | 7 | 16 |
| ACETONE | 1 | 23 | 4 | 3 |
| CARBON DISULFIDE | G | G | G | G |
| 1,1-DICHLOROETHENE | G | G | G | 44 |
| 1,1-DICHLOROETHANE | G | 2 | G | 110 |
| TRANS-1,2-DICHLOROETHENE | G | 17 | G | B |
| CHLOROFORM | G | G | 1 | 45 |
| 1,2-DICHLOROETHANE | G | G | G | 15 |
| 2-BUTANONE | N | 11 | N | N |
| 1,1,1-TRICHLOROETHANE | G | 2 | G | 15 |
| CARBON TETRACHLORIDE | G | G | G | G |
| VINYL ACETATE | N | N | N | N |
| BROMODICHLOROMETHANE | G | G | G | G |
| 1,2-DICHLOROPROPANE | G | G | G | G |
| TRANS-1,3-DICHLOROPROPENE | G | G | G | G |
| TRICHLOROETHENE | G | 7 | G | 380 |
| CHLORODIBROMOMETHANE | G | G | G | G |
| 1,1,2-TRICHLOROETHANE | G | G | G | 3 |
| BENZENE | G | G | G | 18 |
| CIS-1,3-DICHLOROPROPENE | G | G | G | G |
| 2-CHLOROETHYLVINYL ETHER | N | N | N | N |
| BROMOFORM | G | G | G | G |
| 4-METHYL-2-PENTANONE | N | N | N | N |
| 2-HEXANONE | N | N | N | 3 |
| TETRACHLOROETHENE | G | 4 | 3 | 190 |
| 1,1,2,2-TETRACHLOROETHANE | G | G | G | G |
| TOLUENE | 2 | 1 | 1 | 2 |
| CHLOROBENZENE | G | G | G | G |
| ETHYLBENZENE | G | G | G | G |
| STYRENE | G | G | G | G |
| XYLENES | G | G | G | G |
| ACROLEIN | N | N | N | N |
| ACRYLONITRILE | N | N | N | N |
| FLUOROTRICHLOROMETHANE | 5 | 3 | 3 | 13 |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
GROUND WATER - VOLATILE ORGANICS-NON-HSL
UNITS ARE UG/L

| | GW-103 | GW-225 |
|---|---|---|
| DICHLORODIFLUOROMETHANE | K | N |
| ACETONITRILE | R | V |
| IODOMETHANE | K | N |
| ETHYL CYANIDE | W | K |
| 3-CHLOROPROPENE | R | V |
| METHACRYLONITRILE | R | V |
| DIBROMOMETHANE | K | N |
| ISOBUTYL ALCOHOL | R | V |
| 1,2-DIBROMOETHANE | R | V |
| 1,1,1,2-TETRACHLOROETHANE | K | N |
| 1,2,3-TRICHLOROPROPANE | K | N |
| TRANS-1,4-DICHLORO-2-BUTENE | W | M |
| 1,2-DIBROMO-3-CHLOROPROPANE | R | V |
| 2-CHLORO-1,3-BUTADIENE | L | K |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SPRING WATER - VOLATILE ORGANICS-NON-HSL
UNITS ARE UG/L

| | SS-1 | SS-2 | SS-3 | SS-4 |
|---|---|---|---|---|
| DICHLORODIFLUOROMETHANE | N | N | N | N |
| ACETONITRILE | V | V | V | 2 |
| IODOMETHANE | N | N | N | N |
| ETHYL CYANIDE | M | M | M | M |
| 3-CHLOROPROPENE | V | V | V | V |
| METHACRYLONITRILE | V | V | V | V |
| DIBROMOMETHANE | N | N | N | N |
| ISOBUTYL ALCOHOL | V | V | V | V |
| 1,2-DIBROMOETHANE | V | V | V | V |
| 1,1,1,2-TETRACHLOROETHANE | N | N | N | N |
| 1,2,3-TRICHLOROPROPANE | N | N | N | N |
| TRANS-1,4-DICHLORO-2-BUTENE | M | M | M | M |
| 1,2-DIBROMO-3-CHLOROPROPANE | V | V | V | V |
| 2-CHLORO-1,3-BUTADIENE | K | K | K | K |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SPRING WATER - VOLATILE ORGANICS-NON-HSL
UNITS ARE UG/L

| | SS-5 | SS-7 | SS-8 |
|---|---|---|---|
| DICHLORODIFLUOROMETHANE | N | N | 9 |
| ACETONITRILE | V | V | V |
| IODOMETHANE | N | N | N |
| ETHYL CYANIDE | M | M | M |
| 3-CHLOROPROPENE | V | V | V |
| METHACRYLONITRILE | V | V | V |
| DIBROMOMETHANE | N | N | N |
| ISOBUTYL ALCOHOL | V | V | V |
| 1,2-DIBROMOETHANE | V | V | V |
| 1,1,1,2-TETRACHLOROETHANE | N | N | N |
| 1,2,3-TRICHLOROPROPANE | N | N | N |
| TRANS-1,4-DICHLORO-2-BUTENE | M | M | M |
| 1,2-DIBROMO-3-CHLOROPROPANE | V | V | V |
| 2-CHLORO-1,3-BUTADIENE | K | K | K |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SURFACE WATER - VOLATILE ORGANICS-NON-HSL
UNITS ARE UG/L

| | BCK-05.15 | BCK-09.43 | BCK-12.46 | TRIB.07-3 |
|---|---|---|---|---|
| DICHLORODIFLUOROMETHANE | N | N | N | N |
| ACETONITRILE | V | V | V | V |
| IODOMETHANE | N | N | N | N |
| ETHYL CYANIDE | M | M | M | M |
| 3-CHLOROPROPENE | V | V | V | V |
| METHACRYLONITRILE | V | V | V | V |
| DIBROMOMETHANE | N | N | N | N |
| ISOBUTYL ALCOHOL | V | V | V | V |
| 1,2-DIBROMOETHANE | V | V | V | 35 |
| 1,1,1,2-TETRACHLOROETHANE | N | N | N | N |
| 1,2,3-TRICHLOROPROPANE | N | N | N | N |
| TRANS-1,4-DICHLORO-2-BUTENE | M | M | M | M |
| 1,2-DIBROMO-3-CHLOROPROPANE | V | V | V | V |
| 2-CHLORO-1,3-BUTADIENE | K | K | K | K |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
GROUND WATER - SEMI-VOLATILE ORGS.-HSL
UNITS ARE UG/L

| | GW-103 | GW-225 |
|---|---|---|
| PHENOL | N | N |
| BIS(2-CHLOROETHYL)ETHER | N | N |
| 2-CHLOROPHENOL | N | N |
| 1,3-DICHLOROBENZENE | N | N |
| 1,4-DICHLOROBENZENE | N | N |
| BENZYL ALCOHOL | 2 | N |
| 1,2-DICHLOROBENZENE | N | N |
| 2-METHYLPHENOL | N | N |
| BIS(2-CHLOROISOPROPYL)ETHER | N | N |
| 4-METHYLPHENOL | N | N |
| N-NITROSODI-N-PROPYLAMINE | N | N |
| HEXACHLOROETHANE | N | N |
| NITROBENZENE | N | N |
| ISOPHORONE | N | N |
| 2-NITROPHENOL | 81 | N |
| 2,4-DIMETHYLPHENOL | N | N |
| BENZOIC ACID | M | M |
| BIS(2-CHLOROETHOXY)METHANE | N | N |
| 2,4-DICHLOROPHENOL | N | N |
| 1,2,4-TRICHLOROBENZENE | N | N |
| NAPHTHALENE | 2 | N |
| 4-CHLOROANILINE | N | N |
| HEXACHLOROBUTADIENE | N | N |
| 4-CHLORO-3-METHYLPHENOL | N | N |
| 2-METHYLNAPHTHALENE | N | N |
| HEXACHLOROCYCLOPENTADIENE | N | N |
| 2,4,6-TRICHLOROPHENOL | N | N |
| 2,4,5-TRICHLOROPHENOL | M | M |
| 2-CHLORONAPHTHALENE | N | N |
| 2-NITROANILINE | M | M |
| DIMETHYLPHTHALATE | N | N |
| ACENAPHTHYLENE | N | N |
| 3-NITROANILINE | M | M |
| ACENAPHTHENE | N | N |
| 2,4-DINITROPHENOL | 200 | M |
| 4-NITROPHENOL | 200 | M |
| DIBENZOFURAN | N | N |
| 2,4-DINITROTOLUENE | N | N |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
GROUND WATER - SEMI-VOLATILE ORGS.-HSL
UNITS ARE UG/L

| | GW-103 | GW-225 |
|---|---|---|
| 2,6-DINITROTOLUENE | N | N |
| DIETHYLPHTHALATE | N | N |
| 4-CHLOROPHENYL PHENYL ETHER | N | N |
| FLUORENE | N | N |
| 4-NITROANILINE | M | M |
| 4,6-DINITRO-2-METHYLPHENOL | M | M |
| N-NITROSODIPHENYLAMINE | N | N |
| 4-BROMOPHENYL PHENYL ETHER | N | N |
| HEXACHLOROBENZENE | N | N |
| PENTACHLOROPHENOL | M | M |
| PHENANTHRENE | 2 | N |
| ANTHRACENE | N | N |
| DI-N-BUTYLPHTHALATE | N | 2 |
| FLUORANTHENE | N | N |
| PYRENE | N | 1 |
| BUTYL BENZYL PHTHALATE | N | N |
| 3,3'-DICHLOROBENZIDINE | V | V |
| BENZO(A)ANTHRACENE | N | N |
| BIS(2-ETHYLHEXYL)PHTHALATE | N | 27 |
| CHRYSENE | N | N |
| DI-N-OCTYLPHTHALATE | N | N |
| BENZO(B)FLUORANTHENE | N | N |
| BENZO(K)FLUORANTHENE | N | N |
| BENZO(A)PYRENE | N | N |
| INDENO(1,2,3-CD)PYRENE | N | N |
| DIBENZO(A,H)ANTHRACENE | N | N |
| BENZO(G,H,I)PERYLENE | N | N |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SPRING WATER - SEMI-VOLATILE ORGS.-HSL
UNITS ARE UG/L

| | SS-1 | SS-2 | SS-3 | SS-4 |
|---|---|---|---|---|
| PHENOL | N | N | N | N |
| BIS(2-CHLOROETHYL)ETHER | N | N | N | N |
| 2-CHLOROPHENOL | N | N | N | N |
| 1,3-DICHLOROBENZENE | N | N | N | N |
| 1,4-DICHLOROBENZENE | N | N | N | N |
| BENZYL ALCOHOL | N | N | N | N |
| 1,2-DICHLOROBENZENE | N | N | N | N |
| 2-METHYLPHENOL | N | N | N | N |
| BIS(2-CHLOROISOPROPYL)ETHER | N | N | N | N |
| 4-METHYLPHENOL | N | N | N | N |
| N-NITROSODI-N-PROPYLAMINE | N | N | N | N |
| HEXACHLOROETHANE | N | N | N | N |
| NITROBENZENE | N | N | N | N |
| ISOPHORONE | N | N | N | N |
| 2-NITROPHENOL | N | N | N | N |
| 2,4-DIMETHYLPHENOL | N | N | N | N |
| BENZOIC ACID | M | M | M | M |
| BIS(2-CHLOROETHOXY)METHANE | N | N | N | N |
| 2,4-DICHLOROPHENOL | N | N | N | N |
| 1,2,4-TRICHLOROBENZENE | N | N | N | N |
| NAPHTHALENE | N | N | N | N |
| 4-CHLOROANILINE | N | N | N | N |
| HEXACHLOROBUTADIENE | N | N | N | N |
| 4-CHLORO-3-METHYLPHENOL | N | N | N | N |
| 2-METHYLNAPHTHALENE | N | N | N | N |
| HEXACHLOROCYCLOPENTADIENE | N | N | N | N |
| 2,4,6-TRICHLOROPHENOL | N | N | N | N |
| 2,4,5-TRICHLOROPHENOL | M | M | M | M |
| 2-CHLORONAPHTHALENE | N | N | N | N |
| 2-NITROANILINE | M | M | M | M |
| DIMETHYLPHTHALATE | N | N | N | N |
| ACENAPHTHYLENE | N | N | N | N |
| 3-NITROANILINE | M | M | M | M |
| ACENAPHTHENE | N | N | N | N |
| 2,4-DINITROPHENOL | M | M | M | M |
| 4-NITROPHENOL | M | M | M | M |
| DIBENZOFURAN | N | N | N | N |
| 2,4-DINITROTOLUENE | N | N | N | N |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SPRING WATER - SEMI-VOLATILE ORGS.-HSL
UNITS ARE UG/L

| | SS-1 | SS-2 | SS-3 | SS-4 |
|---|---|---|---|---|
| 2,6-DINITROTOLUENE | N | N | N | N |
| DIETHYLPHTHALATE | N | N | N | N |
| 4-CHLOROPHENYL PHENYL ETHER | N | N | N | N |
| FLUORENE | N | N | N | N |
| 4-NITROANILINE | M | M | M | M |
| 4,6-DINITRO-2-METHYLPHENOL | M | M | M | M |
| N-NITROSODIPHENYLAMINE | N | N | N | N |
| 4-BROMOPHENYL PHENYL ETHER | N | N | N | N |
| HEXACHLOROBENZENE | N | N | N | N |
| PENTACHLOROPHENOL | M | M | M | M |
| PHENANTHRENE | N | N | N | N |
| ANTHRACENE | N | N | N | N |
| DI-N-BUTYLPHTHALATE | N | N | N | N |
| FLUORANTHENE | N | N | N | N |
| PYRENE | N | N | N | N |
| BUTYL BENZYL PHTHALATE | N | N | N | N |
| 3,3'-DICHLOROBENZIDINE | V | V | V | V |
| BENZO(A)ANTHRACENE | N | N | N | N |
| BIS(2-ETHYLHEXYL)PHTHALATE | N | N | N | N |
| CHRYSENE | N | N | N | N |
| DI-N-OCTYLPHTHALATE | N | N | N | N |
| BENZO(B)FLUORANTHENE | N | N | N | N |
| BENZO(K)FLUORANTHENE | N | N | N | N |
| BENZO(A)PYRENE | N | N | N | N |
| INDENO(1,2,3-CD)PYRENE | N | N | N | N |
| DIBENZO(A,H)ANTHRACENE | N | N | N | N |
| BENZO(G,H,I)PERYLENE | N | N | N | N |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SPRING WATER - SEMI-VOLATILE ORGS.-HSL
UNITS ARE UG/L

| | SS-5 | SS-7 | SS-8 |
|---|---|---|---|
| PHENOL | N | N | N |
| BIS(2-CHLOROETHYL)ETHER | N | N | N |
| 2-CHLOROPHENOL | N | N | N |
| 1,3-DICHLOROBENZENE | N | N | N |
| 1,4-DICHLOROBENZENE | N | N | N |
| BENZYL ALCOHOL | N | N | N |
| 1,2-DICHLOROBENZENE | N | N | N |
| 2-METHYLPHENOL | N | N | N |
| BIS(2-CHLOROISOPROPYL)ETHER | N | N | N |
| 4-METHYLPHENOL | N | N | N |
| N-NITROSODI-N-PROPYLAMINE | N | N | N |
| HEXACHLOROETHANE | N | N | N |
| NITROBENZENE | N | N | N |
| ISOPHORONE | N | N | N |
| 2-NITROPHENOL | N | N | N |
| 2,4-DIMETHYLPHENOL | N | N | N |
| BENZOIC ACID | M | M | M |
| BIS(2-CHLOROETHOXY)METHANE | N | N | N |
| 2,4-DICHLOROPHENOL | N | N | N |
| 1,2,4-TRICHLOROBENZENE | N | N | N |
| NAPHTHALENE | N | N | N |
| 4-CHLOROANILINE | N | N | N |
| HEXACHLOROBUTADIENE | N | N | N |
| 4-CHLORO-3-METHYLPHENOL | N | N | N |
| 2-METHYLNAPHTHALENE | N | N | N |
| HEXACHLOROCYCLOPENTADIENE | N | N | N |
| 2,4,6-TRICHLOROPHENOL | N | N | N |
| 2,4,5-TRICHLOROPHENOL | M | M | M |
| 2-CHLORONAPHTHALENE | N | N | N |
| 2-NITROANILINE | M | M | M |
| DIMETHYLPHTHALATE | N | N | N |
| ACENAPHTHYLENE | N | N | N |
| 3-NITROANILINE | M | M | M |
| ACENAPHTHENE | N | N | N |
| 2,4-DINITROPHENOL | M | M | M |
| 4-NITROPHENOL | M | M | M |
| DIBENZOFURAN | N | N | N |
| 2,4-DINITROTOLUENE | N | N | N |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SPRING WATER - SEMI-VOLATILE ORGS.-HSL
UNITS ARE UG/L

| | SS-5 | SS-7 | SS-8 |
|---|---|---|---|
| 2,6-DINITROTOLUENE | N | N | N |
| DIETHYLPHTHALATE | N | N | N |
| 4-CHLOROPHENYL PHENYL ETHER | N | N | N |
| FLUORENE | N | N | N |
| 4-NITROANILINE | M | M | M |
| 4,6-DINITRO-2-METHYLPHENOL | M | M | M |
| N-NITROSODIPHENYLAMINE | N | N | N |
| 4-BROMOPHENYL PHENYL ETHER | N | N | N |
| HEXACHLOROBENZENE | N | N | N |
| PENTACHLOROPHENOL | M | M | M |
| PHENANTHRENE | N | N | N |
| ANTHRACENE | N | N | N |
| DI-N-BUTYLPHTHALATE | N | N | N |
| FLUORANTHENE | N | N | N |
| PYRENE | N | N | N |
| BUTYL BENZYL PHTHALATE | N | N | N |
| 3,3'-DICHLOROBENZIDINE | V | V | V |
| BENZO(A)ANTHRACENE | N | N | N |
| BIS(2-ETHYLHEXYL)PHTHALATE | N | N | N |
| CHRYSENE | N | N | N |
| DI-N-OCTYLPHTHALATE | N | N | N |
| BENZO(B)FLUORANTHENE | N | N | N |
| BENZO(K)FLUORANTHENE | N | N | N |
| BENZO(A)PYRENE | N | N | N |
| INDENO(1,2,3-CD)PYRENE | N | N | N |
| DIBENZO(A,H)ANTHRACENE | N | N | N |
| BENZO(G,H,I)PERYLENE | N | N | N |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SURFACE WATER - SEMI-VOLATILE ORGS.-HSL
UNITS ARE UG/L

| | BCK-05.15 | BCK-09.43 | BCK-12.46 | TRIB.07-3 |
|---|---|---|---|---|
| PHENOL | N | N | N | N |
| BIS(2-CHLOROETHYL)ETHER | N | N | N | N |
| 2-CHLOROPHENOL | N | N | N | N |
| 1,3-DICHLOROBENZENE | N | N | N | N |
| 1,4-DICHLOROBENZENE | N | N | N | N |
| BENZYL ALCOHOL | N | N | N | N |
| 1,2-DICHLOROBENZENE | N | N | N | N |
| 2-METHYLPHENOL | N | N | N | N |
| BIS(2-CHLOROISOPROPYL)ETHER | N | N | N | N |
| 4-METHYLPHENOL | N | N | N | N |
| N-NITROSODI-N-PROPYLAMINE | N | N | N | N |
| HEXACHLOROETHANE | N | N | N | N |
| NITROBENZENE | N | N | N | N |
| ISOPHORONE | N | N | N | N |
| 2-NITROPHENOL | N | N | N | N |
| 2,4-DIMETHYLPHENOL | N | N | N | N |
| BENZOIC ACID | M | M | M | M |
| BIS(2-CHLOROETHOXY)METHANE | N | N | N | N |
| 2,4-DICHLOROPHENOL | N | N | N | N |
| 1,2,4-TRICHLOROBENZENE | N | N | N | N |
| NAPHTHALENE | N | N | N | N |
| 4-CHLOROANILINE | N | N | N | N |
| HEXACHLOROBUTADIENE | N | N | N | N |
| 4-CHLORO-3-METHYLPHENOL | N | N | N | N |
| 2-METHYLNAPHTHALENE | N | N | N | N |
| HEXACHLOROCYCLOPENTADIENE | N | N | N | N |
| 2,4,6-TRICHLOROPHENOL | N | N | N | N |
| 2,4,5-TRICHLOROPHENOL | M | M | M | M |
| 2-CHLORONAPHTHALENE | N | N | N | N |
| 2-NITROANILINE | M | M | M | M |
| DIMETHYLPHTHALATE | N | N | N | N |
| ACENAPHTHYLENE | N | N | N | N |
| 3-NITROANILINE | M | M | M | M |
| ACENAPHTHENE | N | N | N | N |
| 2,4-DINITROPHENOL | M | M | M | M |
| 4-NITROPHENOL | M | M | M | M |
| DIBENZOFURAN | N | N | N | N |
| 2,4-DINITROTOLUENE | N | N | N | N |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SEDIMENT - SEMI-VOLATILE ORGS.-HSL
UNITS ARE UG/KG

| | BCK-05.15 | BCK-09.43 | BCK-12.46 | TRIB.07-3 |
|---|---|---|---|---|
| 2,6-DINITROTOLUENE | N | N | N | N |
| DIETHYLPHTHALATE | N | N | N | N |
| 4-CHLOROPHENYL PHENYL ETHER | N | N | N | N |
| FLUORENE | N | N | N | N |
| 4-NITROANILINE | M | M | M | M |
| 4,6-DINITRO-2-METHYLPHENOL | M | M | M | M |
| N-NITROSODIPHENYLAMINE | N | N | N | N |
| 4-BROMOPHENYL PHENYL ETHER | N | N | N | N |
| HEXACHLOROBENZENE | N | N | N | N |
| PENTACHLOROPHENOL | M | M | M | M |
| PHENANTHRENE | N | N | N | N |
| ANTHRACENE | N | N | N | N |
| DI-N-BUTYLPHTHALATE | N | N | N | N |
| FLUORANTHENE | N | N | N | N |
| PYRENE | N | N | N | N |
| BUTYL BENZYL PHTHALATE | N | N | N | N |
| 3,3'-DICHLOROBENZIDINE | V | V | V | V |
| BENZO(A)ANTHRACENE | N | N | N | N |
| BIS(2-ETHYLHEXYL)PHTHALATE | N | N | N | N |
| CHRYSENE | N | N | N | N |
| DI-N-OCTYLPHTHALATE | N | N | N | N |
| BENZO(B)FLUORANTHENE | N | N | N | N |
| BENZO(K)FLUORANTHENE | N | N | N | N |
| BENZO(A)PYRENE | N | N | N | N |
| INDENO(1,2,3-CD)PYRENE | N | N | N | N |
| DIBENZO(A,H)ANTHRACENE | N | N | N | N |
| BENZO(G,H,I)PERYLENE | N | N | N | N |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
GROUND WATER - SEMI-VOLATILE ORGS. - NON-HSL
UNITS ARE UG/L

| | GW-103 | GW-225 |
|---|---|---|
| ACETOPHENONE | N | N |
| 2-ACETYLAMINOFLUORENE | N | N |
| 4-AMINOBIPHENYL | N | N |
| ANILINE | N | N |
| ARAMITE | V | V |
| 2-SEC-BUTYL-4,6-DINITROPHENOL | N | N |
| CHLOROBENZILATE | N | N |
| META-CRESOL | N | N |
| DIALLATE | N | N |
| 2,6-DICHLOROPHENOL | N | N |
| P-(DIMETHYLAMINO)AZOBENZENE | N | N |
| 7,12-DIMETHYLBENZ(A)ANTHRACENE | N | N |
| 3,3'-DIMETHYLBENZIDINE | N | N |
| ALPHA,ALPHA-DIMETHYLPHENETHYLAMINE | N | N |
| META-DINITROBENZENE | N | N |
| 1,4-DIOXANE | N | N |
| DIPHENYLAMINE | N | N |
| ETHYL METHACRYLATE | N | N |
| ETHYL METHANESULFONATE | N | N |
| HEXACHLORODIBENZO-P-DIOXINS | V | V |
| HEXACHLORODIBENZOFURANS | V | V |
| HEXACHLOROPHENE | Y | Y |
| HEXACHLOROPROPENE | N | N |
| ISODRIN | V | V |
| ISOSAFROLE | N | N |
| METHAPYRILENE | N | N |
| 3-METHYLCHOLANTHRENE | N | N |
| METHYL METHACRYLATE | N | N |
| METHYL METHANESULFONATE | N | N |
| 1,4-NAPHTHOQUINONE | N | N |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
GROUND WATER - SEMI-VOLATILE ORGS. - NON-HSL
UNITS ARE UG/L

| | GW-103 | GW-225 |
|---|---|---|
| 1-NAPHTHYLAMINE | N | N |
| 2-NAPHTHYLAMINE | N | N |
| 4-NITROQUINOLINE-1-OXIDE | V | V |
| N-NITROSODI-N-BUTYLAMINE | N | N |
| N-NITROSODIETHYLAMINE | N | N |
| N-NITROSODIMETHYLAMINE | N | N |
| N-NITROSOMETHYLETHYLAMINE | N | N |
| N-NITROSOMORPHOLINE | N | N |
| 5-NITRO-O-TOLUIDINE | N | N |
| N-NITROSOPIPERIDINE | M | M |
| N-NITROSOPYRROLIDINE | N | N |
| PENTACHLOROBENZENE | N | N |
| PENTACHLORODIBENZO-P-DIOXINS | V | V |
| PENTACHLORODIBENZOFURANS | V | V |
| PENTACHLOROETHANE | N | N |
| PENTACHLORONITROBENZENE | M | M |
| PHENACETIN | N | N |
| P-PHENYLENEDIAMINE | N | N |
| 2-PICOLINE | N | N |
| PRONAMIDE | N | N |
| PYRIDINE | N | N |
| SAFROLE | N | N |
| 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN | N | N |
| 1,2,4,5-TETRACHLOROBENZENE | N | N |
| TETRACHLORODIBENZO-P-DIOXINS | V | V |
| TETRACHLORODIBENZOFURANS | V | V |
| 2,3,4,6-TETRACHLOROPHENOL | N | N |
| O-TOLUIDINE | N | N |
| O,O,O-TRIETHYL PHOSPHOROTHIOATE | N | N |
| SYM-TRINITROBENZENE | N | N |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SPRING WATER - SEMI-VOLATILE ORGS. - NON-HSL
UNITS ARE UG/L

| | SS-1 | SS-2 | SS-3 | SS-4 |
|---|---|---|---|---|
| ACETOPHENONE | N | N | N | N |
| 2-ACETYLAMINOFLUORENE | N | N | N | N |
| 4-AMINOBIPHENYL | N | N | N | N |
| ANILINE | N | N | N | N |
| ARAMITE | V | V | V | V |
| 2-SEC-BUTYL-4,6-DINITROPHENOL | N | N | N | N |
| CHLOROBENZILATE | N | N | N | N |
| META-CRESOL | N | N | N | N |
| DIALLATE | N | N | N | N |
| 2,6-DICHLOROPHENOL | N | N | N | N |
| P-(DIMETHYLAMINO)AZOBENZENE | N | N | N | N |
| 7,12-DIMETHYLBENZ(A)ANTHRACENE | N | N | N | N |
| 3,3'-DIMETHYLBENZIDINE | N | N | N | N |
| ALPHA,ALPHA-DIMETHYLPHENETHYLAMINE | N | N | N | N |
| META-DINITROBENZENE | N | N | N | N |
| 1,4-DIOXANE | N | N | N | N |
| DIPHENYLAMINE | N | N | N | N |
| ETHYL METHACRYLATE | N | N | N | N |
| ETHYL METHANESULFONATE | N | N | N | N |
| HEXACHLORODIBENZO-P-DIOXINS | V | V | V | V |
| HEXACHLORODIBENZOFURANS | V | V | V | V |
| HEXACHLOROPHENE | Y | Y | Y | Y |
| HEXACHLOROPROPENE | N | N | N | N |
| ISODRIN | V | V | V | V |
| ISOSAFROLE | N | N | N | N |
| METHAPYRILENE | N | N | N | N |
| 3-METHYLCHOLANTHRENE | N | N | N | N |
| METHYL METHACRYLATE | N | N | N | N |
| METHYL METHANESULFONATE | N | N | N | N |
| 1,4-NAPHTHOQUINONE | N | N | N | N |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SPRING WATER - SEMI-VOLATILE ORGS.- NON-HSL
UNITS ARE UG/L

| | SS-1 | SS-2 | SS-3 | SS-4 |
|---|---|---|---|---|
| 1-NAPHTHYLAMINE | N | N | N | N |
| 2-NAPHTHYLAMINE | N | N | N | N |
| 4-NITROQUINOLINE-1-OXIDE | V | V | V | V |
| N-NITROSODI-N-BUTYLAMINE | N | N | N | N |
| N-NITROSODIETHYLAMINE | N | N | N | N |
| N-NITROSODIMETHYLAMINE | N | N | N | N |
| N-NITROSOMETHYLETHYLAMINE | N | N | N | N |
| N-NITROSOMORPHOLINE | N | N | N | N |
| 5-NITRO-O-TOLUIDINE | N | N | N | N |
| N-NITROSOPIPERIDINE | M | M | M | M |
| N-NITROSOPYRROLIDINE | N | N | N | N |
| PENTACHLOROBENZENE | N | N | N | N |
| PENTACHLORODIBENZO-P-DIOXINS | V | V | V | V |
| PENTACHLORODIBENZOFURANS | V | V | V | V |
| PENTACHLOROETHANE | N | N | N | N |
| PENTACHLORONITROBENZENE | M | M | M | M |
| PHENACETIN | N | N | N | N |
| P-PHENYLENEDIAMINE | N | N | N | N |
| 2-PICOLINE | N | N | N | N |
| PRONAMIDE | N | N | N | N |
| PYRIDINE | N | N | N | N |
| SAFROLE | N | N | N | N |
| 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN | N | N | N | N |
| 1,2,4,5-TETRACHLOROBENZENE | N | N | N | N |
| TETRACHLORODIBENZO-P-DIOXINS | V | V | V | V |
| TETRACHLORODIBENZOFURANS | V | V | V | V |
| 2,3,4,6-TETRACHLOROPHENOL | N | N | N | N |
| O-TOLUIDINE | N | N | N | N |
| O,O,O-TRIETHYL PHOSPHOROTHIOATE | N | N | N | N |
| SYM-TRINITROBENZENE | N | N | N | N |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SPRING WATER - SEMI-VOLATILE ORGS.- NON-HSL
UNITS ARE UG/L

| | SS-5 | SS-7 | SS-8 |
|---|---|---|---|
| ACETOPHENONE | N | N | N |
| 2-ACETYLAMINOFLUORENE | N | N | N |
| 4-AMINOBIPHENYL | N | N | N |
| ANILINE | N | N | N |
| ARAMITE | V | V | V |
| 2-SEC-BUTYL-4,6-DINITROPHENOL | N | N | N |
| CHLOROBENZILATE | N | N | N |
| META-CRESOL | N | N | N |
| DIALLATE | N | N | N |
| 2,6-DICHLOROPHENOL | N | N | N |
| P-(DIMETHYLAMINO)AZOBENZENE | N | N | N |
| 7,12-DIMETHYLBENZ(A)ANTHRACENE | N | N | N |
| 3,3'-DIMETHYLBENZIDINE | N | N | N |
| ALPHA,ALPHA-DIMETHYLPHENETHYLAMINE | N | N | N |
| META-DINITROBENZENE | N | N | N |
| 1,4-DIOXANE | N | N | N |
| DIPHENYLAMINE | N | N | N |
| ETHYL METHACRYLATE | N | N | N |
| ETHYL METHANESULFONATE | N | N | N |
| HEXACHLORODIBENZO-P-DIOXINS | V | V | V |
| HEXACHLORODIBENZOFURANS | V | V | V |
| HEXACHLOROPHENE | Y | Y | Y |
| HEXACHLOROPROPENE | N | N | N |
| ISODRIN | V | V | V |
| ISOSAFROLE | N | N | N |
| METHAPYRILENE | N | N | N |
| 3-METHYLCHOLANTHRENE | N | N | N |
| METHYL METHACRYLATE | N | N | N |
| METHYL METHANESULFONATE | N | N | N |
| 1,4-NAPHTHOQUINONE | N | N | N |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SPRING WATER - SEMI-VOLATILE ORGS.- NON-HSL
UNITS ARE UG/L

| | SS-5 | SS-7 | SS-8 |
|---|---|---|---|
| 1-NAPHTHYLAMINE | N | N | N |
| 2-NAPHTHYLAMINE | N | N | N |
| 4-NITROQUINOLINE-1-OXIDE | V | V | V |
| N-NITROSODI-N-BUTYLAMINE | N | N | N |
| N-NITROSODIETHYLAMINE | N | N | N |
| N-NITROSODIMETHYLAMINE | N | N | N |
| N-NITROSOMETHYLETHYLAMINE | N | N | N |
| N-NITROSOMORPHOLINE | N | N | N |
| 5-NITRO-O-TOLUIDINE | N | N | N |
| N-NITROSOPIPERIDINE | M | M | M |
| N-NITROSOPYRROLIDINE | N | N | N |
| PENTACHLOROBENZENE | N | N | N |
| PENTACHLORODIBENZO-P-DIOXINS | V | V | V |
| PENTACHLORODIBENZOFURANS | V | V | V |
| PENTACHLOROETHANE | N | N | N |
| PENTACHLORONITROBENZENE | M | M | M |
| PHENACETIN | N | N | N |
| P-PHENYLENEDIAMINE | N | N | N |
| 2-PICOLINE | N | N | N |
| PRONAMIDE | N | N | N |
| PYRIDINE | N | N | N |
| SAFROLE | N | N | N |
| 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN | N | N | N |
| 1,2,4,5-TETRACHLOROBENZENE | N | N | N |
| TETRACHLORODIBENZO-P-DIOXINS | V | V | V |
| TETRACHLORODIBENZOFURANS | V | V | V |
| 2,3,4;6-TETRACHLOROPHENOL | N | N | N |
| O-TOLUIDINE | N | N | N |
| O,O,O-TRIETHYL PHOSPHOROTHIOATE | N | N | N |
| SYM-TRINITROBENZENE | N | N | N |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SURFACE WATER - SEMI-VOLATILE ORGS.- NON-HSL
UNITS ARE UG/L

| | BCK-05.15 | BCK-09.43 | BCK-12.46 | TRIB.07-3 |
|---|---|---|---|---|
| ACETOPHENONE | N | N | N | N |
| 2-ACETYLAMINOFLUORENE | N | N | N | N |
| 4-AMINOBIPHENYL | N | N | N | N |
| ANILINE | N | N | N | N |
| ARAMITE | V | V | V | V |
| 2-SEC-BUTYL-4,6-DINITROPHENOL | N | N | N | N |
| CHLOROBENZILATE | N | N | N | N |
| META-CRESOL | N | N | N | N |
| DIALLATE | N | N | N | N |
| 2,6-DICHLOROPHENOL | N | N | N | N |
| P-(DIMETHYLAMINO)AZOBENZENE | N | N | N | N |
| 7,12-DIMETHYLBENZ(A)ANTHRACENE | N | N | N | N |
| 3,3'-DIMETHYLBENZIDINE | N | N | N | N |
| ALPHA,ALPHA-DIMETHYLPHENETHYLAMINE | N | N | N | N |
| META-DINITROBENZENE | N | N | N | N |
| 1,4-DIOXANE | N | N | N | N |
| DIPHENYLAMINE | N | N | N | N |
| ETHYL METHACRYLATE | N | N | N | N |
| ETHYL METHANESULFONATE | N | N | N | N |
| HEXACHLORODIBENZO-P-DIOXINS | V | V | V | V |
| HEXACHLORODIBENZOFURANS | V | V | V | V |
| HEXACHLOROPHENE | Y | Y | Y | Y |
| HEXACHLOROPROPENE | N | N | N | N |
| ISODRIN | V | V | V | V |
| ISOSAFROLE | N | N | N | N |
| METHAPYRILENE | N | N | N | N |
| 3-METHYLCHOLANTHRENE | N | N | N | N |
| METHYL METHACRYLATE | N | N | N | N |
| METHYL METHANESULFONATE | N | N | N | N |
| 1,4-NAPHTHOQUINONE | N | N | N | N |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SURFACE WATER - SEMI-VOLATILE ORGS.- NON-HSL
UNITS ARE UG/L

| | BCK-05.15 | BCK-09.43 | BCK-12.46 | TRIB.07-3 |
|---|---|---|---|---|
| 1-NAPHTHYLAMINE | N | N | N | N |
| 2-NAPHTHYLAMINE | N | N | N | N |
| 4-NITROQUINOLINE-1-OXIDE | V | V | V | V |
| N-NITROSODI-N-BUTYLAMINE | N | N | N | N |
| N-NITROSODIETHYLAMINE | N | N | N | N |
| N-NITROSODIMETHYLAMINE | N | N | N | N |
| N-NITROSOMETHYLETHYLAMINE | N | N | N | N |
| N-NITROSOMORPHOLINE | N | N | N | N |
| 5-NITRO-O-TOLUIDINE | N | N | N | N |
| N-NITROSOPIPERIDINE | M | M | M | M |
| N-NITROSOPYRROLIDINE | N | N | N | N |
| PENTACHLOROBENZENE | N | N | N | N |
| PENTACHLORODIBENZO-P-DIOXINS | V | V | V | V |
| PENTACHLORODIBENZOFURANS | V | V | V | V |
| PENTACHLOROETHANE | N | N | N | N |
| PENTACHLORONITROBENZENE | M | M | M | M |
| PHENACETIN | N | N | N | N |
| P-PHENYLENEDIAMINE | N | N | N | N |
| 2-PICOLINE | N | N | N | N |
| PRONAMIDE | N | N | N | N |
| PYRIDINE | N | N | N | N |
| SAFROLE | N | N | N | N |
| 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN | N | N | N | N |
| 1,2,4,5-TETRACHLOROBENZENE | N | N | N | N |
| TETRACHLORODIBENZO-P-DIOXINS | V | V | V | V |
| TETRACHLORODIBENZOFURANS | V | V | V | V |
| 2,3,4,6-TETRACHLOROPHENOL | N | N | N | N |
| O-TOLUIDINE | N | N | N | N |
| O,O,O-TRIETHYL PHOSPHOROTHIOATE | N | N | N | N |
| SYM-TRINITROBENZENE | N | N | N | N |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB

BEAR CREEK VALLEY
ORGANIC COMPOUNDS
GROUND WATER - PESTICIDES AND PCBS
UNITS ARE UG/L

| | GW-103 | GW-225 |
|---|---|---|
| ALPHA-BHC | H | H |
| BETA-BHC | H | H |
| DELTA-BHC | H | H |
| LINDANE | H | H |
| HEPTACHLOR | H | H |
| ALDRIN | H | H |
| HEPTACHLOR EPOXIDE | H | H |
| ALPHA-ENDOSULFAN | H | H |
| DIELDRIN | J | J |
| 4,4'-DDE | J | J |
| ENDRIN | J | J |
| BETA-ENDOSULFAN | J | J |
| 4,4'-DDD | J | J |
| ENDRIN ALDEHYDE | J | J |
| ENDOSULFAN SULFATE | J | J |
| 4,4'-DDT | J | J |
| METHOXYCHLOR | B | B |
| ENDRIN KETONE | J | J |
| CHLORDANE | . | B |
| ALPHA CHLORDANE | B | . |
| GAMMA CHLORDANE | B | . |
| CHLORDECONE | J | J |
| TOXAPHENE | C | C |
| PCB-(AROCLOR)-1016 | B | B |
| PCB-(AROCLOR)-1221 | B | B |
| PCB-(AROCLOR)-1232 | B | B |
| PCB-(AROCLOR)-1242 | B | B |
| PCB-(AROCLOR)-1248 | B | B |
| PCB-(AROCLOR)-1254 | C | C |
| PCB-(AROCLOR)-1260 | C | C |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SPRING WATER - PESTICIDES AND PCBS
UNITS ARE UG/L

| | SS-1 | SS-2 | SS-3 | SS-4 |
|---|---|---|---|---|
| ALPHA-BHC | H | H | H | H |
| BETA-BHC | H | H | H | H |
| DELTA-BHC | H | H | H | H |
| LINDANE | H | H | H | H |
| HEPTACHLOR | H | H | H | H |
| ALDRIN | H | H | H | H |
| HEPTACHLOR EPOXIDE | H | H | H | H |
| ALPHA-ENDOSULFAN | H | H | H | H |
| DIELDRIN | J | J | J | J |
| 4,4'-DDE | J | J | J | J |
| ENDRIN | J | J | J | J |
| BETA-ENDOSULFAN | J | J | J | J |
| 4,4'-DDD | J | J | J | J |
| ENDRIN ALDEHYDE | J | J | J | J |
| ENDOSULFAN SULFATE | J | J | J | J |
| 4,4'-DDT | J | J | J | J |
| METHOXYCHLOR | B | B | B | B |
| ENDRIN KETONE | . | . | . | . |
| CHLORDANE | . | . | . | . |
| ALPHA CHLORDANE | B | B | B | B |
| GAMMA CHLORDANE | B | B | B | B |
| CHLORDECONE | J | J | J | J |
| TOXAPHENE | C | C | C | C |
| PCB-(AROCLOR)-1016 | B | B | B | B |
| PCB-(AROCLOR)-1221 | B | B | B | B |
| PCB-(AROCLOR)-1232 | B | B | B | B |
| PCB-(AROCLOR)-1242 | B | B | B | B |
| PCB-(AROCLOR)-1248 | B | B | B | B |
| PCB-(AROCLOR)-1254 | C | C | C | C |
| PCB-(AROCLOR)-1260 | C | C | C | C |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SPRING WATER - PESTICIDES AND PCBS
UNITS ARE UG/L

| | SS-5 | SS-7 | SS-8 |
|---|---|---|---|
| ALPHA-BHC | H | H | H |
| BETA-BHC | H | H | H |
| DELTA-BHC | H | H | H |
| LINDANE | H | H | H |
| HEPTACHLOR | H | H | H |
| ALDRIN | H | H | H |
| HEPTACHLOR EPOXIDE | H | H | H |
| ALPHA-ENDOSULFAN | H | H | H |
| DIELDRIN | J | J | J |
| 4,4'-DDE | J | J | J |
| ENDRIN | J | J | J |
| BETA-ENDOSULFAN | J | J | J |
| 4,4'-DDD | J | J | J |
| ENDRIN ALDEHYDE | J | J | J |
| ENDOSULFAN SULFATE | J | J | J |
| 4,4'-DDT | J | J | J |
| METHOXYCHLOR | B | B | B |
| ENDRIN KETONE | . | . | . |
| CHLORDANE | . | . | . |
| ALPHA CHLORDANE | B | B | B |
| GAMMA CHLORDANE | B | B | B |
| CHLORDECONE | J | J | J |
| TOXAPHENE | C | C | C |
| PCB-(AROCLOR)-1016 | B | B | B |
| PCB-(AROCLOR)-1221 | B | B | B |
| PCB-(AROCLOR)-1232 | B | B | B |
| PCB-(AROCLOR)-1242 | B | B | B |
| PCB-(AROCLOR)-1248 | B | B | B |
| PCB-(AROCLOR)-1254 | C | C | C |
| PCB-(AROCLOR)-1260 | C | C | C |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SURFACE WATER - PESTICIDES AND PCBS
UNITS ARE UG/L

| | BCK-05.15 | BCK-09.43 | BCK-12.46 | TRIB.07-3 |
|---|---|---|---|---|
| ALPHA-BHC | H | H | H | Q |
| BETA-BHC | H | H | H | Q |
| DELTA-BHC | H | H | H | Q |
| LINDANE | H | H | H | Q |
| HEPTACHLOR | H | H | H | Q |
| ALDRIN | H | H | H | Q |
| HEPTACHLOR EPOXIDE | H | H | H | Q |
| ALPHA-ENDOSULFAN | H | H | H | Q |
| DIELDRIN | J | J | J | T |
| 4,4'-DDE | J | J | J | T |
| ENDRIN | J | J | J | T |
| BETA-ENDOSULFAN | J | J | J | T |
| 4,4'-DDD | J | J | J | T |
| ENDRIN ALDEHYDE | J | J | J | T |
| ENDOSULFAN SULFATE | J | J | J | T |
| 4,4'-DDT | J | J | J | T |
| METHOXYCHLOR | B | B | B | X |
| ENDRIN KETONE | . | . | . | . |
| CHLORDANE | . | . | . | . |
| ALPHA CHLORDANE | B | B | B | X |
| GAMMA CHLORDANE | B | B | B | X |
| CHLORDECONE | J | J | J | T |
| TOXAPHENE | C | C | C | Y |
| PCB-(AROCLOR)-1016 | B | B | B | X |
| PCB-(AROCLOR)-1221 | B | B | B | X |
| PCB-(AROCLOR)-1232 | B | B | B | X |
| PCB-(AROCLOR)-1242 | B | B | B | X |
| PCB-(AROCLOR)-1248 | B | B | B | X |
| PCB-(AROCLOR)-1254 | C | C | C | Y |
| PCB-(AROCLOR)-1260 | C | C | C | Y |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
GROUND WATER - HERBICIDES & OP PESTICIDES
UNITS ARE UG/L

| | GW-103 | GW-225 |
|---|---|---|
| 2,4-D | F | C |
| SILVEX | E | B |
| 2,4,5-T | E | B |
| PHORATE | A | A |
| DIMETHOATE | A | A |
| DIOXATHION | C | C |
| DIAZINON | T | T |
| DISULFOTON | T | T |
| DEMETON | T | T |
| METHYL PARATHION | T | T |
| MALATHION | P | P |
| ETHYL PARATHION | P | P |
| DEF | B | B |
| ETHION | B | B |
| AZINPHOS-METHYL | D | D |
| THIONAZIN | B | B |
| FAMPHUR | D | D |
| SULFOTEPP | C | C |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SPRING WATER - HERBICIDES & OP PESTICIDES
UNITS ARE UG/L

| | SS-1 | SS-2 | SS-3 | SS-4 |
|---|---|---|---|---|
| 2,4-D | C | C | C | C |
| SILVEX | B | B | B | B |
| 2,4,5-T | B | B | B | B |
| PHORATE | A | A | A | A |
| DIMETHOATE | A | A | A | A |
| DIOXATHION | C | C | C | C |
| DIAZINON | T | T | T | T |
| DISULFOTON | T | T | T | T |
| DEMETON | T | T | T | T |
| METHYL PARATHION | T | T | T | T |
| MALATHION | P | P | P | P |
| ETHYL PARATHION | P | P | P | P |
| DEF | B | B | B | B |
| ETHION | B | B | B | B |
| AZINPHOS-METHYL | D | D | D | D |
| THIONAZIN | B | B | B | B |
| FAMPHUR | D | D | D | D |
| SULFOTEPP | C | C | C | C |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SPRING WATER - HERBICIDES & OP PESTICIDES
UNITS ARE UG/L

| | SS-5 | SS-7 | SS-8 |
|---|---|---|---|
| 2,4-D | C | C | C |
| SILVEX | B | B | B |
| 2,4,5-T | B | B | B |
| PHORATE | A | A | A |
| DIMETHOATE | A | A | A |
| DIOXATHION | C | C | C |
| DIAZINON | T | T | T |
| DISULFOTON | T | T | T |
| DEMETON | T | T | T |
| METHYL PARATHION | T | T | T |
| MALATHION | P | P | P |
| ETHYL PARATHION | P | P | P |
| DEF | B | B | B |
| ETHION | B | B | B |
| AZINPHOS-METHYL | D | D | D |
| THIONAZIN | B | B | B |
| FAMPHUR | D | D | D |
| SULFOTEPP | C | C | C |

RESULTS OF 1988 APPENDIX 9 SAMPLING BY ROY F. WESTON LAB
BEAR CREEK VALLEY
ORGANIC COMPOUNDS
SURFACE WATER - HERBICIDES & OP PESTICIDES
UNITS ARE UG/L

| | BCK-05.15 | BCK-09.43 | BCK-12.46 | TRIB.07-3 |
|---|---|---|---|---|
| 2,4-D | C | C | C | C |
| SILVEX | B | B | B | B |
| 2,4,5-T | B | B | B | B |
| PHORATE | A | A | A | A |
| DIMETHOATE | A | A | A | A |
| DIOXATHION | C | C | C | C |
| DIAZINON | T | T | T | T |
| DISULFOTON | T | T | T | T |
| DEMETON | T | T | T | T |
| METHYL PARATHION | T | T | T | T |
| MALATHION | P | P | P | P |
| ETHYL PARATHION | P | P | P | P |
| DEF | B | B | B | B |
| ETHION | B | B | B | B |
| AZINPHOS-METHYL | D | D | D | D |
| THIONAZIN | B | B | B | B |
| FAMPHUR | D | D | D | D |
| SULFOTEPP | C | C | C | C |

# APPENDIX D. WATER QUALITY RESULTS FOR USGS SAMPLING SITES IN BEAR CREEK WATERSHED

| PARAMETER | SITE<br>USGS ID<br>DATE | BCK 12.46<br>9.70<br>4/13/84 | BCK 12.46<br>9.70<br>6/3/84 | BCK 12.46<br>9.70<br>9/26/84 | NT-1 0.3<br>9.77<br>4/13/84 | NT-1 0.3<br>9.77<br>6/3/84 |
|---|---|---|---|---|---|---|
| Temperature | °C | 11.0 | 15.0 | 17.0 | 14.0 | 21.0 |
| Conductance | µS/cm | 4000 | 3900 | 7300 | 86 | 145 |
| pH | pH Units | 6.6 | - | 7.0 | 6.8 | - |
| Field Alkalinity | mg/L as $CaCO_3$ | - | - | - | - | - |
| Dissolved Oxygen | mg/L | 1.6 | - | 5.0 | 9.2 | - |
| Discharge | $ft^3/s$ | .02 | <.01 | 0.04 | 0.08 | 0.01 |
| Calcium, Dissolved | mg/L | 530 | - | 820 | 9.8 | - |
| Magnesium, Dissolved | mg/L | 75 | - | 150 | 2.1 | - |
| Sodium, Dissolved | mg/L | 180 | - | 170 | 2.8 | - |
| Potassium, Dissolved | mg/L | 9.7 | - | 20 | 1.2 | - |
| Lab Alkalinity | mg/L as $CaCO_3$ | 314 | - | 156 | 26 | - |
| Chloride, Dissolved | mg/L | 220 | - | 120 | 3.5 | - |
| Sulfate, Dissolved | mg/L | 190 | - | 250 | 11 | - |
| $NO_2$+$NO_3$, Dissolved | mg/L as N | 300 | - | 610 | 3.9 | - |
| Ammonia, Dissolved | mg/L as N | - | - | 0.520 | - | - |
| Nitrogen, Kjeldahl | mg/L as N | - | - | 0.20 | - | - |
| Orthophosphate, Dissolved | mg/L as P | - | - | <.010 | - | - |
| Σ Phosphate, Dissolved | mg/L as P | <.010 | - | <.010 | <.010 | - |
| Σ Phosphate, Total | mg/L as P | - | - | <.010 | - | - |
| Total Dissolved Solids | mg/L | - | - | - | - | - |
| Arsenic, Total | µg/L | - | - | 1 | - | - |
| Barium, Total Recoverable | µg/L | <100 | - | 400 | <100 | - |
| Beryllium, Total Recov. | µg/L | <10 | - | <10 | <10 | - |
| Cadmium, Total Recoverable | µg/L | <1 | - | 33 | <1 | - |
| Chromium, Total Recoverable | µg/L | 30 | - | <1 | 4 | - |
| Cobalt, Total Recoverable | µg/L | - | - | 10 | 3 | - |
| Copper, Total Recoverable | µg/L | 2 | - | 4 | 2 | - |
| Cyanide, Total | mg/L | <.01 | - | 0.07 | <.01 | - |
| Iron, Total Recoverable | µg/L | 740 | - | 210 | 740 | - |
| Lead, Total Recoverable | µg/L | 6 | - | 2 | 6 | - |
| Lithium, Total Recoverable | µg/L | <10 | - | 30 | <10 | - |
| Manganese, Total Recov. | µg/L | 80 | - | 9200 | 80 | - |
| Mercury, Total Recoverable | µg/L | <.1 | - | 0.4 | <.1 | - |
| Molybdenum, Total Recov. | µg/L | <1 | - | 1 | <1 | - |
| Nickel, Total Recoverable | µg/L | - | - | 95 | - | - |
| Selenium, Total | µg/L | - | - | <1 | - | - |
| Strontium, Total Recov. | µg/L | 30 | - | 1900 | 30 | - |
| Uranium, Diss. Extraction | µg/L | - | - | - | 0.40 | - |
| Natural Uranium, Dissolved | µg/L | 1300 | - | 870 | - | - |
| Vanadium, Dissolved | µg/L | <1 | - | 2 | <1 | - |
| Zinc, Total Recoverable | µg/L | 20 | - | 20 | 20 | - |
| Carbon, Total Organic | mg/L as C | 2.2 | - | - | 2.3 | - |
| Carbon, Dissolved Organic | mg/L as C | - | 3.2 | 8.6 | - | 5.0 |
| Carbon, Σ Suspended Org. | mg/L as C | - | - | 0.40 | - | - |
| Gross Alpha, Dissolved | µg/L as U-Nat | - | - | 1300 | - | - |
| Gross Alpha, Σ Suspended | µg/L as U-Nat | - | - | 8.4 | - | - |
| Gross Beta, Dissolved | pCi/L as Cs-137 | - | - | 1200 | - | - |
| Gross Beta, Dissolved | pCi/L as Sr-90&Y-90 | - | - | 1100 | - | - |
| Gross Beta, Σ Suspended | pCi/L as Cs-137 | - | - | 130 | - | - |
| Gross Beta, Σ Suspended | pCi/L as Sr-90&Y-90 | - | - | 120 | - | - |

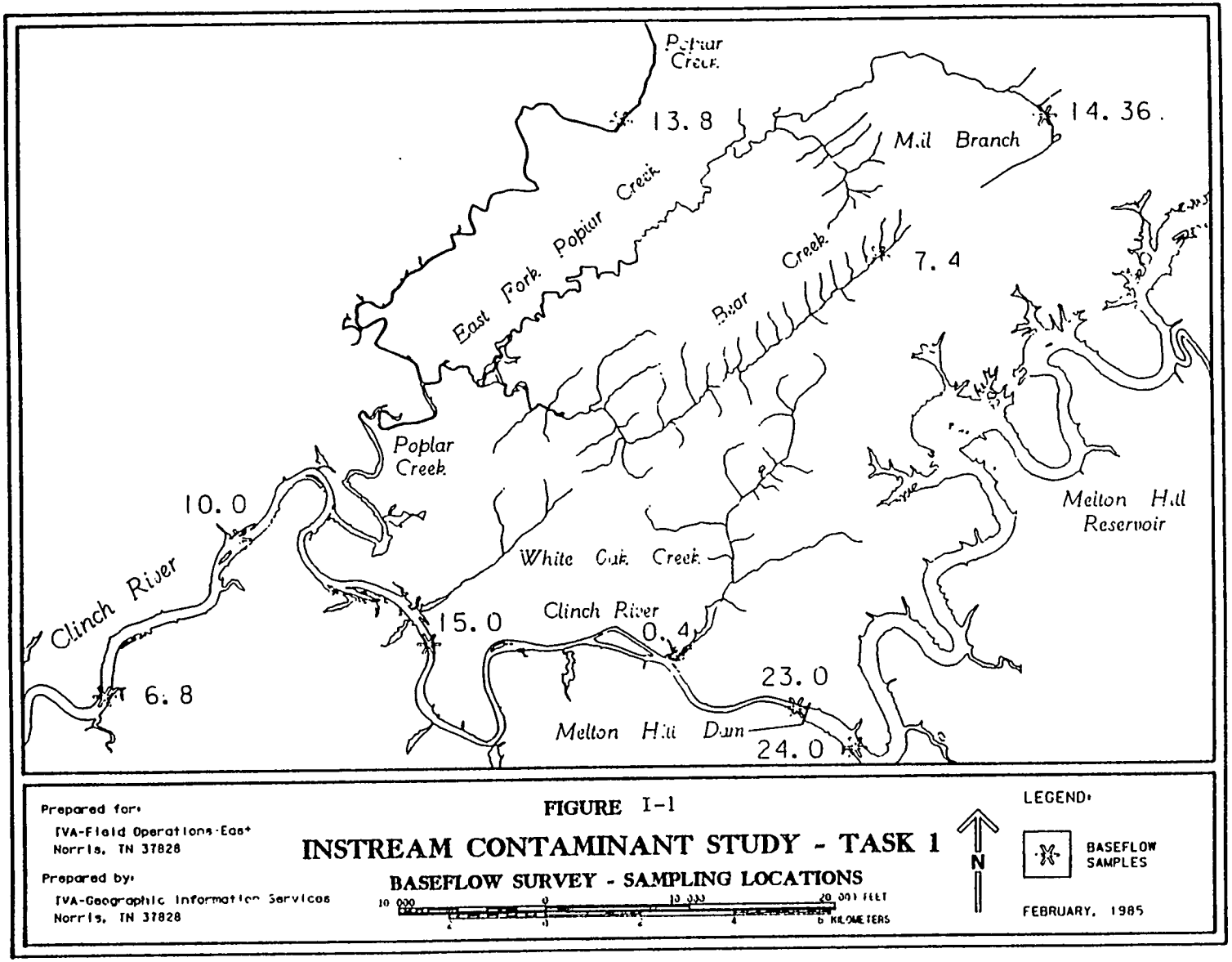
| PARAMETER | SITE<br>USGS ID<br>DATE | NT-1<br>9.65<br>4/13/84 | BCK 11.97<br>9.63<br>4/13/84 | BCK 11.97<br>9.63<br>6/3/84 | BCK 11.97<br>9.63<br>9/26/84 | SS-2<br>9.60<br>4/13/84 | SS-2<br>9.60<br>9/26/84 | SS-4<br>9.52<br>4/12/84 | SS-4<br>9.52<br>9/26/84 |
|---|---|---|---|---|---|---|---|---|---|
| Temperature | °C | 13.0 | 17.0 | 22.0 | 17.0 | 14.0 | 13.5 | 13.0 | 13.0 |
| Conductance | µS/cm | 2300 | 1800 | 2600 | 4500 | 240 | 320 | 530 | 800 |
| pH | pH Units | 5.9 | 7.6 | - | 7.2 | 7.5 | 7.3 | 7.2 | 6.9 |
| Field Alkalinity | mg/L as $CaCO_3$ | - | - | - | - | - | 170 | - | 230 |
| Dissolved Oxygen | mg/L | 8.9 | 9.0 | - | 7.2 | 9.0 | 8.4 | 4.3 | 4.2 |
| Discharge | $ft^3/s$ | 0.11 | 0.29 | 0.07 | <0.01 | 0.14 | 0.03 | 0.21 | 0.05 |
| Calcium, Dissolved | mg/L | 350 | 270 | - | 470 | 27 | 37 | 81 | 120 |
| Magnesium, Dissolved | mg/L | 39 | 35 | - | 67 | 16 | 20 | 20 | 23 |
| Sodium, Dissolved | mg/L | 23 | 39 | - | 66 | 0.60 | 0.50 | 9.1 | 14 |
| Potassium, Dissolved | mg/L | 2.9 | 4.4 | - | 7.6 | 0.40 | 0.70 | 1.7 | 3.1 |
| Lab Alkalinity | mg/L as $CaCO_3$ | 26 | 140 | - | 137 | 139 | - | 199 | - |
| Chloride, Dissolved | mg/L | 19 | 47 | - | 64 | 1.6 | 1.5 | 20 | 23 |
| Sulfate, Dissolved | mg/L | 9.2 | 58 | - | 88 | 1.1 | 3.5 | 24 | 34 |
| $NO_2$+$NO_3$, Dissolved | mg/L as N | 280 | 210 | - | 380 | <.100 | 1.9 | 20.0 | 35 |
| Ammonia, Dissolved | mg/L as N | - | - | - | 0.100 | - | <0.010 | - | 0.280 |
| Nitrogen, Kjeldahl | mg/L as N | - | - | - | 0.10 | - | 0.10 | - | 0.40 |
| Orthophosphate, Dissolved | mg/L as P | - | - | - | <.010 | - | <0.010 | - | <0.010 |
| Σ Phosphate, Dissolved | mg/L as P | <.010 | <.010 | - | <.010 | 0.020 | <0.010 | <0.010 | <0.010 |
| Σ Phosphate, Total | mg/L as P | - | - | - | <.010 | - | <0.010 | - | <0.010 |
| Total Dissolved Solids | mg/L | - | - | - | - | 156 | 176 | 414 | - |
| Arsenic, Total | µg/L | - | - | - | 1 | - | 1 | - | 1 |
| Barium, Total Recoverable | µg/L | 2400 | 800 | - | 900 | 100 | 200 | 100 | 200 |
| Beryllium, Total Recov. | µg/L | <10 | <10 | - | <10 | <10 | <10 | <10 | <10 |
| Cadmium, Total Recoverable | µg/L | 58 | 27 | - | 1 | <1 | <1 | <1 | <1 |
| Chromium, Total Recoverable | µg/L | 1 | 4 | - | <1 | 2 | <1 | 2 | <1 |
| Cobalt, Total Recoverable | µg/L | 20 | 10 | - | 2 | <1 | <1 | 4 | <1 |
| Copper, Total Recoverable | µg/L | 2 | 2 | - | 1 | 1 | <1 | 2 | 1 |
| Cyanide, Total | mg/L | 0.06 | 0.06 | - | 0.06 | <0.01 | <0.01 | <0.01 | 0.01 |
| Iron, Total Recoverable | µg/L | 240 | 120 | - | 260 | 100 | 340 | 150 | 350 |
| Lead, Total Recoverable | µg/L | 2 | 4 | - | 4 | 2 | 1 | 1 | 6 |
| Lithium, Total Recoverable | µg/L | <10 | 20 | - | 10 | <10 | 10 | 20 | 30 |
| Manganese, Total Recov. | µg/L | 5900 | 2900 | - | 50 | <10 | 50 | 40 | 200 |
| Mercury, Total Recoverable | µg/L | 0.1 | 0.1 | - | 0.2 | <0.1 | <0.1 | 0.2 | 0.4 |
| Molybdenum, Total Recov. | µg/L | <1 | <1 | - | 1 | <1 | 1 | <1 | 1 |
| Nickel, Total Recoverable | µg/L | - | - | - | 7 | - | <1 | - | 8 |
| Selenium, Total | µg/L | - | - | - | <1 | - | <1 | - | <1 |
| Strontium, Total Recov. | µg/L | 1100 | 720 | - | 1300 | 20 | 50 | 120 | 250 |
| Uranium, Diss. Extraction | µg/L | 1.0 | - | - | - | - | - | - | - |
| Natural Uranium, Dissolved | µg/L | - | 190 | - | 890 | 0.8 | 1.1 | 110 | 250 |
| Vanadium, Dissolved | µg/L | <1 | <1 | - | 1 | <1 | 1 | <1 | <1 |
| Zinc, Total Recoverable | µg/L | 40 | 30 | - | 10 | 10 | <10 | 20 | <10 |
| Carbon, Total Organic | mg/L as C | 2.3 | 2.7 | - | - | 0.50 | - | 0.90 | - |
| Carbon, Dissolved Organic | mg/L as C | - | - | 1.3 | 6.9 | - | 1.2 | - | 2.0 |
| Carbon, Σ Suspended Org. | mg/L as C | - | - | - | 0.60 | | 0.10 | - | 0.60 |
| Gross Alpha, Dissolved | µg/L as U-Nat | - | 160 | - | 66 | <3.5 | <6.1 | - | - |
| Gross Alpha, Σ Suspended | µg/L as U-Nat | - | 10 | - | 37 | 1.2 | <0.4 | - | - |
| Gross Beta, Dissolved | pCi/L as Cs-137 | - | 320 | - | 49 | <1.8 | <2.6 | - | - |
| Gross Beta, Dissolved | pCi/L as Sr-90&Y-90 | - | 280 | - | 42 | <1.6 | <2.2 | - | - |
| Gross Beta, Σ Suspended | pCi/L as Cs-137 | - | 49 | - | 280 | 0.9 | <0.4 | - | - |
| Gross Beta, Σ Suspended | pCi/L as Sr-90&Y-90 | - | 44 | - | 240 | 0.8 | <0.4 | - | - |

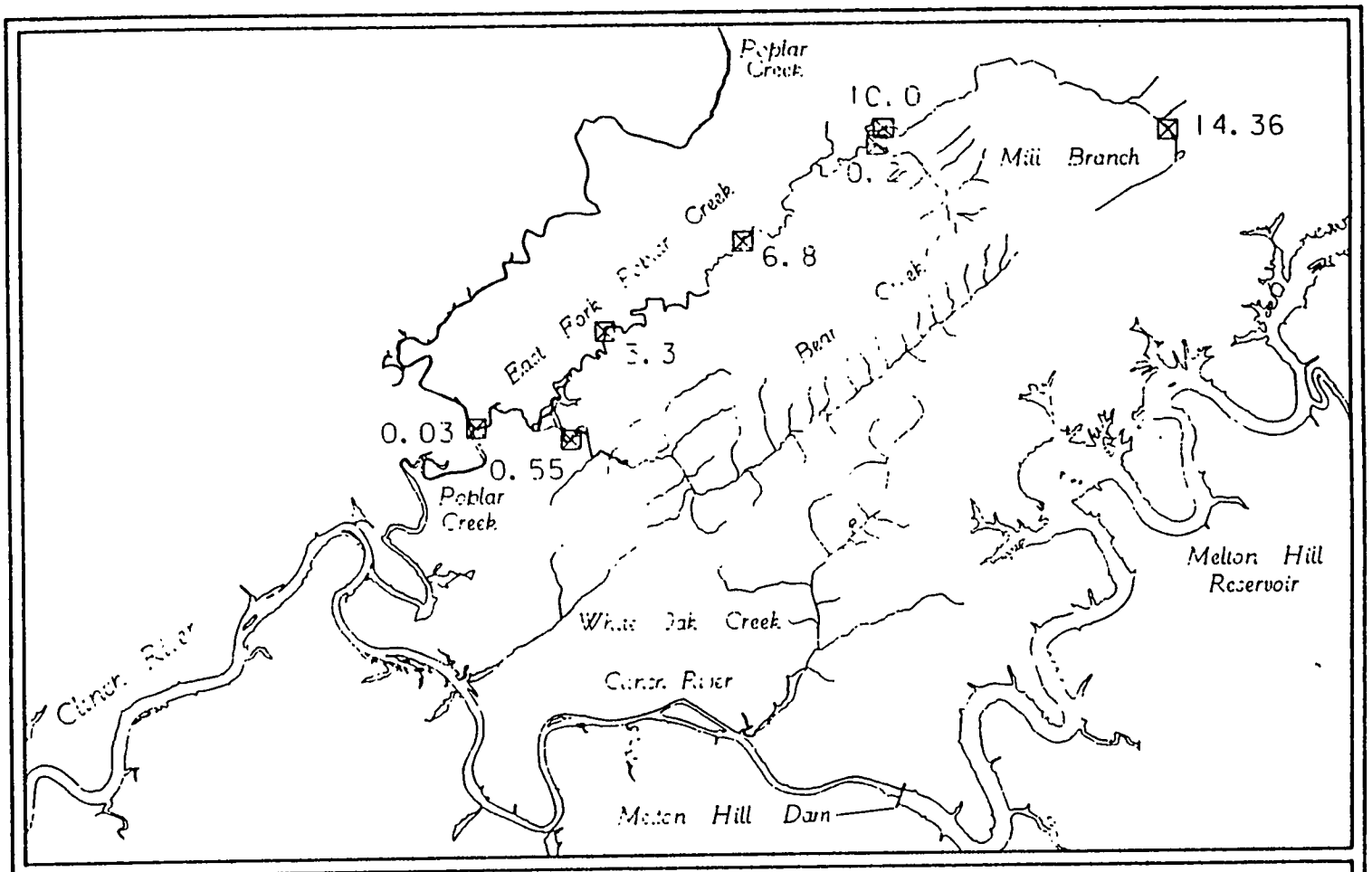
| PARAMETER | SITE<br>USGS ID<br>DATE | BCK 9.40<br>9.47<br>4/12/84 | BCK 9.40<br>9.47<br>6/3/84 | SS-5<br>9.46<br>4/12/84 | SS-5<br>9.46<br>9/26/84 | BCK 9.07<br>9.45<br>4/12/84 | BCK 9.07<br>9.45<br>9/26/84 | BCK 7.11<br>9.31<br>9/26/84 |
|---|---|---|---|---|---|---|---|---|
| Temperature | °C | 16.0 | 16.0 | 14.0 | 13.5 | 11.0 | 14.0 | 16.0 |
| Conductance | µS/cm | 540 | 780 | 360 | 675 | 480 | 700 | 650 |
| pH | pH Units | 8.1 | - | 7.2 | 7.8 | 7.7 | 7.8 | 8.1 |
| Field Alkalinity | mg/L as $CaCO_3$ | - | - | - | 201 | - | 198 | 216 |
| Dissolved Oxygen | mg/L | 10.4 | - | 6.6 | 12.4 | 10.2 | 8.8 | 12.2 |
| Discharge | $ft^3/s$ | 1.3 | 0.13 | 0.75 | 0.12 | 1.9 | 0.09 | 0.08 |
| Calcium, Dissolved | mg/L | 73 | - | 45 | 94 | 62 | 93 | 87 |
| Magnesium, Dissolved | mg/L | 12 | - | 13 | 22 | 13 | 22 | 20 |
| Sodium, Dissolved | mg/L | 9.9 | - | 4.2 | 10 | 7.1 | 9.5 | 9.4 |
| Potassium, Dissolved | mg/L | 2.1 | - | 1.1 | 2.0 | 1.6 | 2.0 | 2.7 |
| Lab Alkalinity | mg/L as $CaCO_3$ | 107 | - | 133 | - | 120 | - | - |
| Chloride, Dissolved | mg/L | 20 | - | 9.9 | 19 | 15 | 18 | 18 |
| Sulfate, Dissolved | mg/L | 25 | - | 12 | 24 | 19 | 23 | 23 |
| $NO_2+NO_3$, Dissolved | mg/L as N | 30.0 | - | 9.90 | 27 | 22.0 | 27 | 24 |
| Ammonia, Dissolved | mg/L as N | - | - | - | 0.010 | - | 0.030 | <0.010 |
| Nitrogen, Kjeldahl | mg/L as N | - | - | - | <0.10 | - | <0.10 | 0.10 |
| Orthophosphate, Dissolved | mg/L as P | - | - | - | <0.010 | - | 0.010 | <0.010 |
| Σ Phosphate, Dissolved | mg/L as P | <0.010 | - | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| Σ Phosphate, Total | mg/L as P | - | - | - | <0.010 | - | <0.010 | <0.010 |
| Total Dissolved Solids | mg/L | 417 | - | 232 | - | 343 | - | 585 |
| Arsenic, Total | µg/L | - | - | - | <1 | - | <1 | 1 |
| Barium, Total Recoverable | µg/L | 200 | - | <100 | 200 | 200 | 200 | 200 |
| Beryllium, Total Recov. | µg/L | <10 | - | <10 | <10 | <10 | <10 | <10 |
| Cadmium, Total Recoverable | µg/L | 1 | - | <1 | <1 | 1 | <1 | <1 |
| Chromium, Total Recoverable | µg/L | 1 | - | 2 | 10 | 2 | <1 | <1 |
| Cobalt, Total Recoverable | µg/L | <1 | - | <1 | <1 | 6 | <1 | <1 |
| Copper, Total Recoverable | µg/L | 2 | - | 1 | 2 | 2 | 1 | 1 |
| Cyanide, Total | mg/L | 0.01 | - | <0.01 | 0.01 | <0.01 | <0.01 | 0.01 |
| Iron, Total Recoverable | µg/L | 480 | - | 100 | 160 | 210 | 530 | 520 |
| Lead, Total Recoverable | µg/L | 1 | - | 2 | 4 | 1 | 2 | 3 |
| Lithium, Total Recoverable | µg/L | 350 | - | 20 | 60 | 210 | 100 | 170 |
| Manganese, Total Recov. | µg/L | 430 | - | 10 | 10 | 250 | 50 | 60 |
| Mercury, Total Recoverable | µg/L | 0.2 | - | 0.2 | <0.1 | 0.2 | <0.1 | <0.1 |
| Molybdenum, Total Recov. | µg/L | 1 | - | 1 | <1 | <1 | 1 | 1 |
| Nickel, Total Recoverable | µg/L | - | - | - | 3 | - | 4 | 7 |
| Selenium, Total | µg/L | - | - | - | <1 | - | <1 | <1 |
| Strontium, Total Recov. | µg/L | 210 | - | 70 | 200 | 120 | 210 | 200 |
| Uranium, Diss. Extraction | µg/L | - | - | - | - | - | - | - |
| Natural Uranium, Dissolved | µg/L | 180 | - | 61 | 160 | 140 | 150 | 150 |
| Vanadium, Dissolved | µg/L | <1 | - | <1 | <1 | <1 | <1 | <1 |
| Zinc, Total Recoverable | µg/L | 10 | - | 50 | 20 | 30 | 10 | 30 |
| Carbon, Total Organic | mg/L as C | 2.0 | - | 0.80 | - | 1.5 | - | - |
| Carbon, Dissolved Organic | mg/L as C | - | 3.4 | - | 21 | - | 6.4 | 3.0 |
| Carbon, Σ Suspended Org. | mg/L as C | - | - | - | 0.20 | - | 0.30 | 0.20 |
| Gross Alpha, Dissolved | µg/L as U-Nat | 94 | - | 20 | 110 | - | - | - |
| Gross Alpha, Σ Suspended | µg/L as U-Nat | 3.7 | - | 1.2 | 2.6 | - | - | - |
| Gross Beta, Dissolved | pCi/L as Cs-137 | 61 | - | 19 | 63 | - | - | - |
| Gross Beta, Dissolved | pCi/L as Sr-90&Y-90 | 53 | - | 16 | 54 | - | - | - |
| Gross Beta, Σ Suspended | pCi/L as Cs-137 | 37 | - | 11 | 31 | - | - | - |
| Gross Beta, Σ Suspended | pCi/L as Sr-90&Y-90 | 34 | - | 9.9 | 29 | - | - | - |

| PARAMETER | SITE<br>USGS ID<br>DATE | BCK 4.55<br>9.18<br>4/12/84 | BCK 4.55<br>9.18<br>6/3/84 | BCK 4.55<br>9.18<br>9/26/84 | SS-8<br>9.16<br>4/12/84 | SS-8<br>9.16<br>9/26/84 | NT-14<br>14.3<br>4/12/84 | NT-14<br>14.3<br>6/3/84 | NT-14<br>14.3<br>9/27/84 |
|---|---|---|---|---|---|---|---|---|---|
| Temperature | °C | 15.0 | 14.5 | 16.0 | 12.0 | 13.0 | 16.0 | 14.0 | 14.5 |
| Conductance | µS/cm | 320 | 420 | 460 | 221 | 315 | 68 | 123 | 215 |
| pH | pH Units | 8.5 | - | 8.4 | 7.3 | 7.6 | 7.8 | - | 7.9 |
| Field Alkalinity | mg/L as $CaCO_3$ | - | - | 182 | - | 162 | - | - | 104 |
| Dissolved Oxygen | mg/L | 10.0 | - | 16.8 | 9.6 | 9.3 | 10.5 | - | 12.2 |
| Discharge | $ft^3/s$ | 4.3 | 1.2 | <0.01 | 0.71 | 0.14 | 0.21 | 0.04 | 0.01 |
| Calcium, Dissolved | mg/L | 41 | - | 61 | 28 | 39 | 6.4 | - | 25 |
| Magnesium, Dissolved | mg/L | 9.7 | - | 18 | 9.0 | 16 | 1.9 | - | 8.6 |
| Sodium, Dissolved | mg/L | 4.5 | - | 5.0 | 2.0 | 1.1 | 2.0 | - | 6.9 |
| Potassium, Dissolved | mg/L | 1.4 | - | 2.1 | 0.80 | 0.90 | 1.8 | - | 2.8 |
| Lab Alkalinity | mg/L as $CaCO_3$ | 102 | - | - | 112 | - | 12 | - | - |
| Chloride, Dissolved | mg/L | 10 | - | 11 | 4.0 | 1.9 | 1.2 | - | 3.4 |
| Sulfate, Dissolved | mg/L | 13 | - | 14 | 3.2 | 2.2 | 10 | - | 8.7 |
| $NO_2$+$NO_3$, Dissolved | mg/L as N | 9.20 | - | 14 | 0.150 | 0.27 | <0.100 | - | <0.10 |
| Ammonia, Dissolved | mg/L as N | - | - | <0.010 | - | <0.010 | - | - | <0.010 |
| Nitrogen, Kjeldahl | mg/L as N | - | - | 0.10 | - | 0.20 | - | - | 0.20 |
| Orthophosphate, Dissolved | mg/L as P | - | - | <0.010 | - | <0.010 | - | - | 0.020 |
| Σ Phosphate, Dissolved | mg/L as P | <0.010 | - | <0.010 | <0.010 | <0.010 | 0.050 | - | 0.020 |
| Σ Phosphate, Total | mg/L as P | - | - | <0.010 | - | <0.010 | - | - | - |
| Total Dissolved Solids | mg/L | 210 | - | 266 | 146 | - | 42 | - | 130 |
| Arsenic, Total | µg/L | - | - | 1 | - | 1 | - | - | <1 |
| Barium, Total Recoverable | µg/L | 100 | - | 100 | <100 | 100 | <100 | - | 100 |
| Beryllium, Total Recov. | µg/L | <10 | - | <10 | <10 | <10 | <10 | - | <10 |
| Cadmium, Total Recoverable | µg/L | <1 | - | <1 | <1 | <1 | <1 | - | <1 |
| Chromium, Total Recoverable | µg/L | 2 | - | <1 | 3 | <1 | 1 | - | <1 |
| Cobalt, Total Recoverable | µg/L | 1 | - | 1 | 2 | 1 | <1 | - | <1 |
| Copper, Total Recoverable | µg/L | 3 | - | 1 | 2 | 2 | 2 | - | 1 |
| Cyanide, Total | mg/L | <0.01 | - | <0.01 | <0.01 | <0.01 | <0.01 | - | <0.01 |
| Iron, Total Recoverable | µg/L | 240 | - | 100 | 360 | 310 | 410 | - | 260 |
| Lead, Total Recoverable | µg/L | 1 | - | 5 | 5 | 4 | 2 | - | 3 |
| Lithium, Total Recoverable | µg/L | 90 | - | 110 | 10 | 10 | <10 | - | 10 |
| Manganese, Total Recov. | µg/L | 20 | - | 70 | 10 | 20 | 10 | - | 10 |
| Mercury, Total Recoverable | µg/L | <0.1 | - | <0.1 | 0.1 | <0.1 | <0.1 | - | <0.1 |
| Molybdenum, Total Recov. | µg/L | <1 | - | 1 | <1 | 1 | 1 | - | 1 |
| Nickel, Total Recoverable | µg/L | - | - | 6 | - | 4 | - | - | 4 |
| Selenium, Total | µg/L | - | - | <1 | - | <1 | - | - | <1 |
| Strontium, Total Recov. | µg/L | 60 | - | 110 | 30 | 50 | 20 | - | 100 |
| Uranium, Diss. Extraction | µg/L | - | - | - | 0.23 | - | 0.02 | - | 0.16 |
| Natural Uranium, Dissolved | µg/L | 68 | - | 100 | - | 5.4 | - | - | - |
| Vanadium, Dissolved | µg/L | <1 | - | <1 | <1 | <1 | <1 | - | <1 |
| Zinc, Total Recoverable | µg/L | 20 | - | <10 | 20 | 20 | 20 | - | <10 |
| Carbon, Total Organic | mg/L as C | 1.1 | - | - | 0.80 | - | 1.5 | - | - |
| Carbon, Dissolved Organic | mg/L as C | - | 2.5 | 4.8 | - | 0.50 | - | 1.7 | 5.7 |
| Carbon, Σ Suspended Org. | mg/L as C | - | - | 0.10 | - | 0.10 | - | - | 0.10 |
| Gross Alpha, Dissolved | µg/L as U-Nat | - | - | - | - | - | <0.9 | - | <2.3 |
| Gross Alpha, Σ Suspended | µg/L as U-Nat | - | - | - | - | - | <0.4 | - | <0.4 |
| Gross Beta, Dissolved | pCi/L as Cs-137 | - | - | - | - | - | 2.2 | - | 3.6 |
| Gross Beta, Dissolved | pCi/L as Sr-90&Y-90 | - | - | - | - | - | 1.9 | - | 3.1 |
| Gross Beta, Σ Suspended | pCi/L as Cs-137 | - | - | - | - | - | <0.4 | - | 0.5 |
| Gross Beta, Σ Suspended | pCi/L as Sr-90&Y-90 | - | - | - | - | - | <0.4 | - | 0.4 |

| PARAMETER | SITE<br>USGS ID<br>DATE | NT-14 0.5<br>14.5<br>4/12/84 | NT-14 1.0<br>14.9<br>4/12/84 | NT-14 1.0<br>14.9<br>9/27/84 | WT-1<br>11.2<br>4/12/84 |
|---|---|---|---|---|---|
| Temperature | °C | 11.0 | 9.5 | 15.0 | 13.0 |
| Conductance | µS/cm | 47 | 48 | 300 | 35 |
| pH | pH Units | 9.2 | 8.3 | 7.1 | 6.0 |
| Field Alkalinity | mg/L as $CaCO_3$ | - | - | 154 | 7 |
| Dissolved Oxygen | mg/L | 9.8 | 10.0 | 13.2 | 7.8 |
| Discharge | $ft^3/s$ | 0.03 | 0.10 | 0.01 | 0.01 |
| Calcium, Dissolved | mg/L | 5.0 | 3.7 | 34 | 2.6 |
| Magnesium, Dissolved | mg/L | 1.2 | 1.4 | 14 | 1.0 |
| Sodium, Dissolved | mg/L | 1.5 | 1.2 | 7.0 | 1.1 |
| Potassium, Dissolved | mg/L | 1.0 | 2.3 | 2.4 | 0.90 |
| Lab Alkalinity | mg/L as $CaCO_3$ | 13 | 9.0 | - | 7.0 |
| Chloride, Dissolved | mg/L | 1.4 | 1.3 | 1.4 | 1.2 |
| Sulfate, Dissolved | mg/L | 11 | 12 | 9.1 | 7.7 |
| $NO_2$+$NO_3$, Dissolved | mg/L as N | <0.100 | <0.100 | <0.10 | <0.100 |
| Ammonia, Dissolved | mg/L as N | - | - | <0.010 | - |
| Nitrogen, Kjeldahl | mg/L as N | - | - | 0.20 | - |
| Orthophosphate, Dissolved | mg/L as P | - | - | 0.050 | - |
| Σ Phosphate, Dissolved | mg/L as P | <0.010 | <0.010 | 0.050 | <0.010 |
| Σ Phosphate, Total | mg/L as P | - | - | 0.050 | - |
| Total Dissolved Solids | mg/L | - | 26 | 171 | 20 |
| Arsenic, Total | µg/L | - | - | 1 | - |
| Barium, Total Recoverable | µg/L | <100 | <100 | 200 | <100 |
| Beryllium, Total Recov. | µg/L | <10 | <10 | <10 | <10 |
| Cadmium, Total Recoverable | µg/L | <1 | <1 | <1 | <1 |
| Chromium, Total Recoverable | µg/L | 5 | 3 | <1 | 1 |
| Cobalt, Total Recoverable | µg/L | 3 | 4 | <1 | <1 |
| Copper, Total Recoverable | µg/L | 3 | 2 | 1 | 2 |
| Cyanide, Total | mg/L | <0.01 | <0.01 | <0.01 | <0.01 |
| Iron, Total Recoverable | µg/L | 940 | 270 | 390 | 570 |
| Lead, Total Recoverable | µg/L | 4 | 3 | 3 | 2 |
| Lithium, Total Recoverable | µg/L | 10 | <10 | 10 | <10 |
| Manganese, Total Recov. | µg/L | 20 | 10 | 160 | 30 |
| Mercury, Total Recoverable | µg/L | <0.1 | <0.1 | <0.1 | <0.1 |
| Molybdenum, Total Recov. | µg/L | <1 | <1 | 1 | <1 |
| Nickel, Total Recoverable | µg/L | - | - | 4 | - |
| Selenium, Total | µg/L | - | - | <1 | - |
| Strontium, Total Recov. | µg/L | 20 | 20 | <10 | - |
| Uranium, Diss. Extraction | µg/L | 0.05 | 0.01 | 0.29 | <0.01 |
| Natural Uranium, Dissolved | µg/L | - | - | - | - |
| Vanadium, Dissolved | µg/L | <1 | <1 | <1 | 1 |
| Zinc, Total Recoverable | µg/L | 20 | 20 | 40 | 20 |
| Carbon, Total Organic | mg/L as C | 1.4 | 1.1 | - | 1.3 |
| Carbon, Dissolved Organic | mg/L as C | - | - | 4.0 | - |
| Carbon, Σ Suspended Org. | mg/L as C | - | - | 0.10 | - |
| Gross Alpha, Dissolved | µg/L as U-Nat | - | - | - | - |
| Gross Alpha, Σ Suspended | µg/L as U-Nat | - | - | - | - |
| Gross Beta, Dissolved | pCi/L as Cs-137 | - | - | - | - |
| Gross Beta, Dissolved | pCi/L as Sr-90&Y-90 | - | - | - | - |
| Gross Beta, Σ Suspended | pCi/L as Cs-137 | - | - | - | - |
| Gross Beta, Σ Suspended | pCi/L as Sr-90&Y-90 | - | - | - | - |

# APPENDIX E. SUMMARY OF RESULTS OF TVA SAMPLING AND ANALYSIS IN BEAR CREEK FOR THE OAK RIDGE INTERAGENCY TASK FORCE, WITH MAPS OF SAMPLING LOCATIONS


Poplar Creek
13.8
14.36
Mill Branch
East Fork Poplar Creek
Bear Creek
7.4
Poplar Creek
10.0
Clinch River
White Oak Creek
Clinch River
15.0
0.4
6.8
23.0
Melton Hill Dam
24.0
Melton Hill Reservoir
Prepared for:
TVA-Field Operations-East
Norris, TN 37828
Prepared by:
TVA-Geographic Information Services
Norris, TN 37828
FIGURE I-1
INSTREAM CONTAMINANT STUDY - TASK 1
BASEFLOW SURVEY - SAMPLING LOCATIONS
10 000 0 10 000 20 000 FEET
2 0 2 4 6 KILOMETERS
N
LEGEND:
BASEFLOW SAMPLES
FEBRUARY, 1985




Prepared for:
TVA-Field Operations-East
Norris, TN 37828

Prepared by:
TVA-Geographic Information Services
Norris, TN 37828

FIGURE I-2

**INSTREAM CONTAMINANT STUDY - TASK 1**

**STORMFLOW SURVEYS - SAMPLING LOCATIONS**

N

LEGEND:

STORMFLOW SAMPLES

FEBRUARY, 1985

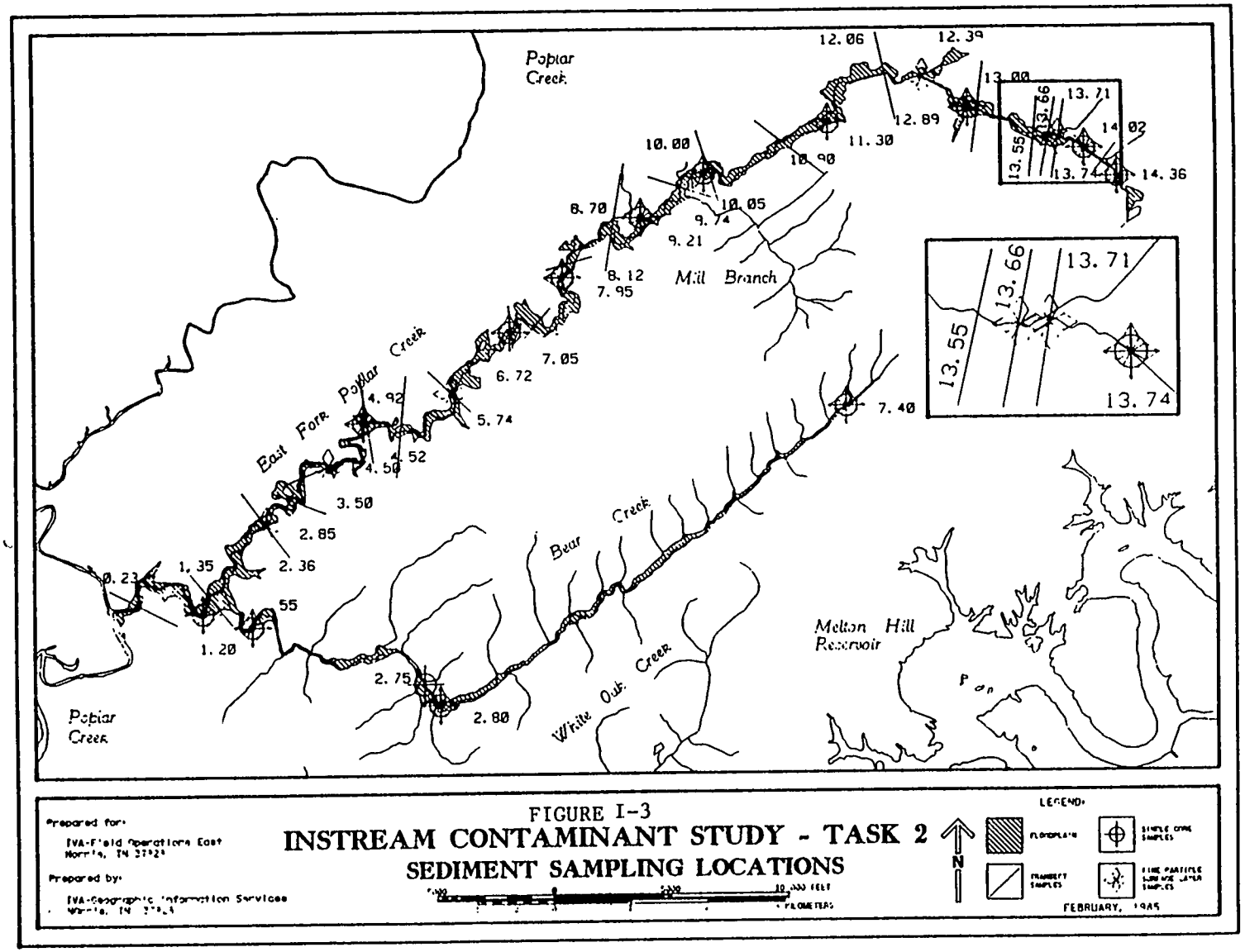



FIGURE I-3

**INSTREAM CONTAMINANT STUDY - TASK 2**

**SEDIMENT SAMPLING LOCATIONS**

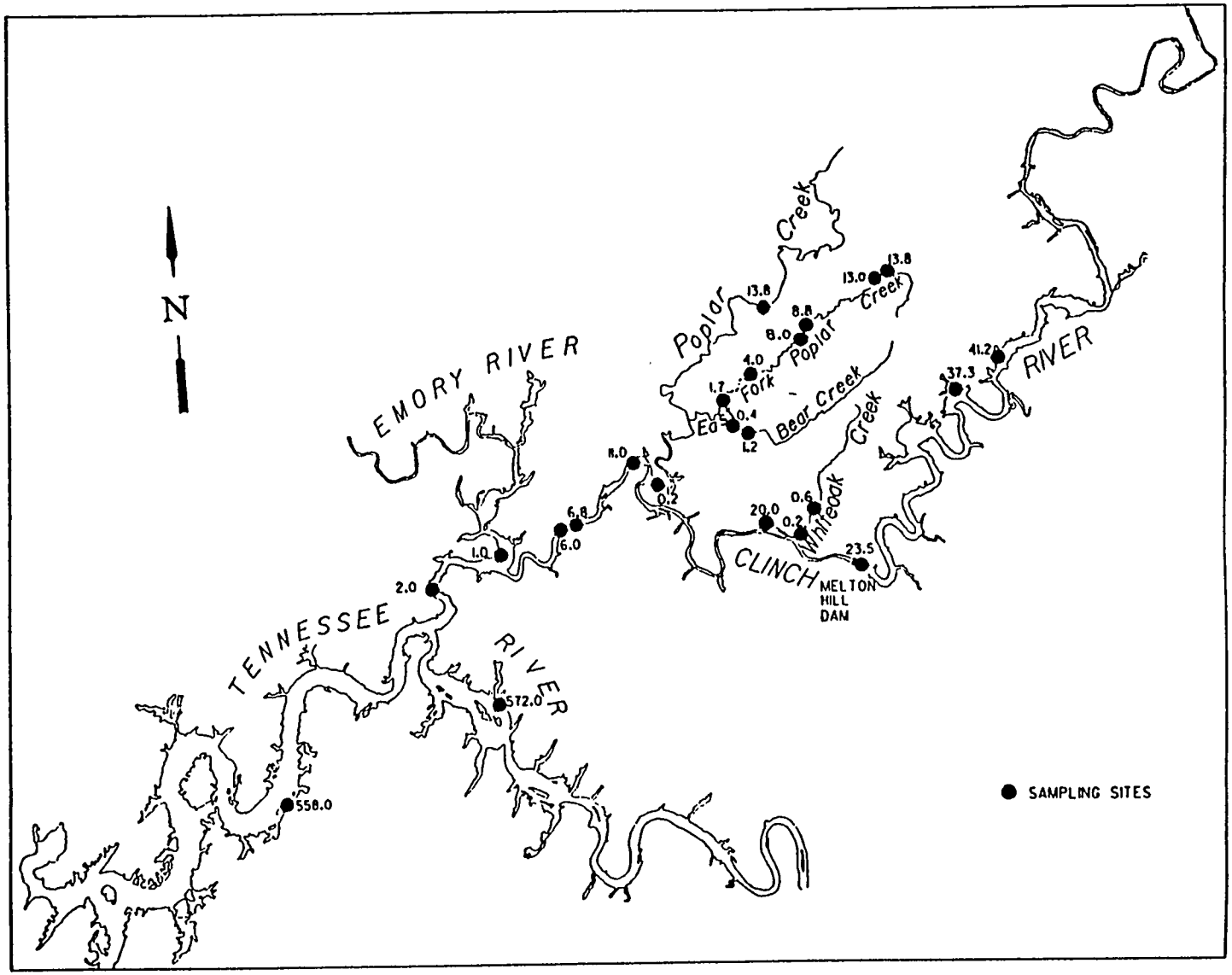



FIGURE I-7
INSTREAM CONTAMINANT STUDY - TASK 4
FISH SAMPLING LOCATIONS

Table II-1

REMARK CODES FOR DATA SUMMARIES
INSTREAM CONTAMINANT STUDY - TASK 5

| Remark Code | Definition |
|---|---|
| A | Value reported is the mean of two or more determinations. |
| C | Value calculated. |
| D | Field duplicate. |
| K | Actual value is known to be less than value given. |
| L | Actual value is known to be greater than value given. |
| M | Presence of material verified but not quantified. In the case of temperature or oxygen reduction potential, M indicates a negative value. In the case of species, M indicates male sex. |
| N | Presumptive evidence of presence of material. |
| R | Sample possibly contaminated or result influenced by other compounds in sample. |
| S | Split sample. |
| TOT | Totals for all analyses. |
| TXT/TE | Alpha numeric data, refer to individual data. |
| U | Indicates material was analyzed for but not detected. In the case of species, U indicates undetermined sex. |

STORET RETRIEVAL DATE 85/06/11

9 TOTAL STATIONS PROCESSED

# STATISTICAL SUMMARY
## INSTREAM CONTAMINANT STUDY BEAR CREEK DATA
## WATER, SEDIMENT, FISH, AND AQUATIC BIOTA
## INSTREAM CONTAMINANT STUDY-TASK 5

| PARAMETER | | | |
|---|---|---|---|
| 2 | HSAMPLOC | % FROM | RT BANK |
| 8 | LAB | IDENT. | NUMBER |
| 10 | WATER | TEMP | CENT |
| 23 | WEIGHT | | POUNDS |
| 24 | LENGTH | | INCHES |
| 63 | NO. OF | SAMPLING | POINTS |
| 65 | STREAM | STAGE | FEET |
| 94 | CNDUCTVY | FIELD | MICROMHO |
| 98 | VSAMPLOC | DEPTH | METERS |
| 300 | DO | | MG/L |
| 400 | PH | | SU |
| 431 | T ALK | FIELD | MG/L |
| 530 | RESIDUE | TOT NFLT | MG/L |
| 535 | RESIDUE | VOL NFLT | MG/L |
| 556 | OIL-GRSE | FREON-GR | MG/L |
| 610 | NH3+NH4- | N TOTAL | MG/L |
| 625 | TOT KJEL | N | MG/L |
| 630 | NO2&NO3 | N-TOTAL | MG/L |
| 665 | PHOS-TOT | | MG/L P |
| 720 | CYANIDE | CN-TOT | MG/L |
| 721 | CYANIDE | SEDMG/KG | DRY WGT |
| 900 | TOT HARD | CACO3 | MG/L |
| 1002 | ARSENIC | AS,TOT | UG/L |
| 1003 | ARSENIC | SEDMG/KG | DRY WGT |
| 1004 | ARSENIC | TISMG/KG | WET WGT |
| 1012 | BERYLIUM | BE,TOT | UG/L |
| 1027 | CADMIUM | CD,TOT | UG/L |
| 1028 | CD NUD | DRY WGT | MG/KG-CD |
| 1029 | CHROMIUM | SEDMG/KG | DRY WGT |
| 1034 | CHROMIUM | CR,TOT | UG/L |
| 1042 | COPPER | CU,TOT | UG/L |
| 1051 | LEAD | PB,TOT | UG/L |
| 1052 | LEAD | SEDMG/KG | DRY WGT |
| 1059 | THALLIUM | TL,TOTAL | UG/L |

| RMK | NUMBER | MEAN | VARIANCE | STAN DEV | MAXIMUM | MINIMUM | BEG DATE | END DATE |
|---|---|---|---|---|---|---|---|---|
| | 9 | 55.000 | 625.00 | 25.000 | 95.0 | 10.3 | 84/05/09 | 84/11/10 |
| D | 2 | 50.000 | 0.000 | 0.000 | 50.0 | 50.0 | 84/06/20 | 84/06/26 |
| TOT | 11 | 54.091 | 504.09 | 22.452 | 95.0 | 10.0 | 84/05/09 | 84/11/10 |
| | 63 | 5578.8 | 22101000. | 4701.2 | 12171 | 7 | 84/05/15 | 85/04/06 |
| R | 14 | 4074600. | 78724000. | 8872.6 | 4089790 | 4061260 | 84/05/15 | 84/11/10 |
| TOT | 77 | 745410. | 9256200. | 1579700. | 4089790 | 7 | 84/05/15 | 85/04/06 |
| | 2 | 15.300 | 5.7803 | 2.4042 | 17.0 | 13.6 | 84/05/09 | 84/05/31 |
| | 26 | .28231 | .03653 | .19113 | .79 | .08 | 84/05/15 | 84/06/07 |
| | 23 | 7.3870 | 3.9103 | 1.9774 | 12.80 | 4.80 | 84/05/15 | 84/06/07 |
| | 46 | 2.3043 | 3.5942 | 1.8958 | 5 | 1 | 84/10/22 | 85/04/06 |
| | 15 | 1.4647 | .08387 | .28961 | 1.90 | 1.05 | 84/05/09 | 85/04/06 |
| | 1 | 160.00 | | | 160 | 160 | 84/05/09 | 84/05/09 |
| L | 1 | 2000.0 | | | 2000 | 2000 | 84/05/31 | 84/05/31 |
| TOT | 2 | 1080.0 | 1692800. | 1301.1 | 2000 | 160 | 84/05/09 | 84/05/31 |
| | 5 | .30000 | .00000 | .00036 | .30 | .30 | 84/05/09 | 84/09/13 |
| | 2 | 9.3500 | .00502 | .07085 | 9.4 | 9.3 | 84/05/09 | 84/05/31 |
| | 3 | 7.3867 | .47065 | .68605 | 7.86 | 6.60 | 84/05/09 | 84/06/26 |
| | 2 | 175.00 | 2.0000 | 1.4142 | 176 | 174 | 84/05/31 | 84/06/26 |
| | 36 | 210.75 | 57297. | 239.37 | 1000 | 2 | 84/05/09 | 85/04/06 |
| | 20 | 26.850 | 595.82 | 24.409 | 100 | 2 | 84/05/31 | 85/04/06 |
| U | 1 | 5.0000 | | | 5.00 | 5.00 | 84/05/31 | 84/05/31 |
| | 1 | .17000 | | | .170 | .170 | 84/05/31 | 84/05/31 |
| | 1 | .38000 | | | .380 | .380 | 84/05/31 | 84/05/31 |
| | 3 | 333.33 | 6533.4 | 80.830 | 380.00 | 240.00 | 84/05/31 | 84/06/26 |
| U | 1 | .01000 | | | .010 | .010 | 84/05/31 | 84/05/31 |
| U | 1 | .02000 | | | .020 | .020 | 84/09/13 | 84/09/13 |
| U | 4 | .82500 | .00250 | .05000 | .90 | .80 | 84/06/20 | 84/06/20 |
| | 1 | 1000.0 | | | 1000 | 1000 | 84/05/31 | 84/05/31 |
| U | 1 | 1.0000 | | | 1 | 1 | 84/05/31 | 84/05/31 |
| | 4 | 7.3500 | 14.970 | 3.8691 | 12.00 | 3.68 | 84/06/20 | 84/06/20 |
| | 16 | .20625 | .01529 | .12366 | .50 | .18 | 84/05/15 | 84/06/07 |
| U | 9 | .10000 | .00000 | .00000 | .10 | .10 | 84/05/15 | 84/06/07 |
| TOT | 25 | .16800 | .01226 | .11076 | .50 | .10 | 84/05/15 | 84/06/07 |
| U | 1 | 1.0000 | | | 1.00 | 1.00 | 84/05/31 | 84/05/31 |
| | 1 | 26.000 | | | 26 | 26 | 84/05/31 | 84/05/31 |
| | 2 | 8.6000 | 3.9201 | 1.9799 | 10.00 | 7.20 | 84/06/20 | 84/06/20 |
| U | 2 | .50000 | .00000 | .00000 | .50 | .50 | 84/06/20 | 84/06/20 |
| TOT | 4 | 4.5500 | 23.177 | 4.8142 | 10.00 | .50 | 84/06/20 | 84/06/20 |
| | 4 | 25.500 | 131.00 | 11.446 | 39.00 | 16.00 | 84/06/20 | 84/06/20 |
| U | 1 | 1.0000 | | | 1 | 1 | 84/05/31 | 84/05/31 |
| | 1 | 15.000 | | | 15 | 15 | 84/05/31 | 84/05/31 |
| | 1 | 1.0000 | | | 1 | 1 | 84/05/31 | 84/05/31 |
| | 4 | 60.250 | 844.92 | 29.067 | 94.00 | 35.00 | 84/06/20 | 84/06/20 |
| U | 1 | 50.000 | | | 50 | 50 | 84/05/31 | 84/05/31 |

STORET RETRIEVAL DATE 85/06/11

9 TOTAL STATIONS PROCESSED

# STATISTICAL SUMMARY
## INSTREAM CONTAMINANT STUDY BEAR CREEK DATA
## WATER, SEDIMENT, FISH, AND AQUATIC BIOTA
## INSTREAM CONTAMINANT STUDY-TASK 5

| PARAMETER | | | |
|---|---|---|---|
| 1067 | NICKEL | NI,TOTAL | UG/L |
| 1068 | NICKEL | SEDMG/KG | DRY WGT |
| 1069 | NICKEL | TISMG/KG | WET WGT |
| 1073 | THALLIUM | TIS-WET | MG/KG |
| 1077 | SILVER | AG,TOT | UG/L |
| 1078 | SILVER | SEDMG/KG | DRY WGT |
| 1092 | ZINC | ZN,TOT | UG/L |
| 1097 | ANTIMONY | SB,TOT | UG/L |
| 1099 | ANTIMONY | TIS-WET | MG/KG |
| 1105 | ALUMINUM | AL,TOT | UG/L |
| 1132 | LITHIUM | LI,TOT | UG/L |
| 1147 | SELENIUM | SE,TOT | UG/L |
| 1149 | SELENIUM | TISMG/KG | WET WGT |
| 1163 | ZR MUD | DRY WGT | MG/KG-ZR |
| 1501 | ALPHA | TOTAL | PC/L |
| 1502 | ALPHA-T | ERROR | PC/L |
| 1507 | ALPHA | SEDIMENT | PC/G |
| 1508 | ALPHA | SED-ERR | PC/G |
| 1521 | ALPHA | FISH | PCI/G |
| 1522 | ALPHA | FISH-ERR | PCI/G |
| 3501 | BETA | TOTAL | PC/L |
| 3502 | BETA-T | ERROR | PC/L |
| 3507 | BETA | SEDIMENT | PC/G |
| 3508 | BETA | SED-ERR | PC/G |
| 3524 | BETA | FISH | PCI/G |
| 3525 | BETA | FISH-ERR | PCI/G |
| 7000 | H-3 | TOTAL | PC/L |
| 7001 | H-3,TOTL | ERROR | PC/L |
| 9507 | RA-226 | SEDIMENT | PC/G |
| 9508 | RA-226 | SED-ERR | PC/G |
| 11506 | RA-224 | SEDIMENT | PCI/G |
| 11507 | RA-224 | SED-ERR | PCI/G |
| 15505 | SR-89 | SEDIMENT | PCI/G |
| 15506 | SR-89 | SED-ERR | PCI/G |
| 15507 | SR-90 | SEDIMENT | PCI/G |
| 15508 | SR-90 | SED-ERR | PCI/G |
| 17509 | PB-212 | SEDIMENT | PCI/G |
| 17510 | PB-212 | SED-ERR | PCI/G |
| 17511 | PB-214 | SEDIMENT | PCI/G |
| 17512 | PB-214 | SED-ERR | PCI/G |
| 17515 | PB 214 | FISH | PCI/G |
| 17516 | PB-214 | FISH-ERR | PCI/G |

| RMK | NUMBER | MEAN | VARIANCE | STAN DEV | MAXIMUM | MINIMUM | BEG DATE | END DATE |
|---|---|---|---|---|---|---|---|---|
| | 1 | 69.000 | | | 69 | 69 | 84/05/31 | 84/05/31 |
| | 4 | 89.000 | 7174.7 | 84.703 | 200.00 | 18.00 | 84/06/20 | 84/06/20 |
| M | 2 | 1.0000 | 0.0000 | 0.0000 | 1.00 | 1.00 | 84/05/15 | 84/05/15 |
| U | 23 | 1.0870 | .08300 | .28811 | 2.00 | 1.00 | 84/05/15 | 84/06/07 |
| TOT | 25 | 1.0800 | .07666 | .27689 | 2.00 | 1.00 | 84/05/15 | 84/06/07 |
| U | 3 | 1.0000 | 0.0000 | 0.0000 | 1.00 | 1.00 | 84/05/17 | 84/05/17 |
| U | 1 | .20000 | | | .2 | .2 | 84/05/31 | 84/05/31 |
| U | 4 | 1.0000 | 0.0000 | 0.0000 | 1.00 | 1.00 | 84/06/20 | 84/06/20 |
| | 1 | 37.000 | | | 37 | 37 | 84/05/31 | 84/05/31 |
| U | 1 | 1.0000 | | | 1 | 1 | 84/05/31 | 84/05/31 |
| U | 3 | 1.0000 | 0.0000 | 0.0000 | 1.00 | 1.00 | 84/05/17 | 84/05/17 |
| | 1 | 140.00 | | | 140 | 140 | 84/05/31 | 84/05/31 |
| | 1 | 10.000 | | | 10 | 10 | 84/05/31 | 84/05/31 |
| U | 1 | 1.0000 | | | 1 | 1 | 84/05/31 | 84/05/31 |
| | 3 | .30000 | .07000 | .26458 | .60 | .10 | 84/05/17 | 84/05/17 |
| | 4 | 482.50 | 5958.3 | 77.190 | 590.00 | 410.00 | 84/06/20 | 84/06/20 |
| | 4 | 14.750 | 134.92 | 11.615 | 31 | 5 | 84/05/31 | 84/11/10 |
| | 4 | 6.2500 | 42.917 | 6.5511 | 16 | 2 | 84/05/31 | 84/11/10 |
| | 12 | 7.0000 | 76.107 | 8.7239 | 32 | 2 | 84/06/20 | 84/09/12 |
| | 12 | 2.0000 | 4.6527 | 2.1570 | 8 | .7 | 84/06/20 | 84/09/12 |
| | 2 | .01000 | .00020 | .01414 | .020 | 0.000 | 84/05/15 | 84/05/15 |
| | 2 | .05500 | .00045 | .02121 | .070 | .040 | 84/05/15 | 84/05/15 |
| | 4 | 109.25 | 21912. | 148.03 | 330 | 16 | 84/05/31 | 84/11/10 |
| | 4 | 13.750 | 308.92 | 17.576 | 40 | 3 | 84/05/31 | 84/11/10 |
| | 12 | 67.250 | 2619.3 | 51.179 | 179 | 26 | 84/06/20 | 84/09/12 |
| | 12 | 13.750 | 104.93 | 10.244 | 35 | 5 | 84/06/20 | 84/09/12 |
| | 2 | 28.500 | .50000 | .70711 | 29.000 | 28.000 | 84/05/15 | 84/05/15 |
| | 2 | 5.5000 | .50000 | .70711 | 6.000 | 5.000 | 84/05/15 | 84/05/15 |
| | 1 | 500.00 | | | 500.0 | 500.0 | 84/05/31 | 84/05/31 |
| | 1 | 110.00 | | | 110.0 | 110.0 | 84/05/31 | 84/05/31 |
| | 2 | .78000 | .00080 | .02828 | .8 | .8 | 84/06/20 | 84/09/12 |
| | 2 | .08500 | .00045 | .02121 | .1 | .07 | 84/06/20 | 84/09/12 |
| | 2 | 1.2000 | 0.0000 | 0.0000 | 1.200 | 1.200 | 84/06/20 | 84/09/12 |
| | 2 | .25000 | .00500 | .07071 | .300 | .200 | 84/06/20 | 84/09/12 |
| | 12 | .27500 | .03113 | .17646 | .500 | 0.000 | 84/06/20 | 84/09/12 |
| | 12 | .31667 | .00151 | .03892 | .400 | .300 | 84/06/20 | 84/09/12 |
| | 12 | .08333 | .00287 | .05365 | .200 | 0.000 | 84/06/20 | 84/09/12 |
| | 12 | .10000 | 1084E-11 | .00010 | .100 | .100 | 84/06/20 | 84/09/12 |
| | 12 | 1.2058 | .16523 | .40771 | 2.100 | .700 | 84/06/20 | 84/09/12 |
| | 12 | .23083 | .03777 | .19435 | .800 | .070 | 84/06/20 | 84/09/12 |
| | 12 | .97500 | .03659 | .19129 | 1.200 | .700 | 84/06/20 | 84/09/12 |
| | 12 | .20667 | .03762 | .19397 | .800 | .080 | 84/06/20 | 84/09/12 |
| | 2 | .65000 | .12500 | .35355 | .900 | .400 | 84/05/15 | 84/05/15 |
| | 2 | .20000 | .00000 | .00000 | .200 | .200 | 84/05/15 | 84/05/15 |

9 TOTAL STATIONS PROCESSED

# STATISTICAL SUMMARY
## INSTREAM CONTAMINANT STUDY BEAR CREEK DATA
## WATER, SEDIMENT, FISH, AND AQUATIC BIOTA
## INSTREAM CONTAMINANT STUDY-TASK 5

| PARAMETER | | | | RMK | NUMBER | MEAN | VARIANCE | STAN DEV | MAXIMUM | MINIMUM | BEG DATE | END DATE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21503 | PA-233 | SEDIMENT | PCI/G | | 4 | .62500 | .37590 | .61392 | 1.500 | .160 | 84/06/20 | 84/09/12 |
| 21504 | PA-233 | SED-ERR | PCI/G | | 4 | .09750 | .00575 | .07588 | .200 | .020 | 84/06/20 | 84/09/12 |
| 21505 | MPA-234 | SEDIMENT | PCI/G | | 9 | 49.667 | 3657.5 | 60.560 | 181.000 | 5.000 | 84/06/20 | 84/09/12 |
| 21506 | MPA-234 | SED-ERR | PCI/G | | 9 | 8.7778 | 56.694 | 7.5296 | 26.000 | 3.000 | 84/06/20 | 84/09/12 |
| 22016 | PU-238 | SEDIMENT | PCI/G | | 1 | .00130 | | | .001 | .001 | 84/06/20 | 84/06/20 |
| 22017 | PU-238 | SEDIMENT | ERRO | | 1 | .00080 | | | .0008 | .0008 | 84/06/20 | 84/06/20 |
| 22018 | PU-239 | SEDIMENT | PCI/G | | 2 | .00150 | .00000 | .00070 | .002 | .001 | 84/06/20 | 84/09/12 |
| 22019 | PU-239 | SEDIMENT | ERRO | | 2 | .00100 | .00000 | .00000 | .001 | .001 | 84/06/20 | 84/09/12 |
| 22102 | TC-99 | FISH | PCI/G | | 3 | .47000 | .21490 | .46357 | 1 | .1 | 84/05/17 | 84/05/17 |
| 22103 | TC-99 | FISHERR | PCI/G | | 3 | .17133 | .00874 | .09351 | .3 | .08 | 84/05/17 | 84/05/17 |
| 22200 | BE-7 | SEDIMENT | PCI/G | | 1 | .40000 | | | .400 | .400 | 84/06/20 | 84/06/20 |
| 22201 | BE-7 | SED-ERR | PCI/G | | 1 | .10000 | | | .100 | .100 | 84/06/20 | 84/06/20 |
| 22300 | K-40 | SEDIMENT | PCI/G | | 12 | 15.167 | 11.789 | 3.4334 | 22.000 | 9.000 | 84/06/20 | 84/09/12 |
| 22301 | K-40 | SED-ERR | PCI/G | | 12 | 1.8333 | .69697 | .83485 | 4.000 | 1.000 | 84/06/20 | 84/09/12 |
| 22302 | K-40 | FISH | PCI/G | | 2 | 16.500 | 4.5000 | 2.1213 | 18.000 | 15.000 | 84/05/15 | 84/05/15 |
| 22303 | K-40 | FISH-ERR | PCI/G | | 2 | 2.5000 | .50000 | .70711 | 3.000 | 2.000 | 84/05/15 | 84/05/15 |
| 22350 | TL-208 | SEDIMENT | PCI/G | | 12 | .42250 | .01833 | .13539 | .700 | .240 | 84/06/20 | 84/09/12 |
| 22351 | TL-208 | SED-ERR | PCI/G | | 12 | .06000 | .00058 | .02412 | .100 | .030 | 84/06/20 | 84/09/12 |
| 22375 | BI-212 | SEDIMENT | PCI/G | | 10 | 1.1900 | .13433 | .36651 | 1.800 | .700 | 84/06/20 | 84/09/12 |
| 22376 | BI-212 | SED-ERR | PCI/G | | 10 | .35000 | .02055 | .14337 | .600 | .200 | 84/06/20 | 84/09/12 |
| 22377 | BI-214 | SEDIMENT | PCI/G | | 12 | .92083 | .02873 | .16952 | 1.100 | .700 | 84/06/20 | 84/09/12 |
| 22378 | BI-214 | SED-ERR | PCI/G | | 12 | .12917 | .00282 | .05316 | .200 | .070 | 84/06/20 | 84/09/12 |
| 22381 | BI-214 | FISH | PCI/G | | 2 | .40000 | .00000 | .00000 | .400 | .400 | 84/05/15 | 84/05/15 |
| 22382 | BI-214 | FISH-ERR | PCI/G | | 2 | .20000 | .02000 | .14142 | .300 | .100 | 84/05/15 | 84/05/15 |
| 22383 | BI-214 | TOTAL | PCI/L | | 1 | 6.0000 | | | 6.000 | 6.000 | 84/10/22 | 84/10/22 |
| 22384 | BI-214 | TOTAL | ERROR | | 1 | 4.0000 | | | 4.000 | 4.000 | 84/10/22 | 84/10/22 |
| 22402 | AC-228 | FISH | PCI/G | | 1 | .70000 | | | .700 | .700 | 84/05/15 | 84/05/15 |
| 22403 | AC-228 | FISH-ERR | PCI/G | | 1 | .40000 | | | .400 | .400 | 84/05/15 | 84/05/15 |
| 22450 | AM-241 | SEDIMENT | PCI/G | | 4 | .01650 | .00025 | .01619 | .040 | .004 | 84/06/20 | 84/09/12 |
| 22451 | AM-241 | SEDIMENT | ERRO | | 4 | .00550 | .00001 | .00341 | .010 | .002 | 84/06/20 | 84/09/12 |
| 22475 | CU-244 | SEDMENT | PCI/G | | 2 | .00700 | .00000 | .00282 | .009 | .005 | 84/06/20 | 84/09/12 |
| 22476 | CU-244 | SEDIMENT | ERRO | | 2 | .00350 | .00000 | .00212 | .005 | .002 | 84/06/20 | 84/09/12 |
| 22507 | TH-234 | SEDIMENT | PCI/G | | 12 | 24.375 | 1181.9 | 34.378 | 115.000 | 2.600 | 84/06/20 | 84/09/12 |
| 22508 | TH-234 | SED-ERR | PCI/G | | 12 | 2.8250 | 11.411 | 3.3780 | 12.000 | .400 | 84/06/20 | 84/09/12 |
| 22608 | URANIUM | SEDIMENT | UG/G | | 12 | 41.950 | 4572.6 | 67.621 | 200.000 | 4.400 | 84/06/20 | 84/09/12 |
| 22609 | URANIUM | SED-ERR | UG/G | | 12 | 7.9750 | 176.93 | 13.302 | 40.000 | .700 | 84/06/20 | 84/09/12 |
| 22612 | U-235 | SEDIMENT | PCI/G | | 3 | 2.1000 | 2.7300 | 1.6523 | 3.800 | .500 | 84/06/20 | 84/09/12 |
| 22613 | U-235 | SED-ERR | PCI/G | | 3 | .50000 | .16000 | .40000 | .900 | .100 | 84/06/20 | 84/09/12 |
| 25503 | AC-228 | SEDIMENT | PCI/G | | 12 | 1.2417 | .16265 | .40330 | 1.800 | .700 | 84/06/20 | 84/09/12 |
| 25504 | AC-228 | SED-ERR | PCI/G | | 12 | .20833 | .00810 | .09003 | .300 | .100 | 84/06/20 | 84/09/12 |
| 28418 | CS-137 | SEDIMENT | PCI/G | | 10 | .22400 | .02380 | .15429 | .500 | .040 | 84/06/20 | 84/09/12 |
| 28419 | CS-137 | SED-ERR | PCI/G | | 10 | .04800 | .00090 | .03011 | .100 | .018 | 84/06/20 | 84/09/12 |
| 28422 | CS-137 | FISH | PCI/G | | 2 | .25000 | .04500 | .21213 | .400 | .100 | 84/05/15 | 84/05/15 |
| 28423 | CS-137 | FISH-ERR | PCI/G | | 2 | .07000 | .00180 | .04242 | .100 | .040 | 84/05/15 | 84/05/15 |

STORET RETRIEVAL DATE 85/06/11

9 TOTAL STATIONS PROCESSED

# STATISTICAL SUMMARY
## INSTREAM CONTAMINANT STUDY BEAR CREEK DATA
## WATER, SEDIMENT, FISH, AND AQUATIC BIOTA
## INSTREAM CONTAMINANT STUDY-TASK 5

| PARAMETER | | | | RMK | NUMBER | MEAN | VARIANCE | STAN DEV | MAXIMUM | MINIMUM | BEG DATE | END DATE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32101 | DICLBRMT | | TOTUG/L | U | 1 | 10.000 | | | 10.0 | 10.0 | 84/05/31 | 84/05/31 |
| 32102 | CARBNTET | | TOTUG/L | U | 1 | 10.000 | | | 10.0 | 10.0 | 84/05/31 | 84/05/31 |
| 32104 | BROMOFRM | WHL-WTR | UG/L | U | 1 | 10.000 | | | 10.0 | 10.0 | 84/05/31 | 84/05/31 |
| 32105 | CLDIBRMT | | TOTUG/L | U | 1 | 10.000 | | | 10.0 | 10.0 | 84/05/31 | 84/05/31 |
| 32106 | CHLRFORM | | TOTUG/L | U | 1 | 10.000 | | | 10.0 | 10.0 | 84/05/31 | 84/05/31 |
| 32730 | PHENOLS | TOTAL | UG/L | | 1 | 6.0000 | | | 6 | 6 | 84/09/13 | 84/09/13 |
| 32731 | PHENOLS | SEDMG/KG | DRY WGT | | 4 | 1.1750 | .14917 | .38622 | 1.70 | .80 | 84/06/20 | 84/06/20 |
| 34010 | TOLUENE | | TOT UG/L | U | 1 | 10.000 | | | 10.00 | 10.00 | 84/05/31 | 84/05/31 |
| 34030 | BENZENE | | TOT UG/L | U | 1 | 10.000 | | | 10.00 | 10.00 | 84/05/31 | 84/05/31 |
| 34200 | ACENAPHT | YLENE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34203 | ACNAPTHY | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34205 | ACENAPHT | HENE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34208 | ACNAPTHE | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34210 | ACROLEIN | | TOTWUG/L | U | 1 | 100.00 | | | 100.000 | 100.000 | 84/05/31 | 84/05/31 |
| 34215 | ACRYLONI | TRILE | TOTWUG/L | U | 1 | 100.00 | | | 100.000 | 100.000 | 84/05/31 | 84/05/31 |
| 34220 | ANTHRACE | NE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34223 | ANTHRACE | SEDUG/KG | DRY WGT | M | 1 | 680.00 | | | 680.000 | 680.000 | 84/06/20 | 84/06/20 |
| | | | | U | 3 | 706.67 | 2634.0 | 51.323 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34230 | BENZBFLU | ORANT TO | TAL UG/L | TOT | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34233 | BENZBFLU | ORANTHUO | DRYUG/KG | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34242 | BENZO(K) | FLUORANT | TOTWUG/L | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34245 | BENZKFLU | SEDUG/KG | DRY WGT | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34247 | BENZO(A) | PYRENE | TOTWUG/L | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34250 | BENZAPYR | SEDUG/KG | DRY WGT | U | 3 | .10000 | .00000 | .00000 | .100 | .100 | 84/05/17 | 84/05/17 |
| 34252 | BERYLIUM | TISMG/KG | WET WGT | U | 1 | .01000 | | | .010 | .010 | 84/05/31 | 84/05/31 |
| 34259 | DELTAOHC | | TOTUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34268 | BISCHLOR | OMETHYLE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34273 | BIS2CHLO | ROETHYLE | TOTWUG/L | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34276 | B2CETETR | SEDUG/KG | DRY WGT | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34278 | BIS2CHLO | ROETHOXY | TOTWUG/L | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34281 | B2CETOXM | SEDUG/KG | DRY WGT | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34283 | BIS2CHLO | ROISOPRO | TOTWUG/L | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34286 | B2CIPETR | SEDUG/KG | DRY WGT | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34292 | NBB PHTH | TOTAL | UG/L | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34295 | NBB PHTH | MUD-DRY | UG/KG | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34301 | CHLOROBE | NZENE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34311 | CHLOROET | HANE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34320 | CHRYSENE | | TOTWUG/L | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34323 | CHRYSENE | SEDUG/KG | DRY WGT | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34336 | DIETHYLP | HTHALATE | TOTWUG/L | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34339 | DETHPHTH | SEDUG/KG | DRY WGT | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34341 | DIMETHYL | PHTHALAT | TOTWUG/L | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34344 | DMETPHTH | SEDUG/KG | DRY WGT | | | | | | | | | |

STORET RETRIEVAL DATE 85/06/11

9 TOTAL STATIONS PROCESSED

# STATISTICAL SUMMARY
## INSTREAM CONTAMINANT STUDY BEAR CREEK DATA
## WATER, SEDIMENT, FISH, AND AQUATIC BIOTA
## INSTREAM CONTAMINANT STUDY-TASK 5

| PARAMETER | | | | RMK | NUMBER | MEAN | VARIANCE | STAN DEV | MAXIMUM | MINIMUM | BEG DATE | END DATE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 34346 | 12DIPHEN | YLHYDRAZ | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34349 | 12DPHNHY | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34351 | ENDSULSF | | TOTUG/L | U | 1 | .01000 | | | .010 | .010 | 84/05/31 | 84/05/31 |
| 34356 | B-ENDO | SULFAN | TOTWUG/L | U | 1 | .01000 | | | .010 | .010 | 84/05/31 | 84/05/31 |
| 34361 | A-ENDO | SULFAN | TOTWUG/L | U | 1 | .01000 | | | .010 | .010 | 84/05/31 | 84/05/31 |
| 34366 | ENDRINAL | DEHYDE | TOTWUG/L | U | 1 | .01000 | | | .010 | .010 | 84/05/31 | 84/05/31 |
| 34371 | ETHYLBEN | ZENE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34376 | FLUORANT | HENE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34379 | FLANTENE | SEDUG/KG | DRY WGT | | 1 | 970.00 | | | 970.000 | 970.000 | 84/06/20 | 84/06/20 |
| | | | | U | 3 | 706.67 | 2634.0 | 51.323 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| | | | | TOT | 4 | 772.50 | 19092. | 138.17 | 970.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34381 | FLUORENE | | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34384 | FLUORENE | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34386 | HEXACHLO | ROCYCLOP | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34389 | HEXCLCPD | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34391 | HEXACHLO | ROBUTADI | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34396 | HEXACHLO | ROETHANE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34399 | HEXACLET | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34403 | INDENOCL | 23CDIPYR | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34406 | I123CDPR | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34408 | ISPHRONE | | TOTUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34411 | ISPHRONE | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34413 | METHYLBR | OMIDE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34418 | METHYLCH | LORIDE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34423 | METHYLEN | ECHLORID | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34428 | NITROSOD | IPROPYLA | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34431 | NITONPRA | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34433 | NITROSOD | IPHENYLA | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34434 | NITROSOD | IPHENYLA | DISSUG/L | U | 1 | .10000 | | | .100 | .100 | 84/05/15 | 84/05/15 |
| 34436 | NITRSOPA | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34438 | NITROSOD | IMETHYLA | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34441 | NITRSOMA | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34445 | NAPTHALE | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34447 | NITROBEN | ZENE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34450 | NITROBEN | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34452 | PARACHLO | ROMETACR | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34461 | PHENANTH | RENE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34464 | PHENANTH | SEDUG/KG | DRY WGT | | 1 | 690.00 | | | 690.000 | 690.000 | 84/06/20 | 84/06/20 |
| | | | | M | 1 | 720.00 | | | 720.000 | 720.000 | 84/06/20 | 84/06/20 |
| | | | | U | 2 | 700.00 | 5000.0 | 70.711 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| | | | | TOT | 4 | 702.50 | 1825.0 | 42.720 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34467 | PHENOL | | SUSPUG/L | U | 1 | .10000 | | | .100 | .100 | 84/05/15 | 84/05/15 |
| 34469 | PYRENE | | TOTWUG/L | U | 2 | 5.0500 | 49.005 | 7.0004 | 10.000 | .100 | 84/05/15 | 84/05/31 |
| 34472 | PYRENE | SEDUG/KG | DRY WGT | | 1 | 710.00 | | | 710.000 | 710.000 | 84/06/20 | 84/06/20 |

STORET RETRIEVAL DATE 85/06/11

9 TOTAL STATIONS PROCESSED

# STATISTICAL SUMMARY
## INSTREAM CONTAMINANT STUDY BEAR CREEK DATA
## WATER, SEDIMENT, FISH, AND AQUATIC BIOTA
## INSTREAM CONTAMINANT STUDY-TASK 5

| PARAMETER | | | RMK | NUMBER | MEAN | VARIANCE | STAN DEV | MAXIMUM | MINIMUM | BEG DATE | END DATE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 34472 PYRENE | SEDUG/KG | DRY WGT | U | 3 | 706.67 | 2634.0 | 51.323 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34472 PYRENE | SEDUG/KG | DRY WGT | TOT | 4 | 707.50 | 1758.3 | 41.932 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34474 SILVER | FISHG/KG | WET WGT | U | 25 | .21600 | .00305 | .05537 | .400 | .200 | 84/05/15 | 84/06/07 |
| 34475 TETRACHL | ORDETHYL | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34488 TRICHLOR | OFLUOROM | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34496 11DICHLO | ROETHANE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34501 11DICHLO | ROETHYLE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34506 111TRICH | LOROETHA | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34511 112TRICH | LOROETHA | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34516 1122TETR | ACHLOROE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34521 BENZOGH | IPERYLE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34524 BZGHIPER | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | |
| 34526 BENZO(A) | ANTHRACE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34529 BENZAANT | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34531 12DICHLO | ROETHANE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34536 12DICHLO | ROBENZEN | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34539 12DCLBEN | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34541 12DICHLO | ROPROPAN | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34546 12DICHLO | ROETHYLE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34551 124TRICH | LOROBENZ | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34554 124TCBEN | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34556 DIBENZ(A | H)ANTHRA | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34559 DBAHANTH | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34566 13DICHLO | ROBENZEN | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34569 13DCLBEN | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.030 | 84/06/20 | 84/06/20 |
| 34571 14DICHLO | ROBENZEN | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34574 14DCLBEN | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34576 2CHLOROE | THYLVINY | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34581 2CHLORON | APHTHALE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34584 2CLNAPTH | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34586 2CHLOROP | HENOL | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34591 2NITROPH | ENOL | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34596 DINOCTPH | | TOTUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34599 DINOCTPH | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34601 24DICHLO | ROPHENOL | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34606 24DIMETH | YLPHENOL | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34611 24DINITR | OTOLUENE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34614 24DNTOLU | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34616 24DINITR | OPHENOL | TOTWUG/L | U | 1 | 100.00 | | | 100.000 | 100.000 | 84/05/31 | 84/05/31 |
| 34621 246TRICH | LOROPHEN | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34626 26DINITR | OTOLUENE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34629 26DNTOLU | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34631 33DICHLO | ROBENZID | TOTWUG/L | U | 1 | 25.000 | | | 25.000 | 25.000 | 84/05/31 | 84/05/31 |
| 34634 33DCBNZD | SEDUG/KG | DRY WGT | U | 4 | 1750.0 | 15657. | 129.10 | 1900.000 | 1600.000 | 84/06/20 | 84/06/20 |

STORET RETRIEVAL DATE 85/06/11

9 TOTAL STATIONS PROCESSED

# STATISTICAL SUMMARY
## INSTREAM CONTAMINANT STUDY BEAR CREEK DATA
## WATER, SEDIMENT, FISH, AND AQUATIC BIOTA
## INSTREAM CONTAMINANT STUDY-TASK 5

| PARAMETER | | | | RMK | NUMBER | MEAN | VARIANCE | STAN DEV | MAXIMUM | MINIMUM | BEG DATE | END DATE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 34636 | 4BROMOPH | ENYLPHEN | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34639 | 4BRPHETR | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34641 | 4CHLOROP | HENYLPHE | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34644 | 4CLPPETR | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.000 | 650.000 | 84/06/20 | 84/06/20 |
| 34646 | 4NITROPH | ENOL | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34657 | 46DINITR | DORTHOCR | TOTWUG/L | U | 1 | 50.000 | | | 50.000 | 50.000 | 84/05/31 | 84/05/31 |
| 34664 | PCB-1221 | TISMG/KG | WET WGT | U | 10 | .10000 | .00000 | .00000 | .100 | .100 | 84/05/15 | 84/05/15 |
| 34667 | PCB-1232 | TISMG/KG | WET WGT | U | 10 | .10000 | .00000 | .00000 | .100 | .100 | 84/05/15 | 84/05/15 |
| 34668 | DICHLORO | DIFLUORO | TOTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34669 | PCB-1248 | TISMG/KG | WET WGT | U | 10 | .10000 | .00000 | .00000 | .100 | .100 | 84/05/15 | 84/05/15 |
| 34670 | PCB-1260 | TISMG/KG | WET WGT | U | 10 | .10000 | .00000 | .00000 | .100 | .100 | 84/05/15 | 84/05/15 |
| 34671 | PCB | 1016 | TOTWUG/L | U | 1 | .10000 | | | .100 | .100 | 84/05/31 | 84/05/31 |
| 34674 | PCB-1016 | TISMG/KG | WET WGT | U | 10 | .10000 | .00000 | .00000 | .100 | .100 | 84/05/15 | 84/05/15 |
| 34689 | PCB-1242 | TISMG/KG | WET WGT | U | 10 | .10000 | .00000 | .00000 | .100 | .100 | 84/05/15 | 84/05/15 |
| 34690 | PCB-1254 | TISMG/KG | WET WGT | | 1 | .20000 | | | .200 | .200 | 84/05/15 | 84/05/15 |
| | | | | U | 9 | .10000 | .00000 | .00000 | .100 | .100 | 84/05/15 | 84/05/15 |
| | | | | TOT | 10 | .11000 | .00100 | .03162 | .200 | .100 | 84/05/15 | 84/05/15 |
| 34694 | PHENOL | | TOT UG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 34696 | NAPTHALE | NE T | OTWUG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 39032 | PCP | | TOT UG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 39100 | B2E PHTH | TOTAL | UG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 39102 | B2E PHTH | MUD-DRY | UG/KG | M | 1 | 680.00 | | | 680 | 680 | 84/06/20 | 84/06/20 |
| | | | | U | 3 | 706.67 | 2634.0 | 51.323 | 750 | 650 | 84/06/20 | 84/06/20 |
| | | | | TOT | 4 | 700.00 | 1933.3 | 43.970 | 750 | 650 | 84/06/20 | 84/06/20 |
| 39110 | DNB PHTH | TOTAL | UG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 39112 | DNB PHTH | MUD-DRY | UG/KG | U | 4 | 700.00 | 1933.3 | 43.970 | 750 | 650 | 84/06/20 | 84/06/20 |
| 39120 | BENZIDIN | | TOTUG/L | U | 1 | 50.000 | | | 50.000 | 50.000 | 84/05/31 | 84/05/31 |
| 39121 | BENZIDIN | SEDUG/KG | DRY WGT | U | 4 | 3475.0 | 49168. | 221.74 | 3700.00 | 3200.00 | 84/06/20 | 84/06/20 |
| 39175 | VINYLCHL | ORIDE | TOT UG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 39180 | TRICHLOR | ETHYLENE | TOT UG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 39300 | P,P'DDT | | TOT UG/L | U | 1 | .01000 | | | .010 | .010 | 84/05/31 | 84/05/31 |
| 39310 | P,P'DDD | | TOT UG/L | U | 1 | .01000 | | | .010 | .010 | 84/05/31 | 84/05/31 |
| 39320 | P,P'DDE | | TOT UG/L | U | 1 | .01000 | | | .010 | .010 | 84/05/31 | 84/05/31 |
| 39330 | ALDRIN | | TOT UG/L | U | 1 | .01000 | | | .010 | .010 | 84/05/31 | 84/05/31 |
| 39337 | ALPHABHC | | TOTUG/L | U | 1 | .01000 | | | .010 | .010 | 84/05/31 | 84/05/31 |
| 39338 | BETA BHC | | TOTUG/L | U | 1 | .01000 | | | .010 | .010 | 84/05/31 | 84/05/31 |
| 39340 | GAMMABHC | LINDANE | TOT.UG/L | U | 1 | .01000 | | | .010 | .010 | 84/05/31 | 84/05/31 |
| 39350 | CHLRDANE | TECH&MET | TOT UG/L | U | 1 | .01000 | | | .010 | .010 | 84/05/31 | 84/05/31 |
| 39380 | DIELDRIN | | TOTUG/L | U | 1 | .01000 | | | .010 | .010 | 84/05/31 | 84/05/31 |
| 39390 | ENDRIN | | TOT UG/L | U | 1 | .01000 | | | .010 | .010 | 84/05/31 | 84/05/31 |
| 39400 | TOXAPHEN | | TOTUG/L | U | 1 | .50000 | | | .500 | .500 | 84/05/31 | 84/05/31 |
| 39410 | HEPTCHLR | | TOTUG/L | U | 1 | .01000 | | | .010 | .010 | 84/05/31 | 84/05/31 |
| 39420 | HPCHLREP | | TOTUG/L | U | 1 | .01000 | | | .010 | .010 | 84/05/31 | 84/05/31 |
| 39488 | PCB-1221 | | TOTUG/L | U | 1 | .10000 | | | .100 | .100 | 84/05/31 | 84/05/31 |

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9 TOTAL STATIONS PROCESSED

# STATISTICAL SUMMARY
## INSTREAM CONTAMINANT STUDY BEAR CREEK DATA
## WATER, SEDIMENT, FISH, AND AQUATIC BIOTA
## INSTREAM CONTAMINANT STUDY-TASK 5

| PARAMETER | | | | RMK | NUMBER | MEAN | VARIANCE | STAN DEV | MAXIMUM | MINIMUM | BEG DATE | END DATE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 39491 | PCB-1221 | SEDUG/KG | DRY WGT | U | 4 | 100.00 | 0.00 | 0.00 | 100.00 | 100.00 | 84/06/20 | 84/06/20 |
| 39492 | PCB-1232 | | TOTUG/L | U | 1 | .10000 | | | .100 | .100 | 84/05/31 | 84/05/31 |
| 39495 | PCB-1232 | SEDUG/KG | DRY WGT | U | 4 | 100.00 | 0.00 | 0.00 | 100.00 | 100.00 | 84/06/20 | 84/06/20 |
| 39496 | PCB-1242 | | TOTUG/L | U | 1 | .10000 | | | .100 | .100 | 84/05/31 | 84/05/31 |
| 39499 | PCB-1242 | SEDUG/KG | DRY WGT | U | 4 | 100.00 | 0.00 | 0.00 | 100.00 | 100.00 | 84/06/20 | 84/06/20 |
| 39500 | PCB-1248 | | TOTUG/L | U | 1 | .10000 | | | .100 | .100 | 84/05/31 | 84/05/31 |
| 39503 | PCB-1248 | SEDUG/KG | DRY WGT | U | 4 | 100.00 | 0.00 | 0.00 | 100.00 | 100.00 | 84/06/20 | 84/06/20 |
| 39504 | PCB-1254 | | TOTUG/L | U | 1 | .10000 | | | .100 | .100 | 84/05/31 | 84/05/31 |
| 39507 | PCB-1254 | SEDUG/KG | DRY WGT | | 1 | 500.00 | | | 500.00 | 500.00 | 84/06/20 | 84/06/20 |
| | | | | U | 3 | 100.00 | 0.00 | 0.00 | 100.00 | 100.00 | 84/06/20 | 84/06/20 |
| | | | | TOT | 4 | 200.00 | 40000. | 200.00 | 500.00 | 100.00 | 84/06/20 | 84/06/20 |
| 39508 | PCB-1260 | | TOTUG/L | U | 1 | .10000 | | | .100 | .100 | 84/05/31 | 84/05/31 |
| 39511 | PCB-1260 | SEDUG/KG | DRY WGT | | 1 | 900.00 | | | 900.00 | 900.00 | 84/06/20 | 84/06/20 |
| | | | | U | 3 | 100.00 | 0.00 | 0.00 | 100.00 | 100.00 | 84/06/20 | 84/06/20 |
| | | | | TOT | 4 | 300.00 | 160000. | 400.00 | 900.00 | 100.00 | 84/06/20 | 84/06/20 |
| 39514 | PCB-1016 | SEDUG/KG | DRY WGT | U | 4 | 100.00 | 0.00 | 0.00 | 100.00 | 100.00 | 84/06/20 | 84/06/20 |
| 39515 | PCBS | FISH | MG/KG | | 1 | .20000 | | | .200 | .200 | 84/05/15 | 84/05/15 |
| | | | | U | 9 | .10000 | .00000 | .00000 | .100 | .100 | 84/05/15 | 84/05/15 |
| | | | | TOT | 10 | .11000 | .00100 | .03162 | .200 | .100 | 84/05/15 | 84/05/15 |
| 39700 | HCB | | TOT UG/L | U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| 39701 | HCB | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750.00 | 650.00 | 84/06/20 | 84/06/20 |
| 39705 | HEXCLBD | SEDUG/KG | DRY WGT | U | 4 | 700.00 | 1933.3 | 43.970 | 750 | 650 | 84/06/20 | 84/06/20 |
| 45579 | % LIPID | EXTRACT | MATERIAL | | 10 | .13700 | .00595 | .07718 | .3 | .05 | 84/05/15 | 84/05/15 |
| 70320 | MOISTURE | CONTENT | PERCENT | | 9 | 31.133 | 56.771 | 7.5347 | 42 | 18 | 84/06/20 | 84/06/20 |
| 70322 | RESIDUE | TOT VOL | PERCENT | | 4 | 513000 | 2.1667 | 1.4720 | 6.6 | 3.2 | 84/06/20 | 84/06/20 |
| 71821 | SPECIFIC | GRAVITY | SEDGM/GM | | 12 | 2.1667 | .22934 | .47889 | 2.590 | 1.049 | 84/06/20 | 85/04/06 |
| 71890 | MERCURY | HG,DISS | UG/L | | 2 | .45000 | .12500 | .35355 | .7 | .2 | 84/10/22 | 84/10/23 |
| | | | | U | 16 | .20000 | 1987E-11 | .00014 | .2 | .2 | 84/05/09 | 85/04/06 |
| | | | | TOT | 18 | .22778 | .01388 | .11785 | .7 | .2 | 84/05/09 | 85/04/06 |
| 71900 | MERCURY | HG,TOTAL | UG/L | | 16 | .54375 | .14929 | .38638 | 1.6 | .2 | 84/05/31 | 85/04/06 |
| | | | | U | 2 | .30000 | .02000 | .14142 | .4 | .2 | 84/05/09 | 84/11/10 |
| | | | | TOT | 18 | .51667 | .13912 | .37298 | 1.6 | .2 | 84/05/09 | 85/04/06 |
| 71921 | MERCURY | SEDMG/KG | DRY WGT | | 3 | .60667 | .06263 | .25027 | .8 | .3 | 84/06/20 | 84/06/20 |
| | | | | U | 1 | .10000 | | | .1 | .1 | 84/06/20 | 84/06/20 |
| | | | | TOT | 4 | .48000 | .10593 | .32547 | .8 | .1 | 84/06/20 | 84/06/20 |
| 71922 | MERCURY | LT 63 U | SEDMG/KG | | 8 | .65000 | .45714 | .67612 | 2.30 | .38 | 84/06/20 | 84/06/20 |
| | | | | A | 5 | 1.4700 | 3.7094 | 1.9260 | 4.90 | .45 | 84/06/20 | 84/06/20 |
| | | | | TOT | 13 | .96538 | 1.6756 | 1.2944 | 4.90 | .30 | 84/06/20 | 84/06/20 |
| 71930 | MERCURY | TISMG/KG | WET WGT | | 22 | .34000 | .01570 | .12532 | .66 | .17 | 84/05/15 | 84/06/07 |
| | | | | U | 4 | .10000 | .00000 | .00000 | .10 | .10 | 84/05/15 | 84/05/15 |
| | | | | TOT | 26 | .30308 | .02099 | .14488 | .66 | .18 | 84/05/15 | 84/06/07 |
| 71936 | LEAD | TISMG/KG | WET WGT | | 3 | .05666 | .00143 | .03785 | .10 | .03 | 84/05/17 | 84/05/17 |
| 71937 | COPPER | TISMG/KG | WET WGT | | 2 | 1.2000 | .02000 | .14143 | 1.30 | 1.10 | 84/05/17 | 84/05/17 |
| | | | | U | 1 | .20000 | | | .20 | .20 | 84/05/17 | 84/05/17 |

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9 TOTAL STATIONS PROCESSED

# STATISTICAL SUMMARY
## INSTREAM CONTAMINANT STUDY BEAR CREEK DATA
## WATER, SEDIMENT, FISH, AND AQUATIC BIOTA
## INSTREAM CONTAMINANT STUDY-TASK 5

| PARAMETER | | | |
|---|---|---|---|
| 71937 | COPPER | TISMG/KG | WET WGT |
| 71938 | ZINC | TISMG/KG | WET WGT |
| 71939 | CR-FISH | UG/G OR | MG/KG WT |
| 71940 | CADMIUM | TISMG/KG | WET WGT |
| 77161 | 1,2DCLPR | TOTAL | UG/L |
| 80181 | TOT SED | PARTSIZE | %<.002MM |
| 80183 | TOT SED | PARTSIZE | %<.008MM |
| 80184 | TOT SED | PARTSIZE | %<.016MM |
| 80203 | TOT SED | SIEVE | %<.062MM |
| 80204 | TOT SED | SIEVE | %<.125MM |
| 80206 | TOT SED | SIEVE | %<.500MM |
| 80208 | TOT SED | SIEVE | %<2.00MM |
| 80322 | SUS PART | >125U | MG/L |
| 80325 | SUS PART | > 63U | MG/L |
| 80326 | SUS PART | >2000 UM | MG/L |
| 80328 | SUS PART | GT500UM | MG/L |
| 80331 | MERCURY | LT 500U | SEDMG/KG |
| 81356 | CATION | EX. CAP. | MEA/100G |
| 81756 | TOT SED | PARTSIZ% | <.0005MM |
| 81900 | SEDIMENT | UPPER | DEPTH IN |
| 81901 | SEDIMENT | LOWER | DEPTH IN |
| 82079 | TURBIDITY | LAB | NTU |
| 84005 | FISH | SPECIES | F &WL |
| 84014 | SPECIES | SEX | TEXT |
| 84068 | SERIES | CODE | ALPHA |

| RMK | NUMBER | MEAN | VARIANCE | STAN DEV | MAXIMUM | MINIMUM | BEG DATE | END DATE |
|---|---|---|---|---|---|---|---|---|
| TOT | 3 | .86667 | .34333 | .58595 | 1.30 | .20 | 84/05/17 | 84/05/17 |
| | 3 | 6.5667 | 5.3433 | 2.3116 | 9.00 | 4.40 | 84/05/17 | 84/05/17 |
| | 19 | .21044 | .02527 | .15899 | .54 | .008 | 84/05/15 | 84/06/07 |
| U | 7 | .02000 | 5045E-13 | .00002 | .02 | .02 | 84/05/15 | 84/06/07 |
| TOT | 25 | .15712 | .02552 | .15975 | .54 | .008 | 84/05/15 | 84/06/07 |
| | 23 | .09460 | .09497 | .30818 | 1.50 | .008 | 84/05/15 | 84/06/07 |
| U | 2 | .00200 | 1000E-14 | .00000 | .002 | .002 | 84/05/17 | 84/05/17 |
| TOT | 25 | .08720 | .08771 | .29617 | 1.50 | .002 | 84/05/15 | 84/06/07 |
| U | 1 | 10.000 | | | 10.000 | 10.000 | 84/05/31 | 84/05/31 |
| | 4 | 13.275 | 15.123 | 3.8888 | 17.2 | 9.1 | 84/06/20 | 84/06/20 |
| | 4 | 21.050 | 29.577 | 5.4385 | 26.5 | 15.3 | 84/06/20 | 84/06/20 |
| | 4 | 26.725 | 44.042 | 6.6364 | 32.7 | 19.8 | 84/06/20 | 84/06/20 |
| | 17 | 36.488 | 145.91 | 12.079 | 62.8 | 16.7 | 84/06/20 | 84/06/20 |
| | 2 | 37.150 | 1.4451 | 1.2021 | 38.0 | 36.3 | 84/06/20 | 84/06/20 |
| | 15 | 86.967 | 258.24 | 16.070 | 98.9 | 49.2 | 84/06/20 | 84/06/20 |
| | 15 | 96.640 | 22.058 | 4.6966 | 100.0 | 85.4 | 84/06/20 | 84/06/20 |
| | 3 | 2.3667 | .08333 | .28868 | 2.7 | 2.2 | 84/10/22 | 85/04/06 |
| | 3 | 7.6667 | 3.6635 | 1.9140 | 9.7 | 5.9 | 84/10/22 | 85/04/06 |
| K | 1 | .10000 | | | .100 | .100 | 85/04/06 | 85/04/06 |
| U | 2 | .10000 | .00000 | .00000 | .100 | .100 | 84/10/22 | 84/11/10 |
| TOT | 3 | .10000 | .00000 | .00000 | .100 | .100 | 84/10/22 | 85/04/06 |
| | 3 | .26667 | .01333 | .11547 | .400 | .200 | 84/10/22 | 85/04/06 |
| | 8 | .50000 | .48000 | .69282 | 2.200 | .100 | 84/06/20 | 84/06/20 |
| A | 5 | .96000 | 2.7030 | 1.6441 | 3.900 | .200 | 84/06/20 | 84/06/20 |
| TOT | 13 | .67692 | 1.2353 | 1.1114 | 3.900 | .100 | 84/06/20 | 84/06/20 |
| | 4 | 8.6000 | 3.2801 | 1.8111 | 11.0 | 6.6 | 84/06/20 | 84/06/20 |
| | 4 | 8.0250 | 11.802 | 3.4355 | 11.9 | 4.4 | 84/06/20 | 84/06/20 |
| | 21 | 10.238 | 71.990 | 8.4847 | 27.000 | 1.000 | 84/06/20 | 84/09/12 |
| S | 1 | 1.0000 | | | 1.000 | 1.000 | 84/06/20 | 84/06/20 |
| TOT | 22 | 9.8182 | 72.442 | 8.5113 | 27.000 | 1.000 | 84/06/20 | 84/09/12 |
| | 21 | 17.286 | 62.215 | 7.8876 | 32.000 | 6.000 | 84/06/20 | 84/09/12 |
| S | 1 | 9.0000 | | | 9.000 | 9.000 | 84/06/20 | 84/06/20 |
| TOT | 22 | 16.909 | 62.373 | 7.8976 | 32.000 | 6.000 | 84/06/20 | 84/09/12 |
| | 20 | 210.33 | 53036. | 230.34 | 900.0 | 1.6 | 84/05/31 | 85/04/06 |
| TE | 29 | TEXT | TEXT | TEXT | TEXT | TEXT | 84/05/15 | 84/06/07 |
| TE | 21 | TEXT | TEXT | TEXT | TEXT | TEXT | 84/05/15 | 84/06/07 |
| TE | 111 | TEXT | TEXT | TEXT | TEXT | TEXT | 84/05/09 | 85/04/06 |

# APPENDIX F. TABLES SUMMARIZING HEALTH AND ENVIRONMENTAL CRITERIA

Table F.1. Inorganics-Health and Environmental Criteria

| | Drinking Water MCLs (mg/L) | Carcinogen RSD Soil (μg/g) | Carcinogen RSD Water (μg/L) | Systemic Toxicant Soil (μg/g) | Systemic Toxicant Water (μg/L) | Aquatic Life Acute (μg/L) | Aquatic Life Chronic (μg/L) |
|---|---|---|---|---|---|---|---|
| Antimony | - | - | - | 7 | 10 | 9000 | 1600 |
| Arsenic | 0.05 | 0.02 | 0.002 | - | - | - | - |
| Barium | 1.0 | - | - | 900 | 2000 | - | - |
| Beryllium | - | - | - | 90 | 200 | 130 | 5.3 |
| Cadmium | 0.01 | - | - | - | - | 3.9 | 1.1 |
| Chromium(III) | - | - | - | 20000 | 40000 | 1700 | 210 |
| Chromium(VI) | 0.05 | - | - | 90 | 200 | 16 | 11 |
| Copper | 1.3 | - | - | - | - | 18 | 12 |
| Cyanide | - | - | - | 300 | 700 | 22 | 5.2 |
| Iron | 0.3 | - | - | - | - | - | 1000 |
| Lead | 0.05 | - | - | - | - | 82 | 3.2 |
| Manganese | 0.05 | - | - | - | - | - | - |
| Mercury | 0.002 | - | - | - | - | 2.4 | 0.012 |
| Nickel | - | - | - | 300 | 700 | 1400 | 160 |
| Selenium | 0.01 | - | - | 50 | 100 | 260 | 35 |
| Silver | 0.05 | - | - | 50 | 100 | 4.1 | 0.12 |
| Thallium | - | - | - | - | - | 1400 | 40 |
| Zinc | 5 | - | - | - | - | 120 | 110 |
| Nitrite (N) | 1 | - | - | - | - | - | - |
| Nitrate (N) | 10 | - | - | - | - | - | - |
| Sulfate | 250 | - | - | - | - | - | - |
| Fluoride | 1.4-2.4 | - | - | - | - | - | - |
| Chloride | 250 | - | - | - | - | - | - |
| $H_2S$ | 0.05 | - | - | 50 | 100 | - | - |
| TDS | 500 | - | - | - | - | - | - |
| pH | 6.5-8.5 | - | - | - | - | - | 6.5-9 |

Table F.2. Volatile Organics-Health and Environmental Criteria

| Contaminant | Drinking Water MCLs (mg/L) | Carcinogen RSD Soil (μg/g) | Carcinogen RSD Water (μg/L) | Systemic Toxicant Soil (μg/g) | Systemic Toxicant Water (μg/L) | Aquatic Life Acute (μg/L) | Aquatic Life Chronic (μg/L) |
|---|---|---|---|---|---|---|---|
| Acetonitrile | - | - | - | 100 | 200 | - | - |
| Benzene | 0.005 | 12.2 | 1.22 | - | - | 5300 | - |
| 2-Butanone | - | - | - | 900 | 2000 | - | - |
| Bromoform | - | - | - | 300 | 700 | - | - |
| Bromomethane | - | - | - | 7 | 10 | - | - |
| Carbon Tetrachloride | 0.005 | 2.7 | 0.27 | 10 | 20 | 35200 | - |
| Chlorobenzene | - | - | - | 500 | 1000 | 250 | 50 |
| Chloroform | - | 57 | 5.7 | 200 | 400 | 28900 | 1240 |
| 1,4-Dichlorobenzene | 0.075 | - | - | - | - | 1120 | 763 |
| Dichlorodifluoromethane | - | - | - | 3000 | 7000 | - | - |
| 1,2-Dichloroethane | 0.005 | 3.8 | 0.38 | - | - | 118000 | 20000 |
| 1,1-Dichloroethene | 0.007 | 5.8 | 0.58 | 200 | 300 | 11600 | - |
| trans-1,2-Dichloroethene | - | - | - | - | - | 11600 | - |
| 1,3-Dichloropropene | - | 1.9 | 0.19 | 5 | 10 | 6060 | 244 |
| Ethylbenzene | - | - | - | - | - | 32000 | - |
| Methylene Chloride | - | 47 | 4.7 | 1000 | 2000 | - | - |
| 1,1,2,2-Tetrachloroethane | - | 17.5 | 1.75 | - | - | 9320 | 2400 |
| Tetrachloroethene | - | 69 | 6.9 | 200 | 400 | 5280 | 840 |
| Toluene | - | - | - | 5000 | 10000 | 17500 | - |
| 1,1,1-Trichloroethane | 0.2 | - | - | 2000 | 3000 | 18000 | - |
| 1,1,2-Trichloroethane | - | 61 | 6.1 | 3000 | 7000 | 18000 | 9400 |
| Trichloroethene | 0.005 | 32 | 3.2 | - | - | 45000 | 21900 |
| Vinyl Chloride | 0.002 | - | - | - | - | - | - |

Table F.3. Miscellaneous Organics-Health and Environmental Criteria

| Contaminant | Drinking Water MCLs (mg/L) | Carcinogen RSD Soil (μg/g) | Carcinogen RSD Water (μg/L) | Systemic Toxicant Soil (μg/g) | Systemic Toxicant Water (μg/L) | Aquatic Life Acute (μg/L) | Aquatic Life Chronic (μg/L) |
|---|---|---|---|---|---|---|---|
| PCBs | - | 0.045 | 0.0045 | - | - | 2.0 | 0.014 |
| 2,4-Dinitrophenol | - | - | - | 30 | 70 | 230 | 150 |
| 2-Nitrophenol | - | - | - | - | - | 230 | 150 |
| 4-Nitrophenol | - | - | - | - | - | 230 | 150 |
| Phenol | - | - | - | 700 | 1000 | 10200 | 2560 |
| Benzo(a)anthracene | - | 0.112 | 0.0112 | - | - | - | - |
| Benzo(a)pyrene | - | 0.0304 | 0.00304 | - | - | - | - |
| Fluoranthene | - | - | - | - | - | 3980 | - |
| Naphthalene | - | - | - | - | - | 2300 | 620 |
| Bis(2-ethylhexyl) phthalate | - | - | - | 300 | 700 | 940 | 3 |
| Butyl benzyl phthalate | - | - | - | - | - | 940 | 3 |
| Di-n-butyl phthalate | - | - | - | 2000 | 4000 | 940 | 3 |
| Di-n-octyl phthalate | - | - | - | - | - | 940 | 3 |
| Dimethyl phthalate | - | - | - | - | - | 940 | 3 |

Table F.4. Radiological health criteria[a]

| Activity | Carcinogenic Effects | | | Non-Carcinogenic Effects | | |
|---|---|---|---|---|---|---|
| | Drinking Water MCL/RMCL (pCi/L) | Fishing Waters (pCi/L) | Drinking Plus Fishing Waters (pCi/L) | Drinking Water MCL (pCi/L) | Fishing Waters (pCi/L) | Drinking Plus Fishing Waters (pCi/L) |
| Gross Alpha | 15 | | | | | |
| Gross Beta | Screen | | | | | |
| Radium-226 | 1 | 220 | 0.9 | | | |
| Radium-228 | 2 | 440 | 1.9 | | | |
| Natural U | 7 | 230 | 6.8 | 40 (0.06 mg/L) | 1330 (2.0 mg/L) | 38.6 (0.058 mg/L) |
| Technetium-99 | 900 | | | | | |
| Uranium-234 | 10 | | | | | |
| Uranium-238 | 10 | | | | | |
| Strontium-90 | 8 | | | | | |

[a]Source: Lappenbusch 1988.

# APPENDIX G. BACKGROUND CONCENTRATIONS OF CONSTITUENTS IN BEAR CREEK VALLEY SURFACE WATER AND SEDIMENT

Table G.1. Background concentrations of constituents in Bear Creek Valley surface water. Sites include NT-2 and Grassy Creek locations GCK-1.4 and GCK-2.4. Data are from Bechtel National Inc., and Roy F. Weston, Inc., sampling campaigns during the period 1983-86. Values reported as "less than" values were included in the statistical summary after deleting the "L" sign and dividing the given value by 2. Minimum, maximum, and mean values of zero mean "not detected."

| | NUMBER OF OBSERVATIONS | MINIMUM VALUE | MAXIMUM VALUE | MEAN |
|---|---|---|---|---|
| MISCELLANEOUS CONSTITUENTS (mg/L) | | | | |
| TOTAL SUSPENDED SOLIDS | 11 | 2.0000 | 122.0000 | 19.2727 |
| ALK., BICARB. AS CACO3 | 10 | 6.0000 | 150.0000 | 97.8000 |
| METHYL ORG. ALK. AS CACO3 | 4 | 22.0000 | 166.0000 | 101.7500 |
| PHENOLPHTH. ALK. AS CACO3 | 4 | 0.5000 | 0.5000 | 0.5000 |
| ALK., CARB. AS CACO3 | 10 | 0.5000 | 1.0000 | 0.7000 |
| NITRATE/NITRITE-N | 14 | 0.0200 | 1.6000 | 0.3379 |
| AMMONIA - N | 14 | 0.0150 | 0.0900 | 0.0425 |
| TOTAL KJELDAHL NITROGEN | 14 | 0.0900 | 0.6000 | 0.2136 |
| SULFATE | 14 | 1.0000 | 27.0000 | 6.5071 |
| CHLORIDE | 10 | 1.2500 | 30.0000 | 5.8850 |
| FLUORIDE | 6 | 0.0430 | 0.1000 | 0.0767 |
| ORTHO PHOSPHATE - P | 4 | 0.0050 | 0.0300 | 0.0112 |
| CHEMICAL OXYGEN DEMAND | 4 | 0.5000 | 39.0000 | 14.0000 |
| BIOCHEMICAL OXYGEN DEMAND | 3 | 0.5000 | 2.0000 | 1.1667 |
| DISSOLVED OXYGEN | 13 | 5.3000 | 12.4000 | 9.3577 |
| PH (IN PH UNITS) | 13 | 5.9000 | 8.3200 | 7.2131 |
| WATER TEMP (DEG CENT) | 13 | 5.0000 | 21.0000 | 12.0538 |
| REDOX (IN MV) | 12 | 0.0000 | 230.0000 | 132.5000 |
| CONDUCTIVITY (UMHOS/CM) | 13 | 50.0000 | 400.0000 | 192.9231 |
| TOTAL METALS (mg/L) | | | | |
| ALUMINUM | 11 | 0.2500 | 1.6000 | 0.4973 |
| ANTIMONY | 11 | 0.0250 | 0.2500 | 0.1750 |
| ANTIMONY (AAS) | 7 | 0.0025 | 0.0125 | 0.0039 |
| ARSENIC | 11 | 0.1000 | 0.2500 | 0.2227 |
| ARSENIC (AAS) | 7 | 0.0025 | 0.0050 | 0.0039 |
| BARIUM | 11 | 0.0290 | 0.2500 | 0.1763 |
| BARIUM (AAS) | 7 | 0.0350 | 0.1500 | 0.0840 |
| BERYLLIUM | 11 | 0.0005 | 0.2500 | 0.1593 |
| BERYLLIUM (AAS) | 0 | . | . | . |
| BORON | 11 | 0.0050 | 0.2500 | 0.1864 |
| CADMIUM | 11 | 0.0010 | 0.2500 | 0.1597 |
| CADMIUM (AAS) | 7 | 0.0012 | 0.0012 | 0.0012 |
| CALCIUM | 11 | 4.3000 | 42.0000 | 25.9364 |
| CERIUM | 0 | . | . | . |

Table G.1 (continued).

| | | | | |
|---|---|---|---|---|
| CHROMIUM | 11 | 0.0050 | 0.2500 | 0.1618 |
| CHROMIUM (AAS) | 7 | 0.0050 | 0.0050 | 0.0050 |
| COBALT | 11 | 0.0050 | 0.2500 | 0.1609 |
| COPPER | 11 | 0.0050 | 0.2500 | 0.1632 |
| GALLIUM | 0 | . | . | . |
| GERMANIUM | 0 | . | . | . |
| GOLD | 0 | . | . | . |
| IRON | 11 | 0.2500 | 3.8000 | 0.7382 |
| IRON (AAS) | 0 | . | . | . |
| LANTHANUM | 0 | . | . | . |
| LEAD | 11 | 0.0500 | 0.2500 | 0.1827 |
| LEAD (AAS) | 7 | 0.0025 | 0.0070 | 0.0031 |
| LITHIUM | 11 | 0.0150 | 0.2500 | 0.1786 |
| MAGNESIUM | 11 | 1.6000 | 17.0000 | 8.9636 |
| MANGANESE | 11 | 0.0280 | 0.4800 | 0.2162 |
| MANGANESE (AAS) | 0 | . | . | . |
| MERCURY (AAS) | 11 | 0.0001 | 0.0010 | 0.0004 |
| MOLYBDENUM | 11 | 0.0100 | 0.2500 | 0.1668 |
| NICKEL | 11 | 0.0050 | 0.2500 | 0.1645 |
| NIOBIUM | 0 | . | . | . |
| PHOSPHOROUS | 0 | . | . | . |
| POTASSIUM | 7 | 0.7300 | 2.0000 | 1.3043 |
| SCANDIUM | 0 | . | . | . |
| SELENIUM | 11 | 0.1000 | 0.2500 | 0.1955 |
| SELENIUM (AAS) | 7 | 0.0025 | 0.0050 | 0.0029 |
| SILICON | 11 | 0.2000 | 8.2000 | 3.9364 |
| SILVER | 11 | 0.0050 | 0.2500 | 0.1632 |
| SILVER (AAS) | 4 | 0.0050 | 0.0050 | 0.0050 |
| SODIUM | 11 | 0.2500 | 5.5000 | 2.2436 |
| SODIUM (AAS) | 0 | . | . | . |
| STRONTIUM | 11 | 0.0180 | 0.2500 | 0.1725 |
| THALLIUM | 11 | 0.1500 | 0.5000 | 0.3091 |
| THALLIUM (AAS) | 0 | . | . | . |
| THORIUM | 0 | . | . | . |
| TIN | 11 | 0.1000 | 0.2500 | 0.2364 |
| TITANIUM | 11 | 0.0015 | 0.2500 | 0.1674 |
| URANIUM | 11 | 0.2500 | 1.0000 | 0.5227 |
| URANIUM (FLUOR) | 7 | 0.0005 | 0.0005 | 0.0005 |
| TOTAL URANIUM (FLUOR) | 0 | . | . | . |
| VANADIUM | 11 | 0.0100 | 0.2500 | 0.1636 |
| YTTRIUM | 0 | . | . | . |
| ZINC | 11 | 0.0050 | 0.2500 | 0.1626 |
| ZIRCONIUM | 0 | . | . | . |
| <u>DISSOLVED METALS (mg/L)</u> | | | | |
| ALUMINUM | 10 | 0.2500 | 0.2500 | 0.2500 |
| ANTIMONY | 10 | 0.2500 | 0.2500 | 0.2500 |
| ANTIMONY (AAS) | 10 | 0.0025 | 0.0125 | 0.0065 |
| ARSENIC | 10 | 0.2500 | 0.2500 | 0.2500 |

Table G.1 (continued).

| | | | | |
|---|---|---|---|---|
| ARSENIC (AAS) | 10 | 0.0025 | 0.0050 | 0.0035 |
| BARIUM | 10 | 0.2500 | 0.2500 | 0.2500 |
| BARIUM (AAS) | 10 | 0.0290 | 1.5000 | 0.2148 |
| BERYLLIUM | 10 | 0.2500 | 0.2500 | 0.2500 |
| BERYLLIUM (AAS) | 0 | . | . | . |
| BORON | 10 | 0.2500 | 0.2500 | 0.2500 |
| CADMIUM | 10 | 0.2500 | 0.2500 | 0.2500 |
| CADMIUM (AAS) | 10 | 0.0012 | 0.0012 | 0.0012 |
| CALCIUM | 10 | 11.0000 | 42.0000 | 27.0600 |
| CERIUM | 0 | . | . | . |
| CHROMIUM | 10 | 0.2500 | 0.2500 | 0.2500 |
| CHROMIUM (AAS) | 10 | 0.0050 | 0.0050 | 0.0050 |
| COBALT | 10 | 0.2500 | 0.2500 | 0.2500 |
| COPPER | 10 | 0.2500 | 0.2500 | 0.2500 |
| GALLIUM | 0 | . | . | . |
| GERMANIUM | 0 | . | . | . |
| GOLD | 0 | . | . | . |
| IRON | 10 | 0.2500 | 1.5000 | 0.4490 |
| IRON (AAS) | 0 | . | . | . |
| LANTHANUM | 0 | . | . | . |
| LEAD | 10 | 0.2500 | 0.6000 | 0.3350 |
| LEAD (AAS) | 10 | 0.0025 | 0.0050 | 0.0027 |
| LITHIUM | 10 | 0.2500 | 0.2500 | 0.2500 |
| MAGNESIUM | 10 | 2.8000 | 14.0000 | 7.7400 |
| MANGANESE | 10 | 0.2500 | 0.2500 | 0.2500 |
| MANGANESE (AAS) | 0 | . | . | . |
| MERCURY | 10 | 0.0001 | 0.0002 | 0.0002 |
| MOLYBDENUM | 10 | 0.2500 | 0.2500 | 0.2500 |
| NICKEL | 10 | 0.2500 | 0.2500 | 0.2500 |
| NIOBIUM | 0 | . | . | . |
| PHOSPHOROUS | 0 | . | . | . |
| POTASSIUM | 10 | 0.2500 | 1.7000 | 1.0540 |
| SCANDIUM | 0 | . | . | . |
| SELENIUM | 10 | 0.2500 | 0.2500 | 0.2500 |
| SELENIUM (AAS) | 10 | 0.0025 | 0.0050 | 0.0027 |
| SILICON | 10 | 2.8000 | 6.0000 | 3.9900 |
| SILVER | 10 | 0.2500 | 0.2500 | 0.2500 |
| SILVER (AAS) | 4 | 0.0050 | 0.0050 | 0.0050 |
| SODIUM | 10 | 0.2500 | 6.3000 | 2.8140 |
| SODIUM (AAS) | 0 | . | . | . |
| STRONTIUM | 10 | 0.2500 | 0.2500 | 0.2500 |
| THALLIUM | 10 | 0.2500 | 1.4000 | 0.5850 |
| THALLIUM (AAS) | 0 | . | . | . |
| THORIUM | 0 | . | . | . |
| TIN | 10 | 0.2500 | 0.2500 | 0.2500 |
| TITANIUM | 10 | 0.2500 | 0.2500 | 0.2500 |
| URANIUM | 10 | 0.2500 | 0.2500 | 0.2500 |
| URANIUM (FLUOR) | 4 | 0.0005 | 0.0005 | 0.0005 |
| TOTAL URANIUM (FLUOR) | 3 | 0.0005 | 0.0005 | 0.0005 |

Table G.1 (continued).

| | | | | |
|---|---|---|---|---|
| VANADIUM | 10 | 0.2500 | 0.2500 | 0.2500 |
| YTTRIUM | 0 | . | . | . |
| ZINC | 10 | 0.2500 | 0.2500 | 0.2500 |
| ZIRCONIUM | 0 | . | . | . |
| RADIOLOGICALS (pCi/L) | | | | |
| 233+234 URANIUM | 4 | 0.0000 | 244.0000 | 61.1575 |
| 235 URANIUM | 4 | 0.0000 | 33.1000 | 8.3250 |
| 238 URANIUM | 4 | 0.0000 | 590.0000 | 147.6075 |
| GROSS ALPHA | 10 | 0.5000 | 580.0000 | 59.9000 |
| GROSS BETA | 10 | 1.5000 | 8.0000 | 2.9000 |
| VOLATILE ORGANIC COMPOUNDS (μg/L) | | | | |
| ACROLEIN | 14 | 0 | 0.0000 | 0.0000 |
| ACRYLONITRILE | 14 | 0 | 0.0000 | 0.0000 |
| BENZENE | 14 | 0 | 0.0000 | 0.0000 |
| BROMOFORM | 14 | 0 | 0.0000 | 0.0000 |
| CARBON TETRACHLORIDE | 14 | 0 | 0.0000 | 0.0000 |
| CHLOROBENZENE | 14 | 0 | 0.0000 | 0.0000 |
| CHLORODIBROMOMETHANE | 14 | 0 | 0.0000 | 0.0000 |
| CHLOROETHANE | 14 | 0 | 0.0000 | 0.0000 |
| 2-CHLOROETHYLVINYL ETHER | 14 | 0 | 0.0000 | 0.0000 |
| CHLOROFORM | 14 | 0 | 0.0000 | 0.0000 |
| BROMODICHLOROMETHANE | 14 | 0 | 0.0000 | 0.0000 |
| DICHLORODIFLUOROMETHANE | 14 | 0 | 0.0000 | 0.0000 |
| 1,1-DICHLOROETHANE | 14 | 0 | 0.0000 | 0.0000 |
| 1,2-DICHLOROETHANE | 14 | 0 | 0.0000 | 0.0000 |
| 1,1-DICHLOROETHENE | 14 | 0 | 0.0000 | 0.0000 |
| 1,2-DICHLOROPROPANE | 14 | 0 | 0.0000 | 0.0000 |
| CIS-1,3-DICHLOROPROPENE | 14 | 0 | 0.0000 | 0.0000 |
| TRANS-1,3-DICHLOROPROPENE | 14 | 0 | 0.0000 | 0.0000 |
| ETHYLBENZENE | 14 | 0 | 0.0000 | 0.0000 |
| BROMOMETHANE | 14 | 0 | 0.0000 | 0.0000 |
| CHLOROMETHANE | 14 | 0 | 0.0000 | 0.0000 |
| METHYLENE CHLORIDE | 14 | 0 | 54.0000 | 8.7857 |
| 1,1,2,2-TETRACHLOROETHANE | 14 | 0 | 0.0000 | 0.0000 |
| TETRACHLOROETHENE | 14 | 0 | 0.0000 | 0.0000 |
| TOLUENE | 14 | 0 | 0.0000 | 0.0000 |
| TRANS-1,2-DICHLOROETHENE | 14 | 0 | 0.0000 | 0.0000 |
| 1,1,1-TRICHLOROETHANE | 14 | 0 | 0.0000 | 0.0000 |
| 1,1,2-TRICHLOROETHANE | 14 | 0 | 0.0000 | 0.0000 |
| TRICHLOROETHENE | 14 | 0 | 5.0000 | 0.3571 |
| FLUOROTRICHLOROMETHANE | 14 | 0 | 5.0000 | 0.3571 |
| VINYL CHLORIDE | 14 | 0 | 0.0000 | 0.0000 |

Table G.1 (continued).

PESTICIDES, HERBICIDES AND PCBs (μg/L)

| | | | | |
|---|---|---|---|---|
| ALDRIN | 3 | 0.0000 | 0.0000 | 0.0000 |
| ALPHA-BHC | 3 | 0.0000 | 0.0000 | 0.0000 |
| BETA-BHC | 3 | 0.0000 | 0.0000 | 0.0000 |
| GAMMA-BHC (LINDANE) | 6 | 0.0000 | 0.0250 | 0.0125 |
| DELTA-BHC | 3 | 0.0000 | 0.0000 | 0.0000 |
| CHLORDANE | 3 | 0.0000 | 0.0000 | 0.0000 |
| 4,4'-DDT | 3 | 0.2500 | 0.2500 | 0.2500 |
| 4,4'-DDE | 3 | 0.2500 | 0.2500 | 0.2500 |
| 4,4'-DDD | 3 | 0.2500 | 0.2500 | 0.2500 |
| DIELDRIN | 3 | 0.2500 | 0.2500 | 0.2500 |
| ALPHA-ENDOSULFAN | 3 | 0.0000 | 0.0000 | 0.0000 |
| BETA-ENDOSULFAN | 3 | 0.2500 | 0.2500 | 0.2500 |
| ENDOSULFAN SULFATE | 3 | 0.2500 | 0.2500 | 0.2500 |
| ENDRIN | 6 | 0.0500 | 0.2500 | 0.1500 |
| ENDRIN ALDEHYDE | 3 | 0.2500 | 0.2500 | 0.2500 |
| HEPTACHLOR | 3 | 0.0000 | 0.0000 | 0.0000 |
| HEPTACHLOR EPOXIDE | 3 | 0.0000 | 0.0000 | 0.0000 |
| TOXAPHENE | 6 | 0.0000 | 0.5000 | 0.2500 |
| METHOXYCHLOR | 6 | 0.0000 | 0.2500 | 0.1250 |
| 2,4,5-TP | 6 | 0.5000 | 0.5000 | 0.5000 |
| 2,4-D | 6 | 0.0000 | 0.5000 | 0.2500 |
| ENDRIN KETONE | 3 | 0.2500 | 0.2500 | 0.2500 |
| 2,4,5-T | 3 | 0.5000 | 0.5000 | 0.5000 |
| PCB-AROCLOR-1016 | 3 | 2.5000 | 2.5000 | 2.5000 |
| PCB-AROCLOR-1221 | 3 | 0.0000 | 0.0000 | 0.0000 |
| PCB-AROCLOR-1232 | 3 | 2.5000 | 2.5000 | 2.5000 |
| PCB-AROCLOR-1242 | 3 | 2.5000 | 2.5000 | 2.5000 |
| PCB-AROCLOR-1248 | 3 | 2.5000 | 2.5000 | 2.5000 |
| PCB-AROCLOR-1254 | 3 | 2.5000 | 2.5000 | 2.5000 |
| PCB-AROCLOR-1260 | 3 | 2.5000 | 2.5000 | 2.5000 |

Table G.2. Background concentrations of constituents in Bear Creek Valley creek sediments. Sites include NT-2 and Grassy Creek locations GCK 1.4 and GCK 2.4 Data are from Bechtel National, Inc. and Roy F. Weston, Inc., sampling campaigns during the period 1983-1986. Values reported as "less than" values were included in the statistical summary after deleting the "L" sign and dividing the given value by 2. Minimum, maximum, and mean values of zero mean "not detected."

| | NUMBER OF OBSERVATIONS | MINIMUM VALUE | MAXIMUM VALUE | MEAN |
|---|---|---|---|---|
| METALS (μg/g) | | | | |
| ALUMINUM | 14 | 17000.0000 | 48200.0000 | 34228.0714 |
| ANTIMONY | 14 | 2.5000 | 169.0000 | 82.0500 |
| ANTIMONY (AAS) | 10 | 0.2400 | 1.2500 | 0.3481 |
| ARSENIC | 14 | 20.0000 | 142.0000 | 74.3679 |
| ARSENIC (AAS) | 10 | 1.9000 | 17.8000 | 6.7580 |
| BARIUM | 14 | 95.0000 | 560.0000 | 257.5000 |
| BARIUM (AAS) | 4 | 100.0000 | 218.0000 | 149.5000 |
| BERYLLIUM | 14 | 0.1000 | 46.5000 | 21.9446 |
| BERYLLIUM (AAS) | 0 | . | . | . |
| BORON | 14 | 0.5000 | 10400.0000 | 3956.0000 |
| CADMIUM | 14 | 1.0000 | 46.5000 | 21.4661 |
| CADMIUM (AAS) | 7 | 0.1225 | 0.4800 | 0.2453 |
| CALCIUM | 14 | 420.0000 | 3330.0000 | 1928.0714 |
| CERIUM | 0 | . | . | . |
| CHROMIUM | 14 | 2.4800 | 98.9000 | 55.4236 |
| CHROMIUM (AAS) | 4 | 4.8050 | 22.0000 | 14.7012 |
| COBALT | 14 | 6.0000 | 50.9000 | 34.8107 |
| COPPER | 14 | 1.0000 | 46.5000 | 21.2243 |
| GALLIUM | 0 | . | . | . |
| GERMANIUM | 0 | . | . | . |
| GOLD | 0 | . | . | . |
| IRON | 14 | 10000.0000 | 54991.0000 | 31716.5000 |
| IRON (AAS) | 0 | . | . | . |
| LANTHANUM | 0 | . | . | . |
| LEAD | 14 | 27.0000 | 259.0000 | 121.6429 |
| LEAD (AAS) | 10 | 12.0000 | 148.0000 | 42.2800 |
| LITHIUM | 14 | 10.0000 | 48.0000 | 31.9679 |
| MAGNESIUM | 14 | 1000.0000 | 13100.0000 | 4646.2857 |
| MANGANESE | 14 | 180.0000 | 2900.0000 | 1648.8571 |
| MANGANESE (AAS) | 0 | . | . | . |
| MERCURY | 8 | 0.0300 | 0.5000 | 0.1639 |
| MOLYBDENUM | 14 | 1.0000 | 46.5000 | 22.1146 |
| NICKEL | 14 | 5.0000 | 64.9000 | 38.0750 |
| NIOBIUM | 0 | . | . | . |
| PHOSPHOROUS | 0 | . | . | . |
| POTASSIUM | 0 | . | . | . |

Table G.2 (continued).

| | | | | |
|---|---|---|---|---|
| SCANDIUM | 0 | . | . | . |
| SELENIUM | 14 | 10.0000 | 208.0000 | 96.6571 |
| SELENIUM (AAS) | 10 | 0.2325 | 0.4950 | 0.2706 |
| SILICON | 14 | 2.5000 | 2555.0000 | 511.8714 |
| SILVER | 14 | 0.5000 | 46.5000 | 21.7575 |
| SILVER (AAS) | 4 | 0.4650 | 0.4950 | 0.4805 |
| SODIUM | 14 | 290.0000 | 8470.0000 | 4167.3571 |
| SODIUM (AAS) | 0 | . | . | . |
| STRONTIUM | 14 | 15.0000 | 46.5000 | 31.4571 |
| THALLIUM | 14 | 15.0000 | 26200.0000 | 2170.7929 |
| THALLIUM (AAS) | 0 | . | . | . |
| THORIUM | 0 | . | . | . |
| TIN | 14 | 10.0000 | 14000.0000 | 1048.1964 |
| TITANIUM | 14 | 460.0000 | 1570.0000 | 1010.7143 |
| URANIUM | 14 | 24.8000 | 200.0000 | 79.4107 |
| URANIUM (FLUOR) | 10 | 0.4100 | 3.3500 | 2.3080 |
| VANADIUM | 14 | 12.0000 | 84.9000 | 49.1821 |
| YTTRIUM | 0 | . | . | . |
| ZINC | 14 | 0.9950 | 90.9000 | 46.3532 |
| ZIRCONIUM | 0 | . | . | . |
| RADIOLOGICALS (pCi/g) | | | | |
| 241 AMERICIUM | 3 | 0.0200 | 0.0610 | 0.0337 |
| 137 CESIUM | 4 | 0.0000 | 0.0880 | 0.0610 |
| 242+243 CURIUM | 3 | 0.0050 | 0.0100 | 0.0083 |
| 244 CURIUM | 3 | 0.0050 | 0.0200 | 0.0150 |
| 237 NEPTUNIUM | 3 | 0.0360 | 0.6670 | 0.2743 |
| 238 PLUTONIUM | 4 | 0.0050 | 0.0350 | 0.0155 |
| 239+240 PLUTONIUM | 4 | 0.0050 | 0.0420 | 0.0157 |
| 232 THORIUM | 4 | 0.7520 | 1.0500 | 0.9245 |
| 230 THORIUM | 4 | 0.6460 | 1.0200 | 0.8215 |
| 233+234 URANIUM | 4 | 0.5900 | 10.3000 | 3.1847 |
| 235 URANIUM | 4 | 0.0220 | 0.9070 | 0.2667 |
| 238 URANIUM | 4 | 0.6570 | 16.2000 | 4.7160 |
| GROSS ALPHA | 10 | 4.0000 | 29.0000 | 11.2000 |
| GROSS BETA | 10 | 6.0000 | 45.0000 | 12.6000 |
| MISCELLANEOUS PARAMETERS (%) | | | | |
| OIL & GREASE IN SEDIMENT (μg/g) | 3 | 15.0000 | 467.0000 | 165.6667 |
| LOSS ON IGNITION-%MOIST. | 10 | 25.5000 | 47.0000 | 35.1700 |
| LOSS ON IGNITION-%ASH | 10 | 50.0000 | 72.1000 | 62.0200 |
| LOSS ON IGNITION-%ORG.MAT. | 10 | 1.8000 | 3.4000 | 2.8000 |
| PER CENT SAND | 10 | 15.0000 | 83.0000 | 51.4900 |
| PER CENT SILT | 10 | 11.0000 | 73.0000 | 38.2700 |
| PER CENT CLAY | 10 | 4.0000 | 18.0000 | 10.2400 |

Table G.2 (continued).

VOLATILE ORGANIC COMPOUNDS μg/g)

| | | | | |
|---|---|---|---|---|
| ACROLEIN | 14 | 0 | 0.0000 | 0.0000 |
| ACRYLONITRILE | 14 | 0 | 0.0000 | 0.0000 |
| BENZENE | 14 | 0 | 0.0000 | 0.0000 |
| BROMOFORM | 14 | 0 | 0.0000 | 0.0000 |
| CARBON TETRACHLORIDE | 14 | 0 | 0.0000 | 0.0000 |
| CHLOROBENZENE | 14 | 0 | 0.0000 | 0.0000 |
| CHLORODIBROMOMETHANE | 14 | 0 | 0.0000 | 0.0000 |
| CHLOROETHANE | 14 | 0 | 0.0000 | 0.0000 |
| 2-CHLOROETHYLVINYL ETHER | 14 | 0 | 0.0000 | 0.0000 |
| CHLOROFORM | 14 | 0 | 0.0000 | 0.0000 |
| BROMODICHLOROMETHANE | 14 | 0 | 0.0000 | 0.0000 |
| DICHLORODIFLUOROMETHANE | 14 | 0 | 0.0000 | 0.0000 |
| 1,1-DICHLOROETHANE | 14 | 0 | 0.0000 | 0.0000 |
| 1,2-DICHLOROETHANE | 14 | 0 | 0.0000 | 0.0000 |
| 1,1-DICHLOROETHENE | 14 | 0 | 0.0000 | 0.0000 |
| 1,2-DICHLOROPROPANE | 14 | 0 | 0.0000 | 0.0000 |
| CIS-1,3-DICHLOROPROPENE | 14 | 0 | 0.0000 | 0.0000 |
| TRANS-1,3-DICHLOROPROPENE | 14 | 0 | 0.0000 | 0.0000 |
| ETHYLBENZENE | 14 | 0 | 0.0000 | 0.0000 |
| BROMOMETHANE | 14 | 0 | 0.0000 | 0.0000 |
| CHLOROMETHANE | 14 | 0 | 0.0000 | 0.0000 |
| METHYLENE CHLORIDE | 14 | 0 | 80.0000 | 12.6786 |
| 1,1,2,2-TETRACHLOROETHANE | 14 | 0 | 0.0000 | 0.0000 |
| TETRACHLOROETHENE | 14 | 0 | 5.0000 | 0.3571 |
| TOLUENE | 14 | 0 | 5.0000 | 0.3571 |
| TRANS-1,2-DICHLOROETHENE | 14 | 0 | 0.0000 | 0.0000 |
| 1,1,1-TRICHLOROETHANE | 14 | 0 | 5.0000 | 0.3571 |
| 1,1,2-TRICHLOROETHANE | 14 | 0 | 0.0000 | 0.0000 |
| TRICHLOROETHENE | 14 | 0 | 0.0000 | 0.0000 |
| FLUOROTRICHLOROMETHANE | 14 | 0 | 0.0000 | 0.0000 |
| VINYL CHLORIDE | 14 | 0 | 0.0000 | 0.0000 |

SEMI-VOLATILE ORGANIC COMPOUNDS (μg/g)

| | | | | |
|---|---|---|---|---|
| ACENAPHTHENE | 4 | 0 | 0.0000 | 0.0000 |
| ACENAPHTHYLENE | 4 | 0 | 0.0000 | 0.0000 |
| ANTHRACENE | 4 | 0 | 0.0000 | 0.0000 |
| BENZIDINE | 4 | 0 | 0.0000 | 0.0000 |
| BENZO(A)ANTHRACENE | 4 | 0 | 0.5000 | 0.1250 |
| BENZO(A)PYRENE | 4 | 0 | 0.0000 | 0.0000 |
| 3,4-BENZOFLUORANTHEN | 3 | 0 | 0.5000 | 0.1667 |
| BENZO(GHI)PERYLENE | 4 | 0 | 0.0000 | 0.0000 |
| BIS(2-CHLORETHOXY)METHANE | 4 | 0 | 0.0000 | 0.0000 |
| BIS(2-CHLORETHYL)ETHER | 4 | 0 | 0.0000 | 0.0000 |
| BIS(2-CHLORISOPROPYL)ETHER | 4 | 0 | 0.0000 | 0.0000 |
| BIS(2-ETHYLHEXYL)PHTHALATE | 4 | 0 | 0.0000 | 0.0000 |
| 4-BROMOPHENYL PHENYL ETHER | 4 | 0 | 0.0000 | 0.0000 |
| BUTYL BENZYL PHTHALATE | 4 | 0 | 0.0000 | 0.0000 |

Table G.2 (continued).

| | | | | |
|---|---|---|---|---|
| 2-CHLORONAPHTHALENE | 4 | 0 | 0.0000 | 0.0000 |
| 4-CHLOROPHENYLPHENYL ETHER | 4 | 0 | 0.0000 | 0.0000 |
| CHRYSENE | 4 | 0 | 0.0000 | 0.0000 |
| DIBENZO(A,H)ANTHRACENE | 4 | 0 | 0.0000 | 0.0000 |
| 1,2-DICHLOROBENZENE | 4 | 0 | 0.0000 | 0.0000 |
| 1,3-DICHLOROBENZENE | 4 | 0 | 0.0000 | 0.0000 |
| 1,4-DICHLOROBENZENE | 4 | 0 | 0.0000 | 0.0000 |
| 3,3'-DICHLOROBENZIDINE | 4 | 0 | 0.0000 | 0.0000 |
| DIETHYLPHTHALATE | 4 | 0 | 0.0000 | 0.0000 |
| DIMETHYLPHTHALATE | 4 | 0 | 0.0000 | 0.0000 |
| DI-N-BUTYLPHTHALATE | 4 | 0 | 0.0000 | 0.0000 |
| 2,4-DINITROTOLUENE | 4 | 0 | 0.0000 | 0.0000 |
| 2,6-DINITROTOLUENE | 4 | 0 | 0.0000 | 0.0000 |
| DI-N-OCTYLPHTHALATE | 4 | 0 | 0.0000 | 0.0000 |
| 1,2-DIPHENYLHYDRAZINE | 3 | 0 | 0.0000 | 0.0000 |
| FLUORANTHENE | 4 | 0 | 0.0000 | 0.0000 |
| FLUORENE | 4 | 0 | 0.0000 | 0.0000 |
| HEXACHLOROBENZENE | 4 | 0 | 0.5000 | 0.1250 |
| HEXACHLOROBUTADIENE | 4 | 0 | 0.0000 | 0.0000 |
| HEXACHLOROCYCLOPENTADIENE | 4 | 0 | 0.0000 | 0.0000 |
| HEXACHLOROETHANE | 4 | 0 | 0.0000 | 0.0000 |
| IDENO(1,2,3-CD)PYRENE | 4 | 0 | 0.0000 | 0.0000 |
| ISOPHORONE | 4 | 0 | 0.0000 | 0.0000 |
| NAPHTHALENE | 4 | 0 | 0.0000 | 0.0000 |
| NITROBENZENE | 4 | 0 | 0.0000 | 0.0000 |
| N-NITROSODIMETHYLAMINE | 3 | 0 | 0.0000 | 0.0000 |
| N-NITROSODI-N-PROPYLAMINE | 4 | 0 | 0.0000 | 0.0000 |
| N-NITROSODIPHENYLAMINE | 3 | 0 | 0.0000 | 0.0000 |
| PHENANTHRENE | 4 | 0 | 0.0000 | 0.0000 |
| PYRENE | 4 | 0 | 0.0000 | 0.0000 |
| 1,2,4-TRICHLOROBENZENE | 4 | 0 | 0.0000 | 0.0000 |
| 2,3,7,8-TCDD | 3 | 0 | 0.0000 | 0.0000 |
| BENZO(K)FLUORANTHENE | 1 | 0 | 0.0000 | 0.0000 |
| 1,2-DIPHENYLHYDRAZINE | 1 | 0 | 0.0000 | 0.0000 |
| N-NITROSODIPHENYLAMINE | 1 | 0 | 0.0000 | 0.0000 |
| BENZO(B)FLUORANTHENE | 1 | 0 | 0.0000 | 0.0000 |
| 2-CHLOROPHENOL | 4 | 0 | 0 | 0 |
| 2,4-DICHLOROPHENOL | 4 | 0 | 0 | 0 |
| 2,4-DIMETHYLPHENOL | 4 | 0 | 0 | 0 |
| 4,6-DINITRO-2-METHYLPHENOL | 4 | 0 | 0 | 0 |
| 2,4-DINITROPHENOL | 4 | 0 | 0 | 0 |
| 2-NITROPHENOL | 4 | 0 | 0 | 0 |
| 4-NITROPHENOL | 4 | 0 | 0 | 0 |
| P-CHLORO-M-CRESOL | 4 | 0 | 0 | 0 |
| PENTACHLOROPHENOL | 4 | 0 | 0 | 0 |
| PHENOL | 4 | 0 | 0 | 0 |
| 2,4,6-TRICHLOROPHENOL | 4 | 0 | 0 | 0 |

Table G.2 (continued).

PCBs (μg/g)

| | | | | |
|---|---|---|---|---|
| PCB-AROCLOR-1254 | 8 | 0.0050 | 0.0500 | 0.0256 |
| PCB-AROCLOR-1260 | 14 | 0.0050 | 0.0500 | 0.0346 |
| PCB-AROCLOR-1242,1248,101 | 4 | 0.0250 | 0.0250 | 0.0250 |

# APPENDIX H. SUMMARY OF WATER QUALITY DATA FOR GROUNDWATER WELLS INCLUDED IN EVALUATION FOR RFI PLAN

Table H.1. Statistical summary of water quality data for wells (see Table 7.7) included in evaluation for RFI Plan. Data are from Bechtel National, Inc., Roy F. Weston, Inc., K-25 Plant and Y-12 Plant sampling campaigns during the period 1983-1987. Values reported as "less than" values were included in the statistical summary after deleting the "L" sign and dividing the given value by 2. Minimum, maximum, and mean values of zero mean "not detected."

| | NUMBER OF OBSERVATIONS | MINIMUM VALUE | MAXIMUM VALUE | MEAN |
|---|---|---|---|---|
| MISCELLANEOUS CONSTITUENTS (mg/L) | | | | |
| TOTAL SUSPENDED SOLIDS | 190 | 0.5000 | 110520.000 | 946.9184 |
| TOTAL DISSOLVED SOLIDS | 36 | 300.0000 | 12616.000 | 2723.6111 |
| SETTLEABLE SOLIDS | 23 | 0.0500 | 5.500 | 0.8239 |
| TOTAL SOLIDS | 22 | 480.0000 | 12000.000 | 3068.6364 |
| TURBIDITY (IN NTU) | 36 | 0.5500 | 17200.000 | 882.2194 |
| CONDUCTANCE (IN MV/CM) | 19 | 0.0000 | 6.000 | 2.2226 |
| COLOR (APP. COLOR UNITS) | 34 | 0.5000 | 3300.000 | 116.4559 |
| MBAS | 34 | 0.0250 | 0.050 | 0.0257 |
| ALK., BICARB. AS CACO3 | 115 | 0.5000 | 952.000 | 289.6870 |
| METHYL ORG. ALK. AS CACO3 | 35 | 0.5000 | 3590.000 | 328.4143 |
| PHENOLPHTH. ALK. AS CACO3 | 35 | 0.5000 | 698.000 | 26.7571 |
| ALK., CARB. AS CACO3 | 118 | 0.5000 | 248.000 | 4.3093 |
| TOTAL ALKALINITY AS CACO3 | 25 | 160.0000 | 540.000 | 328.8000 |
| NITRATE/NITRITE-N | 95 | 0.0050 | 2640.000 | 72.9135 |
| NITRATE | 1 | 13000.0000 | 13000.000 | 13000.0000 |
| nitrate-n | 117 | 0.0500 | 2122.000 | 325.8240 |
| NITRITE | 29 | 0.1250 | 50.000 | 4.0776 |
| NITRITE-N | 8 | 3.3500 | 16.500 | 13.2875 |
| AMMONIA - N | 121 | 0.0100 | 6.310 | 0.4771 |
| TOTAL KJELDAHL NITROGEN | 188 | 0.0250 | 16.200 | 0.6410 |
| SULFATE | 198 | 2.5000 | 1638.000 | 62.2010 |
| CHLORIDE | 166 | 4.5000 | 550.000 | 60.0970 |
| FLUORIDE | 81 | 0.0500 | 1.000 | 0.2061 |
| HARDNESS | 23 | 330.0000 | 5100.000 | 1811.4348 |
| ORTHO PHOSPHATE - P | 35 | 0.0050 | 0.130 | 0.0246 |
| CHEMICAL OXYGEN DEMAND | 35 | 0.5000 | 538.000 | 27.8429 |
| COLIFORM (CC/100 ML) | 41 | 0.5000 | 250.000 | 24.0610 |
| CYANIDE | 64 | 0.0010 | 0.140 | 0.0062 |
| PHENOLS | 77 | 0.0005 | 0.008 | 0.0011 |
| TOTAL ORG. CARBON (MG/L) | 136 | 0.2500 | 37.0000 | 2.5103 |
| TOTAL ORG. HALIDE (μG/L) | 52 | 5.0000 | 629.0000 | 142.3269 |
| WATER LEVEL (FT +/- GRADE) | 186 | -30.4000 | -0.1000 | -12.5072 |
| DISSOLVED OXYGEN | 171 | 0.0000 | 15.3000 | 4.7425 |
| PH (IN PH UNITS) | 192 | 2.9000 | 10.9000 | 6.9594 |
| WATER TEMP (DEG CENT) | 177 | 6.0000 | 28.0000 | 15.4153 |
| REDOX (IN MV) | 155 | -140.0000 | 440.0000 | 177.0594 |
| CONDUCTIVITY (UMHOS/CM) | 233 | 7.4000 | 16000.0000 | 2274.8751 |

Table H.1 (continued).

TOTAL METALS (mg/L)

| | | | | |
|---|---|---|---|---|
| ALUMINUM | 175 | 0.0100 | 1700.0000 | 41.0643 |
| ANTIMONY | 113 | 0.0250 | 0.2500 | 0.1020 |
| ANTIMONY (AAS) | 35 | 0.0025 | 0.0125 | 0.0071 |
| ARSENIC | 131 | 0.0025 | 2.0000 | 0.1431 |
| ARSENIC (AAS) | 112 | 0.0025 | 0.0730 | 0.0040 |
| BARIUM | 178 | 0.0350 | 13.0000 | 1.4602 |
| BARIUM (AAS) | 76 | 0.0050 | 12.8000 | 1.1931 |
| BERYLLIUM | 183 | 0.0000 | 0.2500 | 0.0537 |
| BERYLLIUM (AAS) | 1 | 0.0005 | 0.0005 | 0.0005 |
| BORON | 163 | 0.0020 | 6.0000 | 0.2469 |
| CADMIUM | 178 | 0.0010 | 0.5600 | 0.0730 |
| CADMIUM (AAS) | 76 | 0.0010 | 0.0600 | 0.0043 |
| CALCIUM | 183 | 17.0000 | 000.0000 | 331.2055 |
| CERIUM | 51 | 0.0100 | 0.5700 | 0.0327 |
| CHROMIUM | 178 | 0.0030 | 1.9000 | 0.1227 |
| CHROMIUM (AAS) | 76 | 0.0050 | 0.9700 | 0.0536 |
| COBALT | 167 | 0.0010 | 2.3000 | 0.1424 |
| COPPER | 170 | 0.0010 | 3.9000 | 0.1400 |
| GALLIUM | 51 | 0.0050 | 0.2000 | 0.0265 |
| GERMANIUM | 0 | . | . | . |
| GOLD | 0 | . | . | . |
| IRON | 188 | 0.0020 | 1200.0000 | 21.6454 |
| IRON (AAS) | 3 | 0.0500 | 10.2000 | 4.6500 |
| LANTHANUM | 51 | 0.0015 | 0.3300 | 0.0118 |
| LEAD | 131 | 0.0050 | 4.7000 | 0.1426 |
| LEAD (AAS) | 112 | 0.0020 | 0.2800 | 0.0244 |
| LITHIUM | 167 | 0.0020 | 5.5000 | 0.1838 |
| MAGNESIUM | 167 | 3.9000 | 330.0000 | 59.6880 |
| MANGANESE | 188 | 0.0018 | 110.0000 | 5.3650 |
| MANGANESE (AAS) | 3 | 0.3000 | 0.4000 | 0.3333 |
| MERCURY | 211 | 0.0001 | 0.0920 | 0.0013 |
| MOLYBDENUM | 167 | 0.0030 | 0.2500 | 0.0689 |
| NICKEL | 167 | 0.0035 | 25.0000 | 0.6518 |
| NIOBIUM | 98 | 0.0035 | 0.0900 | 0.0151 |
| PHOSPHOROUS | 98 | 0.0150 | 3.3000 | 0.1407 |
| POTASSIUM | 133 | 0.3000 | 82.0000 | 10.0060 |
| SCANDIUM | 51 | 0.0002 | 0.0960 | 0.0044 |
| SELENIUM | 131 | 0.0010 | 0.3000 | 0.0952 |
| SELENIUM (AAS) | 112 | 0.0025 | 0.0050 | 0.0029 |
| SILICON | 116 | 1.5000 | 100.0000 | 13.0586 |
| SILVER | 178 | 0.0020 | 1.1000 | 0.0713 |
| SILVER (AAS) | 76 | 0.0050 | 0.0050 | 0.0050 |
| SODIUM | 185 | 2.1000 | 700.0000 | 45.6195 |
| SODIUM (AAS) | 3 | 3.3000 | 10.4000 | 7.5667 |
| STRONTIUM | 167 | 0.0710 | 22.0000 | 1.5419 |
| THALLIUM | 69 | 0.1500 | 0.8400 | 0.3023 |
| THALLIUM (AAS) | 41 | 0.0050 | 0.0100 | 0.0051 |
| THORIUM | 110 | 0.0015 | 1.0000 | 0.0676 |

Table H.1 (continued).

| | | | | |
|---|---|---|---|---|
| TIN | 69 | 0.1000 | 100.0000 | 2.0919 |
| TITANIUM | 167 | 0.0005 | 1.7000 | 0.1067 |
| URANIUM | 69 | 0.2500 | 45.0000 | 1.5323 |
| URANIUM (FLUOR) | 177 | 0.0005 | 158.0000 | 1.4669 |
| % 235 URANIUM | 65 | 0.0560 | 14.3000 | 0.8266 |
| VANADIUM | 167 | 0.0015 | 0.8800 | 0.0684 |
| YTTRIUM | 37 | 0.0005 | 0.3500 | 0.0136 |
| ZINC | 170 | 0.0005 | 5.5000 | 0.2903 |
| ZIRCONIUM | 98 | 0.0005 | 0.0730 | 0.0063 |
| DISSOLVED METALS (mg/L) | | | | |
| ALUMINUM | 108 | 0.0100 | 720.0000 | 31.7776 |
| ANTIMONY | 102 | 0.0250 | 2.3000 | 0.1805 |
| ANTIMONY (AAS) | 61 | 0.0025 | 0.0150 | 0.0053 |
| ARSENIC | 61 | 0.2500 | 1.7000 | 0.2811 |
| ARSENIC (AAS) | 138 | 0.0025 | 0.4500 | 0.0071 |
| BARIUM | 108 | 0.0110 | 20.0000 | 1.5390 |
| BARIUM (AAS) | 92 | 0.0200 | 34.5000 | 1.5363 |
| BERYLLIUM | 108 | 0.0001 | 0.2500 | 0.1463 |
| BERYLLIUM (AAS) | 0 | . | . | . |
| BORON | 108 | 0.0020 | 6.2000 | 0.4339 |
| CADMIUM | 109 | 0.0015 | 0.6000 | 0.1732 |
| CADMIUM (AAS) | 92 | 0.0010 | 0.4600 | 0.0122 |
| CALCIUM | 123 | 15.6000 | 2900.0000 | 289.9854 |
| CERIUM | 0 | . | . | . |
| CHROMIUM | 109 | 0.0050 | 1.1000 | 0.1574 |
| CHROMIUM (AAS) | 92 | 0.0050 | 1.0000 | 0.0173 |
| COBALT | 108 | 0.0025 | 2.3000 | 0.2537 |
| COPPER | 108 | 0.0020 | 4.1000 | 0.2434 |
| GALLIUM | 0 | . | . | . |
| GERMANIUM | 0 | . | . | . |
| GOLD | 0 | . | . | . |
| IRON | 126 | 0.0020 | 22.0000 | 1.2151 |
| IRON (AAS) | 3 | 0.0500 | 0.0500 | 0.0500 |
| LANTHANUM | 0 | . | . | . |
| LEAD | 61 | 0.2500 | 2.9000 | 0.3897 |
| LEAD (AAS) | 138 | 0.0020 | 0.1500 | 0.0072 |
| LITHIUM | 108 | 0.0020 | 3.8000 | 0.2597 |
| MAGNESIUM | 108 | 7.5000 | 330.0000 | 56.6426 |
| MANGANESE | 126 | 0.0005 | 111.0000 | 6.9793 |
| MANGANESE (AAS) | 3 | 0.1000 | 0.2000 | 0.1667 |
| MERCURY | 113 | 0.0001 | 0.0190 | 0.0004 |
| MOLYBDENUM | 108 | 0.0050 | 0.2500 | 0.1436 |
| NICKEL | 108 | 0.0050 | 22.1000 | 0.9450 |
| NIOBIUM | 47 | 0.0035 | 0.0270 | 0.0059 |
| PHOSPHOROUS | 47 | 0.1000 | 0.5300 | 0.1091 |
| POTASSIUM | 108 | 0.2500 | 85.0000 | 8.1858 |
| SCANDIUM | 0 | . | . | . |

Table H.1 (continued).

| | | | | |
|---|---|---|---|---|
| SELENIUM | 61 | 0.2500 | 2.5000 | 0.2869 |
| SELENIUM (AAS) | 137 | 0.0020 | 0.0060 | 0.0028 |
| SILICON | 108 | 0.2500 | 34.0000 | 5.2551 |
| SILVER | 108 | 0.0030 | 0.6700 | 0.1479 |
| SILVER (AAS) | 78 | 0.0050 | 0.0050 | 0.0050 |
| SODIUM | 126 | 1.1000 | 660.0000 | 48.2127 |
| SODIUM (AAS) | 3 | 4.9000 | 25.0000 | 12.4333 |
| STRONTIUM | 108 | 0.0690 | 21.0000 | 1.1996 |
| THALLIUM | 61 | 0.2500 | 1.6000 | 0.4764 |
| THALLIUM (AAS) | 41 | 0.0050 | 0.0050 | 0.0050 |
| THORIUM | 47 | 0.1000 | 0.2300 | 0.1028 |
| TIN | 61 | 0.2500 | 3.0000 | 0.2951 |
| TITANIUM | 108 | 0.0015 | 0.2500 | 0.1513 |
| URANIUM | 61 | 0.2500 | 33.5000 | 0.8618 |
| URANIUM (FLUOR) | 112 | 0.0005 | 159.0000 | 2.1426 |
| TOTAL URANIUM (FLUOR) | 26 | 0.0005 | 31.8000 | 1.2466 |
| VANADIUM | 108 | 0.0025 | 0.2500 | 0.1424 |
| YTTRIUM | 0 | . | . | . |
| ZINC | 108 | 0.0005 | 8.6000 | 0.3581 |
| ZIRCONIUM | 47 | 0.0025 | 0.0470 | 0.0051 |
| RADIOLOGICALS (pCi/L) | | | | |
| 238 PLUTONIUM | 23 | 0.0700 | 1.6500 | 0.2307 |
| 239+240 PLUTONIUM | 23 | 0.0200 | 0.6500 | 0.1372 |
| RADIUM (BQ/L) | 18 | 0.0500 | 1.3000 | 0.3694 |
| 226 RADIUM | 21 | 0.2250 | 4.0000 | 1.1417 |
| 228 RADIUM | 21 | 0.4550 | 4.0000 | 1.5964 |
| 99 TECHNETIUM | 22 | 0.0150 | 400.0000 | 19.1698 |
| 233+234 URANIUM | 30 | 0.0550 | 29.1000 | 5.4440 |
| 235 URANIUM | 30 | 0.0000 | 1.8800 | 0.3775 |
| 238 URANIUM | 30 | 0.0500 | 47.1000 | 7.5809 |
| GROSS ALPHA | 204 | 0.5000 | 16779.0000 | 393.7029 |
| GROSS BETA | 204 | 1.5000 | 47457.0000 | 1205.0436 |
| VOLATILE ORGANIC COMPOUNDS (μg/L) | | | | |
| ACROLEIN | 99 | 0 | 0.0000 | 0.0000 |
| ACRYLONITRILE | 99 | 0 | 0.0000 | 0.0000 |
| BENZENE | 204 | 0 | 30.0000 | 1.0281 |
| BROMOFORM | 198 | 0 | 47.0000 | 0.4243 |
| CARBON TETRACHLORIDE | 198 | 0 | 87.0000 | 1.9394 |
| CHLOROBENZENE | 197 | 0 | 5.0000 | 0.4010 |
| CHLORODIBROMOMETHANE | 197 | 0 | 5.0000 | 0.1066 |
| CHLOROETHANE | 227 | 0 | 10.0000 | 0.5238 |
| 2-CHLOROETHYLVINYL ETHER | 195 | 0 | 5.0000 | 0.0462 |
| CHLOROFORM | 237 | 0 | 240.0000 | 4.9128 |
| BROMODICHLOROMETHANE | 197 | 0 | 5.0000 | 0.1421 |

Table H.1 (continued).

| | | | | |
|---|---|---|---|---|
| DICHLORODIFLUOROMETHANE | 98 | 0 | 110.0000 | 1.6939 |
| 1,1-DICHLOROETHANE | 200 | 0 | 20.0000 | 1.3301 |
| 1,2-DICHLOROETHANE | 201 | 0 | 23.0000 | 0.7016 |
| 1,1-DICHLOROETHENE | 197 | 0 | 25.0000 | 1.2183 |
| 1,2-DICHLOROPROPANE | 197 | 0 | 5.0000 | 0.0761 |
| CIS-1,3-DICHLOROPROPENE | 197 | 0 | 5.0000 | 0.0761 |
| TRANS-1,3-DICHLOROPROPENE | 197 | 0 | 5.0000 | 0.0254 |
| ETHYLBENZENE | 197 | 0 | 5.0000 | 0.2975 |
| BROMOMETHANE | 235 | 0 | 5.0000 | 0.3404 |
| CHLOROMETHANE | 235 | 0 | 12.0000 | 0.3277 |
| METHYLENE CHLORIDE | 239 | 0 | 240.0000 | 7.2198 |
| 1,1,2,2-TETRACHLOROETHANE | 197 | 0 | 22.0000 | 0.2640 |
| TETRACHLOROETHENE | 239 | 0 | 1600.0000 | 63.7132 |
| TOLUENE | 236 | 0 | 5.0000 | 0.9882 |
| TRANS-1,2-DICHLOROETHENE | 195 | 0 | 310.0000 | 6.3215 |
| 1,1,1-TRICHLOROETHANE | 200 | 0 | 55.0000 | 2.1650 |
| 1,1,2-TRICHLOROETHANE | 200 | 0 | 70.0000 | 0.6550 |
| TRICHLOROETHENE | 206 | 0 | 790.0000 | 55.8115 |
| FLUOROTRICHLOROMETHANE | 121 | 0 | 148.0000 | 2.3140 |
| VINYL CHLORIDE | 197 | 0 | 31.0000 | 1.1574 |

PESTICIDES, HERBICIDES, AND PCBs (μg/L)

| | | | | |
|---|---|---|---|---|
| ALDRIN | 2 | 0.0000 | 0.0250 | 0.0125 |
| ALPHA-BHC | 2 | 0.0000 | 0.0250 | 0.0125 |
| BETA-BHC | 2 | 0.0000 | 0.0250 | 0.0125 |
| GAMMA-BHC (LINDANE) | 26 | 0.0000 | 0.0250 | 0.0056 |
| DELTA-BHC | 2 | 0.0000 | 0.0250 | 0.0125 |
| CHLORDANE | 2 | 0.0000 | 0.2500 | 0.1250 |
| 4,4'-DDT | 2 | 0.0500 | 0.2500 | 0.1500 |
| 4,4'-DDE | 2 | 0.0500 | 0.2500 | 0.1500 |
| 4,4'-DDD | 2 | 0.0500 | 0.2500 | 0.1500 |
| DIELDRIN | 2 | 0.0500 | 0.2500 | 0.1500 |
| ALPHA-ENDOSULFAN | 2 | 0.0000 | 0.0250 | 0.0125 |
| BETA-ENDOSULFAN | 2 | 0.0500 | 0.2500 | 0.1500 |
| ENDOSULFAN SULFATE | 2 | 0.0500 | 0.2500 | 0.1500 |
| ENDRIN | 26 | 0.0250 | 0.2500 | 0.0346 |
| ENDRIN ALDEHYDE | 2 | 0.0500 | 0.2500 | 0.1500 |
| HEPTACHLOR | 2 | 0.0000 | 0.0250 | 0.0125 |
| HEPTACHLOR EPOXIDE | 2 | 0.0000 | 0.0250 | 0.0125 |
| TOXAPHENE | 26 | 0.0000 | 0.5000 | 0.1115 |
| METHOXYCHLOR | 26 | 0.0000 | 0.2500 | 0.1019 |
| 2,4,5-TP | 26 | 0.0100 | 0.5000 | 0.0381 |
| 2,4-D | 26 | 0.0000 | 0.5000 | 0.0654 |
| ENDRIN KETONE | 2 | 0.0500 | 0.2500 | 0.1500 |
| 2,4,5-T | 2 | 0.2500 | 0.5000 | 0.3750 |
| PCB-AROCLOR-1016 | 5 | 0.0002 | 2.5000 | 0.5501 |
| PCB-AROCLOR-1221 | 5 | 0.0000 | 0.2500 | 0.0501 |
| PCB-AROCLOR-1232 | 5 | 0.0002 | 2.5000 | 0.5501 |
| PCB-AROCLOR-1242 | 5 | 0.0002 | 2.5000 | 0.5501 |

Table H.1 (continued).

| | | | | |
|---|---|---|---|---|
| PCB-AROCLOR-1248 | 5 | 0.0002 | 2.5000 | 0.5501 |
| PCB-AROCLOR-1254 | 5 | 0.0002 | 2.5000 | 0.6001 |
| PCB-AROCLOR-1260 | 5 | 0.0002 | 2.5000 | 0.6001 |
| PCB-ALL DETECT. AROCLORS | 64 | 0.2500 | 0.2500 | 0.2500 |
| SEMI-VOLATILE ORGANIC COMPOUNDS (μg/L) | | | | |
| ACENAPHTHENE | 10 | 0 | 0.0000 | 0.0000 |
| ACENAPHTHYLENE | 10 | 0 | 0.0000 | 0.0000 |
| ANTHRACENE | 10 | 0 | 0.0000 | 0.0000 |
| BENZIDINE | 2 | 0 | 0.0000 | 0.0000 |
| BENZO(A)ANTHRACENE | 10 | 0 | 0.0000 | 0.0000 |
| BENZO(A)PYRENE | 10 | 0 | 0.0000 | 0.0000 |
| 3,4-BENZOFLUORANTHENE | 0 | . | . | . |
| BENZO(GHI)PERYLENE | 10 | 0 | 0.0000 | 0.0000 |
| BIS(2-CHLORETHOXY)METHANE | 10 | 0 | 0.0000 | 0.0000 |
| BIS(2-CHLORETHYL)ETHER | 10 | 0 | 0.0000 | 0.0000 |
| BIS(2-CHLORISOPROPYL)ETHER | 10 | 0 | 0.0000 | 0.0000 |
| BIS(2-ETHYLHEXYL)PHTHALATE | 10 | 0 | 32.0000 | 9.2000 |
| 4-BROMOPHENYL PHENYL ETHER | 10 | 0 | 0.0000 | 0.0000 |
| BUTYL BENZYL PHTHALATE | 10 | 0 | 1.0000 | 0.2000 |
| 2-CHLORONAPHTHALENE | 10 | 0 | 0.0000 | 0.0000 |
| 4-CHLOROPHENYLPHENYL ETHER | 10 | 0 | 0.0000 | 0.0000 |
| CHRYSENE | 10 | 0 | 0.0000 | 0.0000 |
| DIBENZO(A,H)ANTHRACENE | 10 | 0 | 0.0000 | 0.0000 |
| 1,2-DICHLOROBENZENE | 10 | 0 | 0.0000 | 0.0000 |
| 1,3-DICHLOROBENZENE | 10 | 0 | 0.0000 | 0.0000 |
| 1,4-DICHLOROBENZENE | 10 | 0 | 0.0000 | 0.0000 |
| 3,3'-DICHLOROBENZIDINE | 10 | 0 | 0.0000 | 0.0000 |
| DIETHYLPHTHALATE | 10 | 0 | 0.0000 | 0.0000 |
| DIMETHYLPHTHALATE | 10 | 0 | 0.0000 | 0.0000 |
| DI-N-BUTYLPHTHALATE | 10 | 0 | 2.0000 | 0.2000 |
| 2,4-DINITROTOLUENE | 10 | 0 | 0.0000 | 0.0000 |
| 2,6-DINITROTOLUENE | 10 | 0 | 0.0000 | 0.0000 |
| DI-N-OCTYLPHTHALATE | 10 | 0 | 3.0000 | 0.5000 |
| 1,2-DIPHENYLHYDRAZINE | 0 | . | . | . |
| FLUORANTHENE | 10 | 0 | 0.0000 | 0.0000 |
| FLUORENE | 10 | 0 | 0.0000 | 0.0000 |
| HEXACHLOROBENZENE | 10 | 0 | 0.0000 | 0.0000 |
| HEXACHLOROBUTADIENE | 10 | 0 | 0.0000 | 0.0000 |
| HEXACHLOROCYCLOPENTADIENE | 10 | 0 | 0.0000 | 0.0000 |
| HEXACHLOROETHANE | 10 | 0 | 0.0000 | 0.0000 |
| IDENO(1,2,3-CD)PYRENE | 10 | 0 | 0.0000 | 0.0000 |
| ISOPHORONE | 10 | 0 | 0.0000 | 0.0000 |
| NAPHTHALENE | 10 | 0 | 1.0000 | 0.4000 |
| NITROBENZENE | 10 | 0 | 0.0000 | 0.0000 |
| N-NITROSODIMETHYLAMINE | 2 | 0 | 0.0000 | 0.0000 |
| N-NITROSODI-N-PROPYLAMINE | 10 | 0 | 0.0000 | 0.0000 |
| N-NITROSODIPHENYLAMINE | 10 | 0 | 0.0000 | 0.0000 |
| PHENANTHRENE | 10 | 0 | 0.0000 | 0.0000 |

Table H.1 (continued).

| | | | | |
|---|---|---|---|---|
| PYRENE | 10 | 0 | 0.0000 | 0.0000 |
| 1,2,4-TRICHLOROBENZENE | 10 | 0 | 0.0000 | 0.0000 |
| 2,3,7,8-TCDD | 0 | . | . | . |
| BENZO(K)FLUORANTHENE | 10 | 0 | 0.0000 | 0.0000 |
| 1,2-DIPHENYLHYDRAZINE | 0 | . | . | . |
| N-NITROSODIPHENYLAMINE | 0 | . | . | . |
| BENZO(B)FLUORANTHENE | 10 | 0 | 0.0000 | 0.0000 |
| 2-CHLOROPHENOL | 10 | 0 | 0.0000 | 0.0000 |
| 2,4-DICHLOROPHENOL | 10 | 0 | 0.0000 | 0.0000 |
| 2,4-DIMETHYLPHENOL | 10 | 0 | 0.0000 | 0.0000 |
| 4,6-DINITRO-2-METHYLPHENOL | 10 | 0 | 0.0000 | 0.0000 |
| 2,4-DINITROPHENOL | 10 | 0 | 77.0000 | 8.8000 |
| 2-NITROPHENOL | 10 | 0 | 71.0000 | 23.5000 |
| 4-NITROPHENOL | 10 | 0 | 120.0000 | 33.1000 |
| P-CHLORO-M-CRESOL | 0 | . | . | . |
| PENTACHLOROPHENOL | 10 | 0 | 0.0000 | 0.0000 |
| PHENOL | 10 | 0 | 0.0000 | 0.0000 |
| 2,4,6-TRICHLOROPHENOL | 10 | 0 | 0.0000 | 0.0000 |

# APPENDIX I. COMPLETE RESULTS OF ANALYSES OF BEAR CREEK FLOODPLAIN SOIL CORES COLLECTED APRIL 1985

Results of Analyses of Core B at BCK-1.05. Core Collected April, 1985.
(Units are µg/g, dry weight, except as noted.)

| | BCK-1.05 CORE B | | | | | |
|---|---|---|---|---|---|---|
| CONTAMINANT | 0-3 in. | 3-8 in. | 8-13 in. | 13-18 in. | 18-23 in. | 23-27 in. |
| Σ Alpha (pCi/g) | 26.46 | 14.58 | 12.96 | 6.75 | 10.80 | 12.42 |
| Alpha Counting Error | 17.01 | 14.31 | 14.04 | 12.15 | 13.23 | 13.50 |
| Σ Beta (pCi/g) | 29.70 | 22.14 | 17.28 | 17.28 | 12.15 | 10.53 |
| Beta Counting Error | 10.80 | 8.91 | 8.64 | 8.91 | 8.37 | 7.56 |
| Cs-137 (pCi/g) | 0.38 | 0.64 | 0.12 | <0.05 | <0.05 | <0.05 |
| Cs-137 Counting Error | 0.05 | 0.05 | 0.03 | . | . | . |
| K-40 (pCi/g) | 17.10 | 18.20 | 16.60 | 15.80 | 16.40 | 12.60 |
| K-40 Counting Error | 1.10 | 1.00 | 0.90 | 1.10 | 1.00 | 0.90 |
| U-235 (pCi/g) | <0.14 | <0.14 | <0.14 | <0.14 | <0.14 | <0.14 |
| U-235 Counting Error | . | . | . | . | . | . |
| U-238 (pCi/g) | <3.00 | <3.00 | <3.00 | <3.00 | <3.00 | <3.00 |
| U-238 Counting Error | . | . | . | . | . | . |
| Σ Uranium | 18.00 | 12.00 | 1.90 | 0.70 | 0.53 | 0.68 |
| TCE | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| PCE | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| PCBs | 0.34 | 0.40 | 0.05 | 0.05 | . | . |
| Ag | <3.30 | <3.10 | <3.10 | <3.10 | <3.20 | <3.10 |
| Al | 17000.00 | 18000.00 | 16000.00 | 16000.00 | 15000.00 | 15000.00 |
| As | <9.40 | <9.00 | <9.00 | <9.00 | <9.20 | <9.00 |
| Ba | 110.00 | 110.00 | 92.00 | 92.00 | 94.00 | 110.00 |
| Be | 0.78 | 0.78 | 0.70 | 0.75 | 0.75 | 0.90 |
| Ca | 2700.00 | 1900.00 | 900.00 | 670.00 | 670.00 | 760.00 |
| Cd | 2.60 | 2.30 | 1.50 | 1.30 | 1.30 | 1.70 |
| Co | 13.00 | 13.00 | 13.00 | 13.00 | 13.00 | 16.00 |
| Cr | 21.00 | 21.00 | 19.00 | 20.00 | 19.00 | 25.00 |
| Cu | 16.00 | 15.00 | 11.00 | 9.00 | 8.40 | 8.30 |
| Fe | 15000.00 | 15000.00 | 14000.00 | 14000.00 | 14000.00 | 18000.00 |
| Ga | <24.00 | <22.00 | <22.00 | <22.00 | <23.00 | <22.00 |
| Hf | 8.10 | 8.50 | 7.70 | 6.90 | 7.30 | 9.50 |
| Li | 22.00 | 22.00 | 14.00 | 16.00 | 13.00 | 13.00 |
| Mg | 2000.00 | 1900.00 | 1600.00 | 1700.00 | 1500.00 | 1400.00 |
| Mn | 650.00 | 720.00 | 650.00 | 780.00 | 840.00 | 1400.00 |
| Mo | <0.94 | <0.90 | <0.90 | <0.90 | <0.92 | <0.90 |
| Na | 150.00 | 160.00 | 140.00 | 57.00 | 57.00 | 51.00 |
| Ni | 28.00 | 29.00 | 17.00 | 13.00 | 12.00 | 13.00 |
| P | 340.00 | 340.00 | 270.00 | 250.00 | 250.00 | 330.00 |
| Pb | 28.00 | 30.00 | 23.00 | 20.00 | 19.00 | 25.00 |
| Sb | <14.00 | <13.00 | <13.00 | <13.00 | <14.00 | <13.00 |
| Se | <19.00 | <18.00 | <18.00 | <18.00 | <18.00 | <18.00 |
| Sr | 7.30 | 7.40 | 5.50 | 5.40 | 5.10 | 4.90 |
| Ti | 83.00 | 93.00 | 73.00 | 100.00 | 88.00 | 87.00 |
| V | 24.00 | 25.00 | 23.00 | 25.00 | 23.00 | 30.00 |
| Zn | 43.00 | 43.00 | 32.00 | 29.00 | 29.00 | 28.00 |
| Zr | 5.10 | 4.80 | 4.70 | 3.90 | 3.40 | |

Results of Analyses of Core C at BCK-1.05. Core Collected April, 1985.
(Units are µg/g, dry weight, except as noted.)

BCK-1.05 CORE C

| CONTAMINANT | 0-3 in. | 3-8 in. | 8-13 in. | 13-18 in. | 18-23 in. |
|---|---|---|---|---|---|
| Σ Alpha (pCi/g) | 20.25 | 2.43 | 18.09 | 14.58 | 14.85 |
| Alpha Counting Error | 15.39 | 9.99 | 14.58 | 14.04 | 14.31 |
| Σ Beta (pCi/g) | 19.71 | 15.12 | 16.74 | 15.66 | 13.77 |
| Beta Counting Error | 8.37 | 7.83 | 7.83 | 8.10 | 8.37 |
| Cs-137 (pCi/g) | 0.66 | 0.49 | 0.07 | <0.05 | <0.05 |
| Cs-137 Counting Error | 0.05 | 0.04 | 0.03 | . | . |
| K-40 (pCi/g) | 17.20 | 17.00 | 16.70 | 16.60 | 17.80 |
| K-40 Counting Error | 0.80 | 0.90 | 0.80 | 0.80 | 0.80 |
| U-235 (pCi/g) | <0.14 | <0.14 | <0.14 | <0.14 | <0.14 |
| U-235 Counting Error | . | . | . | . | . |
| U-238 (pCi/g) | 9.20 | <3.00 | <3.00 | 7.20 | <3.00 |
| U-238 Counting Error | 1.80 | . | . | 2.80 | . |
| Σ Uranium | 11.00 | 4.50 | 0.81 | 0.71 | 0.61 |
| TCE | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| PCE | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| PCBs | 0.33 | 0.15 | 0.05 | 0.05 | . |
| Ag | <3.20 | <3.10 | <3.30 | <3.40 | <3.10 |
| Al | 17000.00 | 16000.00 | 17000.00 | 16000.00 | 16000.00 |
| As | <9.10 | <8.90 | <9.60 | <9.60 | <8.70 |
| Ba | 110.00 | 97.00 | 110.00 | 100.00 | 110.00 |
| Be | 0.75 | 0.75 | 0.75 | 0.71 | 0.78 |
| Ca | 1700.00 | 990.00 | 730.00 | 800.00 | 690.00 |
| Cd | 2.10 | 1.90 | 1.70 | 1.50 | 1.50 |
| Co | 13.00 | 14.00 | 15.00 | 13.00 | 14.00 |
| Cr | 23.00 | 22.00 | 23.00 | 19.00 | 22.00 |
| Cu | 16.00 | 14.00 | 12.00 | 11.00 | 11.00 |
| Fe | 16000.00 | 16000.00 | 16000.00 | 14000.00 | 16000.00 |
| Ga | <23.00 | <22.00 | <24.00 | <24.00 | <22.00 |
| Hf | 6.60 | 6.60 | 7.40 | 7.70 | 6.90 |
| Li | 19.00 | 15.00 | 13.00 | 13.00 | 12.00 |
| Mg | 1900.00 | 1600.00 | 1600.00 | 1500.00 | 1500.00 |
| Mn | 780.00 | 780.00 | 780.00 | 780.00 | 570.00 |
| Mo | <0.91 | <0.89 | <0.96 | <0.96 | <0.87 |
| Na | 180.00 | 170.00 | 170.00 | 170.00 | 140.00 |
| Ni | 24.00 | 20.00 | 15.00 | 14.00 | 14.00 |
| P | 360.00 | 310.00 | 260.00 | 250.00 | 270.00 |
| Pb | 28.00 | 26.00 | 23.00 | 22.00 | 21.00 |
| Sb | <14.00 | <13.00 | <14.00 | <14.00 | <13.00 |
| Se | <18.00 | <18.00 | <19.00 | <19.00 | <17.00 |
| Sr | 6.90 | 5.60 | 5.30 | 5.40 | 5.10 |
| Ti | 86.00 | 82.00 | 83.00 | 84.00 | 83.00 |
| V | 24.00 | 24.00 | 24.00 | 22.00 | 24.00 |
| Zn | 45.00 | 39.00 | 34.00 | 31.00 | 31.00 |
| Zr | 4.50 | 3.90 | 3.80 | 3.60 | 4.2 |

Results of Analyses of Core A at BCK-4.70. Core Collected April, 1985.
(Units are µg/g, dry weight, except as noted.)

BCK-4.70 CORE A

| CONTAMINANT | 0-3 in. | 3-8 in. | 8-13 in. | 13-19 in. |
|---|---|---|---|---|
| Σ Alpha (pCi/g) | 48.60 | 14.58 | 22.14 | 13.23 |
| Alpha Counting Error | 21.60 | 14.04 | 15.93 | 14.31 |
| Σ Beta (pCi/g) | 51.30 | 14.04 | 8.10 | 15.93 |
| Beta Counting Error | 10.80 | 7.83 | 7.29 | 8.91 |
| Cs-137 (pCi/g) | 1.48 | 0.18 | <0.05 | 0.02 |
| Cs-137 Counting Error | 0.09 | 0.03 | . | 0.01 |
| K-40 (pCi/g) | 14.30 | 13.40 | 14.50 | 13.00 |
| K-40 Counting Error | 1.10 | 1.00 | 0.90 | 0.80 |
| U-235 (pCi/g) | 1.80 | <0.14 | <0.14 | <0.14 |
| U-235 Counting Error | 0.30 | . | . | . |
| U-238 (pCi/g) | 57.50 | <3.00 | <3.00 | <3.00 |
| U-238 Counting Error | 7.30 | . | . | . |
| Σ Uranium | 146.00 | 4.94 | 1.14 | 1.45 |
| TCE | <0.01 | <0.01 | <0.01 | <0.01 |
| PCE | <0.01 | <0.01 | 0.02 | <0.01 |
| PCBs | 11.30 | 0.40 | 0.05 | 0.05 |
| Ag | <3.40 | <3.20 | <2.80 | <3.10 |
| Al | 18000.00 | 21000.00 | 22000.00 | 21000.00 |
| As | <9.70 | <9.10 | <8.00 | <9.00 |
| Ba | 130.00 | 180.00 | 180.00 | 150.00 |
| Be | 1.20 | 1.20 | 1.20 | 1.00 |
| Ca | 3400.00 | 1600.00 | 1600.00 | 1400.00 |
| Cd | 4.80 | 2.30 | 2.30 | 2.10 |
| Co | 15.00 | 16.00 | 15.00 | 14.00 |
| Cr | 22.00 | 33.00 | 36.00 | 32.00 |
| Cu | 16.00 | 11.00 | 9.60 | 8.00 |
| Fe | 15000.00 | 20000.00 | 22000.00 | 20000.00 |
| Ga | <24.00 | <23.00 | <20.00 | <22.00 |
| Hf | 9.50 | 9.90 | 9.60 | 8.60 |
| Li | 43.00 | 28.00 | 29.00 | 24.00 |
| Mg | 1600.00 | 1900.00 | 1900.00 | 1900.00 |
| Mn | 840.00 | 650.00 | 580.00 | 540.00 |
| Mo | <0.97 | <0.91 | <0.80 | <0.90 |
| Na | 48.00 | 57.00 | 65.00 | 56.00 |
| Ni | 30.00 | 24.00 | 24.00 | 21.00 |
| P | 450.00 | 250.00 | 220.00 | 170.00 |
| Pb | 32.00 | 25.00 | 24.00 | 21.00 |
| Sb | <15.00 | <14.00 | <12.00 | <13.00 |
| Se | <19.00 | <18.00 | 17.00 | <18.00 |
| Sr | 10.00 | 7.00 | 6.10 | 5.60 |
| Ti | 49.00 | 56.00 | 55.00 | 69.00 |
| V | 20.00 | 30.00 | 31.00 | 28.00 |
| Zn | 58.00 | 48.00 | 48.00 | 41.00 |
| Zr | 4.20 | 5.90 | 4.70 | 4.70 |

Results of Analyses of Core B at BCK-4.70. Core Collected April, 1985.
(Units are µg/g, dry weight, except as noted.)

BCK-4.70 CORE B

| CONTAMINANT | 0-3 in. | 3-8 in. | 8-13 in. | 13-18 in. | 18-23 in. |
|---|---|---|---|---|---|
| Σ Alpha (pCi/g) | 9.45 | 40.50 | 18.90 | 89.10 | 32.40 |
| Alpha Counting Error | 13.50 | 21.60 | 16.20 | 32.40 | 18.90 |
| Σ Beta (pCi/g) | 27.00 | 48.60 | 43.20 | 118.80 | 51.30 |
| Beta Counting Error | 10.80 | 13.50 | 13.50 | 21.60 | 13.50 |
| Cs-137 (pCi/g) | 0.14 | 0.18 | 0.26 | 0.46 | 0.70 |
| Cs-137 Counting Error | 0.02 | 0.04 | 0.05 | 0.05 | 0.07 |
| K-40 (pCi/g) | 12.10 | 11.60 | 11.70 | 13.80 | 12.60 |
| K-40 Counting Error | 0.50 | 0.90 | 0.90 | 1.00 | 1.00 |
| U-235 (pCi/g) | 0.50 | 0.55 | 1.51 | 2.44 | 0.55 |
| U-235 Counting Error | 0.02 | 0.11 | 0.18 | 0.41 | 0.36 |
| U-238 (pCi/g) | 21.30 | 34.80 | 60.40 | 60.90 | 19.80 |
| U-238 Counting Error | 2.80 | 5.00 | 6.50 | 6.60 | 4.00 |
| Σ Uranium | 48.00 | 60.00 | 163.00 | 168.00 | 44.00 |
| TCE | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| PCE | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| PCBs | 1.44 | 1.84 | 8.30 | 132.00 | 18.50 |
| Ag | <3.40 | <2.80 | <3.40 | <3.30 | <3.30 |
| Al | 12000.00 | 12000.00 | 17000.00 | 15000.00 | 12000.00 |
| As | <9.70 | <7.90 | <9.60 | <9.40 | <9.40 |
| Ba | 100.00 | 100.00 | 120.00 | 130.00 | 94.00 |
| Be | 0.78 | 0.88 | 1.20 | 1.30 | 0.73 |
| Ca | 2200.00 | 1700.00 | 1800.00 | 2800.00 | 1300.00 |
| Cd | 4.80 | 5.20 | 6.90 | 6.60 | 3.60 |
| Co | 13.00 | 15.00 | 17.00 | 15.00 | 12.00 |
| Cr | 16.00 | 17.00 | 19.00 | 20.00 | 18.00 |
| Cu | 9.40 | 9.60 | 13.00 | 14.00 | 9.30 |
| Fe | 11000.00 | 12000.00 | 13000.00 | 14000.00 | 1300.00 |
| Ga | <24.00 | <20.00 | <24.00 | <24.00 | <23.00 |
| Hf | 8.10 | 7.70 | 8.90 | 8.30 | 4.30 |
| Li | 25.00 | 34.00 | 46.00 | 28.00 | 20.00 |
| Mg | 1300.00 | 1200.00 | 1400.00 | 1500.00 | 1200.00 |
| Mn | 780.00 | 840.00 | 1000.00 | 980.00 | 390.00 |
| Mo | <0.97 | <0.79 | <0.96 | <0.94 | <0.94 |
| Na | 36.00 | 50.00 | 53.00 | 53.00 | 45.00 |
| Ni | 30.00 | 32.00 | 35.00 | 28.00 | 19.00 |
| P | 220.00 | 200.00 | 240.00 | 270.00 | 210.00 |
| Pb | 15.00 | 18.00 | 20.00 | 24.00 | 21.00 |
| Sb | <15.00 | <12.00 | <14.00 | <14.00 | <14.00 |
| Se | <19.00 | <16.00 | <19.00 | <19.00 | <19.00 |
| Sr | 5.90 | 5.30 | 6.10 | 8.10 | 4.60 |
| Ti | 50.00 | 44.00 | 55.00 | 49.00 | 46.00 |
| V | 16.00 | 15.00 | 18.00 | 19.00 | 17.00 |
| Zn | 31.00 | 34.00 | 44.00 | 48.00 | 34.00 |
| Zr | 3.90 | 3.30 | 3.90 | 4.80 | 4.30 |

Results of Analyses of Core C at BCK-4.70. Collected April, 1985.
(Units are µg/g, dry weight, except as noted.)

BCK-4.70 CORE C

| CONTAMINANT | 0-3 in. | 3-8 in. | 8-13 in. | 13-18 in. | 18-20 in. |
|---|---|---|---|---|---|
| Σ Alpha (pCi/g) | 21.60 | 17.01 | 11.88 | 19.98 | 22.68 |
| Alpha Counting Error | 17.55 | 14.04 | 12.69 | 15.12 | 17.28 |
| Σ Beta (pCi/g) | 23.76 | 16.20 | 12.96 | 17.82 | 12.69 |
| Beta Counting Error | 11.34 | 7.02 | 7.02 | 7.83 | 9.18 |
| Cs-137 (pCi/g) | 0.93 | 0.24 | 0.07 | 0.01 | <0.05 |
| Cs-137 Counting Error | 0.06 | 0.03 | 0.02 | 0.02 | . |
| K-40 (pCi/g) | 13.20 | 12.20 | 10.40 | 11.40 | 9.10 |
| K-40 Counting Error | 0.90 | 0.70 | 0.60 | 0.60 | 0.50 |
| U-235 (pCi/g) | <0.14 | <0.14 | <0.14 | <0.14 | <0.14 |
| U-235 Counting Error | . | . | . | . | . |
| U-238 (pCi/g) | 18.20 | 5.60 | <3.00 | <3.00 | <3.00 |
| U-238 Counting Error | 4.50 | 2.10 | . | . | . |
| Σ Uranium | 39.00 | 4.53 | 2.56 | 2.16 | 0.76 |
| TCE | 0.03 | 0.16 | 0.03 | 0.33 | . |
| PCE | <0.01 | 0.02 | <0.01 | 0.04 | . |
| PCBs | 1.25 | 0.30 | 0.16 | 0.15 | 0.05 |
| Ag | <3.10 | <3.10 | <3.30 | <3.20 | <3.00 |
| Al | 16000.00 | 18000.00 | 18000.00 | 15000.00 | 15000.00 |
| As | <8.90 | <8.90 | <9.40 | <9.20 | <8.40 |
| Ba | 120.00 | 130.00 | 130.00 | 99.00 | 85.00 |
| Be | 1.00 | 1.00 | 1.00 | 0.82 | 0.74 |
| Ca | 3200.00 | 1800.00 | 1500.00 | 1300.00 | 1200.00 |
| Cd | 3.90 | 1.90 | 1.70 | 1.40 | 1.50 |
| Co | 15.00 | 13.00 | 14.00 | 12.00 | 13.00 |
| Cr | 25.00 | 22.00 | 29.00 | 21.00 | 28.00 |
| Cu | 12.00 | 9.10 | 6.10 | 5.00 | 5.10 |
| Fe | 15000.00 | 14000.00 | 15000.00 | 14000.00 | 17000.00 |
| Ga | <22.00 | <22.00 | <23.00 | <23.00 | <21.00 |
| Hf | 8.60 | 6.90 | 6.60 | 3.60 | 4.90 |
| Li | 27.00 | 20.00 | 19.00 | 16.00 | 16.00 |
| Mg | 1600.00 | 1700.00 | 1700.00 | 1400.00 | 1400.00 |
| Mn | 910.00 | 560.00 | 620.00 | 400.00 | 350.00 |
| Mo | <0.89 | <0.89 | <0.94 | <0.92 | <0.84 |
| Na | 63.00 | 68.00 | 64.00 | 56.00 | 66.00 |
| Ni | 29.00 | 19.00 | 18.00 | 15.00 | 14.00 |
| P | 330.00 | 220.00 | 180.00 | 160.00 | 170.00 |
| Pb | 27.00 | 23.00 | 20.00 | 19.00 | 19.00 |
| Sb | <13.00 | <13.00 | <14.00 | <14.00 | <13.00 |
| Se | <18.00 | <18.00 | <19.00 | <18.00 | <17.00 |
| Sr | 7.20 | 5.50 | 5.10 | 4.50 | 4.10 |
| Ti | 51.00 | 55.00 | 60.00 | 60.00 | 58.00 |
| V | 21.00 | 22.00 | 23.00 | 20.00 | 22.00 |
| Zn | 47.00 | 41.00 | 39.00 | 33.00 | 32.00 |
| Zr | 4.70 | 4.00 | 4.10 | 4.20 | 3.30 |

Results of Analyses of Core A at BCK-9.91. Core Collected April, 1985.
(Units are µg/g, dry weight, except as noted.)

| | BCK-9.91 CORE A | | | |
|---|---|---|---|---|
| CONTAMINANT | 0-3 in. | 3-6 in. | 6-9 in. | 9-13 in. |
| Σ Alpha (pCi/g) | 37.80 | 2.70 | . | 3.24 |
| Alpha Counting Error | 21.60 | 10.26 | . | 16.74 |
| Σ Beta (pCi/g) | 21.87 | 16.47 | . | 22.95 |
| Beta Counting Error | 10.26 | 8.37 | . | 12.96 |
| Cs-137 (pCi/g) | 1.05 | 0.20 | <0.05 | 0.06 |
| Cs-137 Counting Error | 0.06 | 0.04 | . | 0.02 |
| K-40 (pCi/g) | 11.40 | 10.50 | 9.90 | 13.40 |
| K-40 Counting Error | 0.90 | 0.80 | 0.80 | 0.80 |
| U-235 (pCi/g) | <0.14 | <0.14 | <0.14 | <0.14 |
| U-235 Counting Error | . | . | . | . |
| U-238 (pCi/g) | 13.80 | <3.00 | <3.00 | <3.00 |
| U-238 Counting Error | 6.80 | . | . | . |
| Σ Uranium | 50.00 | 5.68 | . | 1.13 |
| TCE | <0.01 | <0.01 | . | <0.01 |
| PCE | <0.01 | <0.01 | . | <0.01 |
| PCBs | 1.20 | 0.05 | . | . |
| Ag | <3.10 | <2.90 | <3.00 | <2.40 |
| Al | 20000.00 | 21000.00 | 21000.00 | 21000.00 |
| As | <8.90 | <8.20 | <8.60 | <6.90 |
| Ba | 130.00 | 130.00 | 130.00 | 160.00 |
| Be | 0.87 | 0.86 | 0.82 | 1.10 |
| Ca | 1700.00 | 1000.00 | 810.00 | 850.00 |
| Cd | 3.60 | 2.30 | 1.80 | 3.20 |
| Co | 19.00 | 20.00 | 18.00 | 28.00 |
| Cr | 32.00 | 29.00 | 27.00 | 62.00 |
| Cu | 16.00 | 11.00 | 9.10 | 13.00 |
| Fe | 20000.00 | 21000.00 | 18000.00 | 37000.00 |
| Ga | <22.00 | <21.00 | <22.00 | <17.00 |
| Hf | 9.60 | 9.90 | 9.10 | . |
| Li | 24.00 | 17.00 | 15.00 | 17.00 |
| Mg | 1500.00 | 1400.00 | 1500.00 | . |
| Mn | 1200.00 | 1400.00 | 1400.00 | 2100.00 |
| Mo | <0.89 | <0.82 | <0.86 | . |
| Na | 81.00 | 78.00 | 81.00 | . |
| Ni | 25.00 | 18.00 | 17.00 | . |
| P | 300.00 | 290.00 | 260.00 | 400.00 |
| Pb | 39.00 | 30.00 | 26.00 | . |
| Sb | <13.00 | <12.00 | <13.00 | . |
| Se | 19.00 | 17.00 | <17.00 | 33.00 |
| Sr | 8.60 | 6.30 | 5.60 | . |
| Ti | 90.00 | 83.00 | 86.00 | . |
| V | 28.00 | 29.00 | 27.00 | . |
| Zn | 53.00 | 36.00 | 32.00 | 42.00 |
| Zr | 6.90 | 6.50 | 5.00 | 8.30 |

Results of Analyses of Core B at BCK-9.91. Core Collected April, 1985.
(Units are µg/g, dry weight, except as noted.)

BCK-9.91 CORE B

| CONTAMINANT | 0-3 in. | 3-6 in. | 6-9 in. | 9-15 in. | 15-20 in. |
|---|---|---|---|---|---|
| Σ Alpha (pCi/g) | 17.55 | 7.83 | 10.53 | 18.90 | 12.42 |
| Alpha Counting Error | 16.74 | 14.04 | 12.69 | 15.39 | 13.23 |
| Σ Beta (pCi/g) | 27.00 | 14.85 | 14.04 | 10.53 | 11.88 |
| Beta Counting Error | 10.80 | 10.53 | 7.83 | 8.10 | 7.56 |
| Cs-137 (pCi/g) | 1.25 | 0.46 | 0.06 | <0.05 | <0.05 |
| Cs-137 Counting Error | 0.08 | 0.05 | 0.03 | . | . |
| K-40 (pCi/g) | 9.30 | 8.60 | 8.10 | 8.70 | 11.20 |
| K-40 Counting Error | 0.80 | 0.70 | 0.80 | 0.70 | 0.90 |
| U-235 (pCi/g) | <0.14 | <0.14 | <0.14 | <0.14 | <0.14 |
| U-235 Counting Error | . | . | . | . | . |
| U-238 (pCi/g) | 17.90 | 3.60 | <3.00 | <3.00 | <3.00 |
| U-238 Counting Error | 3.60 | 2.20 | . | . | . |
| Σ Uranium | 48.00 | 8.00 | 2.50 | 0.62 | 0.51 |
| TCE | 0.06 | <0.01 | <0.01 | 0.08 | <0.01 |
| PCE | <0.01 | <0.01 | <0.01 | 0.06 | <0.01 |
| PCBs | 0.87 | 0.05 | 0.05 | . | . |
| Ag | <2.20 | <3.00 | <3.20 | <2.90 | <3.20 |
| Al | 14000.00 | 14000.00 | 15000.00 | 15000.00 | 14000.00 |
| As | <6.30 | <8.60 | <9.10 | <8.30 | <9.10 |
| Ba | 110.00 | 95.00 | 94.00 | 100.00 | 110.00 |
| Be | 0.72 | 0.68 | 0.72 | 0.74 | 0.79 |
| Ca | 3000.00 | 1500.00 | 1100.00 | 980.00 | 790.00 |
| Cd | 3.70 | 1.90 | 1.60 | 1.40 | 1.40 |
| Co | 16.00 | 16.00 | 17.00 | 17.00 | 17.00 |
| Cr | 19.00 | 19.00 | 20.00 | 21.00 | 19.00 |
| Cu | 14.00 | 9.80 | 8.50 | 7.90 | 8.10 |
| Fe | 14000.00 | 14000.00 | 14000.00 | 15000.00 | 15000.00 |
| Ga | <16.00 | <21.00 | <23.00 | <21.00 | <23.00 |
| Hf | 7.00 | 6.20 | 6.30 | 6.60 | 6.50 |
| Li | 19.00 | 13.00 | 12.00 | 12.00 | 11.00 |
| Mg | 1200.00 | 1200.00 | 1200.00 | 1200.00 | 1200.00 |
| Mn | 840.00 | 840.00 | 910.00 | 910.00 | 980.00 |
| Mo | <0.63 | <0.86 | <0.91 | <0.83 | <0.91 |
| Na | 62.00 | 74.00 | 79.00 | 78.00 | 86.00 |
| Ni | 23.00 | 17.00 | 15.00 | 15.00 | 16.00 |
| P | 310.00 | 240.00 | 210.00 | 200.00 | 200.00 |
| Pb | 32.00 | 34.00 | 24.00 | 23.00 | 23.00 |
| Sb | <9.50 | <13.00 | <14.00 | <12.00 | <14.00 |
| Se | <13.00 | <17.00 | <18.00 | <17.00 | <18.00 |
| Sr | 7.20 | 5.50 | 4.90 | 4.60 | 4.20 |
| Ti | 52.00 | 65.00 | 68.00 | 68.00 | 64.00 |
| V | 19.00 | 20.00 | 20.00 | 21.00 | 20.00 |
| Zn | 45.00 | 34.00 | 30.00 | 27.00 | 27.00 |
| Zr | 5.10 | 3.70 | 3.30 | 3.50 | 3.30 |

Results of Analyses of Core C at BCK-9.91. Core Collected April, 1985.
(Units are µg/g, dry weight, execpt as noted.)

| BCK-9.91 CORE C | | | | |
|---|---|---|---|---|
| CONTAMINANT | 0-3 in. | 3-6 in. | 6-9 in. | 9-14 in. |
| Σ Alpha (pCi/g) | 12.96 | 6.48 | 35.10 | 8.37 |
| Alpha Counting Error | 14.04 | 11.34 | 18.90 | 12.15 |
| Σ Beta (pCi/g) | 20.52 | 12.42 | 7.83 | 12.15 |
| Beta Counting Error | 8.91 | 7.56 | 7.83 | 7.56 |
| Cs-137 (pCi/g) | 1.33 | 0.16 | <0.05 | <0.05 |
| Cs-137 Counting Error | 0.07 | 0.03 | . | . |
| K-40 (pCi/g) | 8.80 | 8.30 | 9.00 | 8.60 |
| K-40 Counting Error | 0.70 | 0.50 | 0.60 | 0.50 |
| U-235 (pCi/g) | 0.40 | <0.14 | <0.14 | <0.14 |
| U-235 Counting Error | 0.10 | . | . | . |
| U-238 (pCi/g) | 9.30 | <3.00 | <3.00 | <3.00 |
| U-238 Counting Error | 2.50 | . | . | . |
| Σ Uranium | 25.00 | 1.47 | 0.57 | 0.55 |
| TCE | <0.01 | <0.01 | <0.01 | <0.01 |
| PCE | <0.01 | <0.01 | <0.01 | <0.01 |
| PCBs | 0.02 | 0.05 | 0.05 | . |
| Ag | <3.00 | <3.00 | <3.20 | <3.30 |
| Al | 15000.00 | 14000.00 | 15000.00 | 15000.00 |
| As | <8.60 | <8.70 | <9.20 | <9.40 |
| Ba | 100.00 | 89.00 | 88.00 | 96.00 |
| Be | 0.69 | 0.69 | 0.76 | 0.77 |
| Ca | 2300.00 | 920.00 | 730.00 | 730.00 |
| Cd | 2.20 | 1.40 | 1.50 | 1.50 |
| Co | 15.00 | 15.00 | 17.00 | 17.00 |
| Cr | 19.00 | 18.00 | 19.00 | 21.00 |
| Cu | 12.00 | 8.90 | 8.10 | 11.00 |
| Fe | 13000.00 | 13000.00 | 14000.00 | 15000.00 |
| Ga | <22.00 | <22.00 | <23.00 | <24.00 |
| Hf | 5.80 | 5.40 | 6.10 | 5.90 |
| Li | 16.00 | 10.00 | 10.00 | 12.00 |
| Mg | 1300.00 | 1100.00 | 1100.00 | 1200.00 |
| Mn | 780.00 | 840.00 | 980.00 | 910.00 |
| Mo | <0.86 | <0.87 | <0.92 | <0.94 |
| Na | 91.00 | 88.00 | 100.00 | 170.00 |
| Ni | 19.00 | 14.00 | 15.00 | 16.00 |
| P | 320.00 | 220.00 | 220.00 | 220.00 |
| Pb | 32.00 | 23.00 | 25.00 | 25.00 |
| Sb | <13.00 | <13.00 | <14.00 | <14.00 |
| Se | <17.00 | <17.00 | <18.00 | <19.00 |
| Sr | 6.70 | 4.10 | 3.80 | 3.70 |
| Ti | 63.00 | 66.00 | 66.00 | 66.00 |
| V | 20.00 | 20.00 | 20.00 | 21.00 |
| Zn | 44.00 | 31.00 | 30.00 | 32.00 |
| Zr | 3.40 | 2.70 | <2.80 | 2.90 |

Results of Analyses of Core A at BCK-11.09. Core Collected April, 1985.
(Units are µg/g, dry weight, except as noted.)

BCK-11.09 CORE A

| CONTAMINANT | 0-3 in. | 3-6 in. | 6-12 in. | 12-19 in. |
|---|---|---|---|---|
| Σ Alpha (pCi/g) | 62.10 | 11.07 | 8.64 | 6.75 |
| Alpha Counting Error | 24.30 | 13.23 | 7.56 | 11.88 |
| Σ Beta (pCi/g) | 35.10 | 20.79 | 15.66 | 13.77 |
| Beta Counting Error | 10.80 | 9.18 | 8.10 | 8.10 |
| Cs-137 (pCi/g) | 1.05 | 0.53 | <0.05 | <0.05 |
| Cs-137 Counting Error | 0.07 | 0.05 | . | . |
| K-40 (pCi/g) | 11.80 | 9.10 | 10.40 | 10.80 |
| K-40 Counting Error | 1.10 | 0.80 | 0.80 | 0.70 |
| U-235 (pCi/g) | 0.70 | 0.40 | <0.14 | <0.14 |
| U-235 Counting Error | 0.20 | 0.20 | . | . |
| U-238 (pCi/g) | 28.60 | <3.00 | <3.00 | <3.00 |
| U-238 Counting Error | 5.00 | . | . | . |
| Σ Uranium | 62.00 | 12.40 | 1.20 | 1.00 |
| TCE | 0.19 | 0.41 | 0.45 | <0.01 |
| PCE | 0.03 | 0.05 | 0.05 | <0.01 |
| PCBs | 0.20 | 0.05 | 0.05 | . |
| Ag | <3.40 | <3.20 | <3.10 | <3.00 |
| Al | 16000.00 | 12000.00 | 14000.00 | 19000.00 |
| As | <9.60 | <9.20 | <8.80 | <8.60 |
| Ba | 120.00 | 96.00 | 120.00 | 200.00 |
| Be | 0.76 | 0.68 | 0.78 | 1.20 |
| Ca | 2200.00 | 870.00 | 690.00 | 1200.00 |
| Cd | 3.00 | 1.70 | 1.50 | 1.90 |
| Co | 15.00 | 14.00 | 16.00 | 19.00 |
| Cr | 22.00 | 19.00 | 21.00 | 26.00 |
| Cu | 23.00 | 9.70 | 6.60 | 8.20 |
| Fe | 17000.00 | 15000.00 | 15000.00 | 18000.00 |
| Ga | <24.00 | <23.00 | <22.00 | <21.00 |
| Hf | 7.70 | 6.90 | 8.10 | 9.60 |
| Li | 24.00 | 14.00 | 16.00 | 23.00 |
| Mg | 1500.00 | 1000.00 | 1200.00 | 1600.00 |
| Mn | 610.00 | 720.00 | 840.00 | 1200.00 |
| Mo | <0.96 | <0.92 | <0.88 | <0.86 |
| Na | 58.00 | 34.00 | 42.00 | 53.00 |
| Ni | 23.00 | 15.00 | 15.00 | 24.00 |
| P | 360.00 | 240.00 | 200.00 | 250.00 |
| Pb | 33.00 | 21.00 | 19.00 | 25.00 |
| Sb | <14.00 | <14.00 | <13.00 | <13.00 |
| Se | <19.00 | <18.00 | <18.00 | 18.00 |
| Sr | 9.60 | 5.20 | 4.80 | 7.30 |
| Ti | 66.00 | 54.00 | 58.00 | 60.00 |
| V | 22.00 | 18.00 | 19.00 | 22.00 |
| Zn | 54.00 | 25.00 | 20.00 | 26.00 |
| Zr | 5.00 | 3.00 | 3.30 | 4.70 |

Results of Analyses of Core B at BCK-11.09. Core Collected April, 1985.
(Units are µg/g, dry weight, except as noted.)

BCK-11.09 CORE B

| CONTAMINANT | 0-3 in. | 3-8 in. | 8-13 in. | 13-18 in. | 18-23 in. |
|---|---|---|---|---|---|
| Σ Alpha (pCi/g) | 45.90 | 21.60 | 20.79 | 6.75 | 12.69 |
| Alpha Counting Error | 24.30 | 16.20 | 15.66 | 11.88 | 13.77 |
| Σ Beta (pCi/g) | 56.70 | 17.28 | 9.18 | 15.93 | 16.74 |
| Beta Counting Error | 16.20 | 8.91 | 7.56 | 8.64 | 8.37 |
| Cs-137 (pCi/g) | 1.06 | 0.57 | <0.05 | <0.05 | 0.05 |
| Cs-137 Counting Error | 0.06 | 0.04 | . | . | 0.02 |
| K-40 (pCi/g) | 9.50 | 7.40 | 7.40 | 7.20 | 9.60 |
| K-40 Counting Error | 0.70 | 0.60 | 0.50 | 0.80 | 0.60 |
| U-235 (pCi/g) | 0.97 | <0.14 | <0.14 | <0.14 | <0.14 |
| U-235 Counting Error | 0.39 | . | . | . | . |
| U-238 (pCi/g) | 36.10 | 16.90 | <3.00 | 0.80 | <3.00 |
| U-238 Counting Error | 4.10 | 3.70 | . | 0.80 | . |
| Σ Uranium | 104.00 | 31.00 | 1.51 | 1.31 | 1.38 |
| TCE | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| PCE | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| PCBs | 0.28 | 0.05 | 0.05 | . | . |
| Ag | <3.20 | <3.20 | <3.40 | <3.00 | <3.00 |
| Al | 15000.00 | 14000.00 | 15000.00 | 17000.00 | 20000.00 |
| As | <9.20 | <9.10 | <9.60 | <8.50 | <8.50 |
| Ba | 130.00 | 110.00 | 120.00 | 160.00 | 170.00 |
| Be | 0.84 | 0.77 | 0.87 | 1.10 | 1.20 |
| Ca | 2600.00 | 1200.00 | 810.00 | 1000.00 | 1200.00 |
| Cd | 3.80 | 2.20 | 1.40 | 1.60 | 1.90 |
| Co | 15.00 | 15.00 | 14.00 | 15.00 | 18.00 |
| Cr | 20.00 | 21.00 | 23.00 | 23.00 | 28.00 |
| Cu | 32.00 | 17.00 | 10.00 | 17.00 | 28.00 |
| Fe | 15000.00 | 14000.00 | 13000.00 | 15000.00 | 19000.00 |
| Ga | <23.00 | <23.00 | <24.00 | <21.00 | <21.00 |
| Hf | 7.70 | 7.50 | 7.20 | 8.60 | 11.00 |
| Li | 23.00 | 17.00 | 16.00 | 19.00 | 23.00 |
| Mg | 1300.00 | 1000.00 | 1100.00 | 1300.00 | 1600.00 |
| Mn | 720.00 | 720.00 | 780.00 | 980.00 | 1200.00 |
| Mo | <0.92 | <0.91 | <0.96 | <0.85 | <0.85 |
| Na | 45.00 | 33.00 | 43.00 | 49.00 | 62.00 |
| Ni | 26.00 | 18.00 | 19.00 | 18.00 | 21.00 |
| P | 360.00 | 270.00 | 230.00 | 240.00 | 270.00 |
| Pb | 43.00 | 30.00 | 21.00 | 21.00 | 23.00 |
| Sb | <14.00 | <14.00 | <14.00 | <13.00 | <13.00 |
| Se | <18.00 | <18.00 | <19.00 | <17.00 | <17.00 |
| Sr | 10.00 | 6.60 | 5.30 | 6.00 | 6.70 |
| Ti | 61.00 | 62.00 | 63.00 | 59.00 | 69.00 |
| V | 21.00 | 21.00 | 20.00 | 21.00 | 26.00 |
| Zn | 76.00 | 40.00 | 25.00 | 25.00 | 29.00 |
| Zr | 5.10 | 3.60 | 2.90 | 3.60 | 4.60 |

Results of Analyses of Core C at BCK-11.09. Core Collected April, 1985.
(Units are µg/g, dry weight, except as noted.)

| BCK-11.09 CORE C | | | | |
|---|---|---|---|---|
| CONTAMINANT | 0-3 in. | 3-8 in. | 8-13 in. | 13-18 in. |
| Σ Alpha (pCi/g) | 102.60 | 19.71 | 9.72 | 15.66 |
| Alpha Counting Error | 35.10 | 15.93 | 14.04 | 15.12 |
| Σ Beta (pCi/g) | 116.10 | 19.98 | 10.53 | 8.64 |
| Beta Counting Error | 21.60 | 9.45 | 9.72 | 8.64 |
| Cs-137 (pCi/g) | 1.75 | 0.43 | <0.05 | <0.05 |
| Cs-137 Counting Error | 0.09 | 0.04 | . | . |
| K-40 (pCi/g) | 10.80 | 10.50 | 10.50 | 13.60 |
| K-40 Counting Error | 0.90 | 0.70 | 0.70 | 0.90 |
| U-235 (pCi/g) | 2.80 | 0.90 | <0.14 | <0.14 |
| U-235 Counting Error | 0.30 | 0.50 | . | . |
| U-238 (pCi/g) | 92.70 | 13.20 | <3.00 | 1.80 |
| U-238 Counting Error | 8.00 | 2.80 | . | 1.60 |
| Σ Uranium | 241.00 | 38.00 | 2.88 | 1.62 |
| TCE | <0.01 | <0.01 | <0.01 | <0.01 |
| PCE | <0.01 | <0.01 | <0.01 | <0.01 |
| PCBs | 0.54 | 0.05 | 0.05 | . |
| Ag | <3.10 | <3.20 | <2.50 | <3.00 |
| Al | 20000.00 | 19000.00 | 17000.00 | 22000.00 |
| As | <8.70 | <9.10 | <7.10 | <8.70 |
| Ba | 140.00 | 150.00 | 190.00 | 270.00 |
| Be | 1.10 | 1.10 | 1.20 | 1.40 |
| Ca | 3300.00 | 1300.00 | 950.00 | 1300.00 |
| Cd | 6.20 | 3.00 | 2.60 | 3.20 |
| Co | 18.00 | 26.00 | 29.00 | 29.00 |
| Cr | 26.00 | 35.00 | 36.00 | 43.00 |
| Cu | 51.00 | 18.00 | 9.20 | 12.00 |
| Fe | 18000.00 | 24000.00 | 28000.00 | 35000.00 |
| Ga | <22.00 | <23.00 | <18.00 | <22.00 |
| Hf | 11.00 | 13.00 | 13.00 | 15.00 |
| Li | 36.00 | 24.00 | 21.00 | 29.00 |
| Mg | 1800.00 | 1500.00 | 1400.00 | 1900.00 |
| Mn | 780.00 | 1600.00 | 1800.00 | 1800.00 |
| Mo | <0.87 | <0.91 | <0.71 | <0.87 |
| Na | 64.00 | 58.00 | 48.00 | 71.00 |
| Ni | 43.00 | 25.00 | 21.00 | 31.00 |
| P | 440.00 | 280.00 | 240.00 | 270.00 |
| Pb | 57.00 | 37.00 | 33.00 | 34.00 |
| Sb | <13.00 | 15.00 | 14.00 | 14.00 |
| Se | <17.00 | 20.00 | 22.00 | 28.00 |
| Sr | 13.00 | 7.70 | 6.00 | 7.50 |
| Ti | 60.00 | 74.00 | 56.00 | 60.00 |
| V | 24.00 | 31.00 | 29.00 | 34.00 |
| Zn | 120.00 | 43.00 | 27.00 | 34.00 |
| Zr | 6.80 | 6.70 | 4.30 | 4.40 |

Results of Analyses of Core A at BCK-12.10. Core Collected April, 1985.
(Units are µg/g, dry weight, except as noted.)

| | BCK-12.10 CORE A | | | |
|---|---|---|---|---|
| CONTAMINANT | 0-3 in. | 3-9 in. | 9-15 in. | 15-23 in. |
| Σ Alpha (pCi/g) | 62.10 | 20.79 | 22.14 | 19.17 |
| Alpha Counting Error | 2.70 | 18.90 | 16.20 | 16.20 |
| Σ Beta (pCi/g) | 43.20 | 15.66 | 10.26 | 15.12 |
| Beta Counting Error | 16.20 | 12.42 | 7.83 | 9.18 |
| Cs-137 (pCi/g) | 2.30 | 0.11 | <0.05 | <0.05 |
| Cs-137 Counting Error | 0.10 | 0.03 | . | . |
| K-40 (pCi/g) | 8.50 | 5.80 | 5.70 | 6.70 |
| K-40 Counting Error | 1.20 | 0.60 | 0.50 | 0.60 |
| U-235 (pCi/g) | <0.14 | <0.14 | <0.14 | <0.14 |
| U-235 Counting Error | . | . | . | . |
| U-238 (pCi/g) | 15.30 | 10.40 | <3.00 | 4.50 |
| U-238 Counting Error | 6.60 | 2.10 | . | 1.90 |
| Σ Uranium | 42.00 | 39.00 | 13.00 | 10.00 |
| TCE | <0.01 | <0.01 | <0.01 | <0.01 |
| PCE | <0.01 | <0.01 | <0.01 | <0.01 |
| PCBs | 0.28 | 0.05 | 0.05 | . |
| Ag | <2.50 | <2.50 | <2.50 | <2.50 |
| Al | 23000.00 | 10000.00 | 11000.00 | 13000.00 |
| As | <5.00 | <5.00 | <5.00 | <5.00 |
| Ba | 95.00 | 59.00 | 73.00 | 73.00 |
| Be | 2.20 | 0.93 | 0.87 | 0.66 |
| Ca | 8500.00 | 920.00 | 1200.00 | 1000.00 |
| Cd | 12.00 | 1.70 | 3.10 | 0.66 |
| Co | 37.00 | 9.80 | 14.00 | 9.80 |
| Cr | 19.00 | 14.00 | 13.00 | 15.00 |
| Cu | 33.00 | 4.00 | 6.50 | 4.50 |
| Fe | 15000.00 | 13000.00 | 15000.00 | 14000.00 |
| Ga | <15.00 | <15.00 | <15.00 | <15.00 |
| Hf | . | . | . | . |
| Li | 46.00 | <10.00 | 12.00 | 14.00 |
| Mg | 1600.00 | 620.00 | 650.00 | 910.00 |
| Mn | 1300.00 | 480.00 | 1100.00 | 220.00 |
| Mo | 2.10 | <2.00 | <2.00 | <2.00 |
| Na | 110.00 | 38.00 | 40.00 | 51.00 |
| Ni | 63.00 | 12.00 | 14.00 | 10.00 |
| P | 490.00 | 190.00 | 210.00 | 140.00 |
| Pb | 66.00 | 22.00 | 28.00 | 24.00 |
| Sb | 12.00 | 11.00 | 12.00 | <9.90 |
| Se | <10.00 | <10.00 | <10.00 | <10.00 |
| Sr | 18.00 | 3.70 | 4.30 | 4.40 |
| Ti | 71.00 | 48.00 | 51.00 | 62.00 |
| V | 17.00 | 13.00 | 15.00 | 15.00 |
| Zn | 86.00 | 20.00 | 22.00 | 21.00 |
| Zr | 5.30 | 2.10 | 3.00 | 3.00 |

Results of Analyses of Core B at BCK-12.10. Core Collected April, 1985.
(Units are µg/g, dry weight, except as noted.)

| | BCK-12.10 CORE B | | | |
|---|---|---|---|---|
| CONTAMINANT | 0-3 in. | 3-9 in. | 9-15 in. | 15-21 in. |
| Σ Alpha (pCi/g) | 54.00 | 15.93 | 2.43 | 32.40 |
| Alpha Counting Error | 27.00 | 17.55 | 10.80 | 24.30 |
| Σ Beta (pCi/g) | 27.00 | 12.69 | 15.12 | 7.56 |
| Beta Counting Error | 13.50 | 12.15 | 8.64 | 13.23 |
| Cs-137 (pCi/g) | 0.91 | 0.18 | <0.05 | <0.05 |
| Cs-137 Counting Error | 0.07 | 0.04 | . | . |
| K-40 (pCi/g) | 5.20 | 5.30 | 5.20 | 4.90 |
| K-40 Counting Error | 0.60 | 0.70 | 0.60 | 0.60 |
| U-235 (pCi/g) | <0.14 | <0.14 | <0.14 | <0.14 |
| U-235 Counting Error | . | . | . | . |
| U-238 (pCi/g) | <3.00 | 2.30 | <3.00 | <3.00 |
| U-238 Counting Error | . | 4.10 | . | . |
| Σ Uranium | 180.00 | 16.00 | 2.20 | 3.70 |
| TCE | <0.01 | <0.01 | <0.01 | <0.01 |
| PCE | <0.01 | <0.01 | <0.01 | <0.01 |
| PCBs | 0.05 | 0.05 | 0.05 | . |
| Ag | <2.50 | <2.50 | <2.50 | <2.50 |
| Al | 14000.00 | 12000.00 | 13000.00 | 12000.00 |
| As | <5.00 | <5.00 | <5.00 | <5.00 |
| Ba | 150.00 | 120.00 | 140.00 | 86.00 |
| Be | 1.10 | 1.00 | 1.40 | 1.00 |
| Ca | 1300.00 | 1000.00 | 930.00 | 1000.00 |
| Cd | 1.90 | 0.82 | 0.40 | 0.29 |
| Co | 19.00 | 24.00 | 25.00 | 14.00 |
| Cr | 20.00 | 21.00 | 73.00 | 17.00 |
| Cu | 12.00 | 7.60 | 7.30 | 4.60 |
| Fe | 22000.00 | 29000.00 | 39000.00 | 16000.00 |
| Ga | <15.00 | <15.00 | <15.00 | <15.00 |
| Hf | . | . | . | . |
| Li | 16.00 | 11.00 | 11.00 | 11.00 |
| Mg | 890.00 | 670.00 | 600.00 | 750.00 |
| Mn | 1900.00 | 2000.00 | 2000.00 | 1300.00 |
| Mo | <2.00 | <2.00 | <2.00 | <2.00 |
| Na | 35.00 | 35.00 | 35.00 | 55.00 |
| Ni | 18.00 | 15.00 | 17.00 | 11.00 |
| P | 310.00 | 270.00 | 420.00 | 220.00 |
| Pb | 48.00 | 40.00 | 37.00 | 28.00 |
| Sb | 13.00 | 14.00 | 16.00 | 12.00 |
| Se | <10.00 | <10.00 | <10.00 | <10.00 |
| Sr | 8.30 | 5.40 | 4.00 | 4.30 |
| Ti | 59.00 | 66.00 | 79.00 | 50.00 |
| V | 21.00 | 21.00 | 48.00 | 15.00 |
| Zn | 39.00 | 26.00 | 23.00 | 20.00 |
| Zr | 4.70 | 5.50 | 10.00 | 2.80 |

Results of Analyses of Core C at BCK-12.10. Core Collected April, 1985.
(Units are µg/g, dry weight, except as noted.)

| | BCK-12.10 CORE C | | | |
|---|---|---|---|---|
| CONTAMINANT | 0-3 in. | 3-9 in. | 9-15 in. | 15-18 in. |
| Σ Alpha (pCi/g) | 35.10 | 25.65 | 14.85 | 5.40 |
| Alpha Counting Error | 2.70 | 16.74 | 14.85 | 14.04 |
| Σ Beta (pCi/g) | 22.14 | 12.15 | 6.48 | 8.37 |
| Beta Counting Error | 18.09 | 7.83 | 8.37 | 11.34 |
| Cs-137 (pCi/g) | 0.26 | 0.51 | 0.02 | <0.05 |
| Cs-137 Counting Error | 0.04 | 0.04 | 0.02 | . |
| K-40 (pCi/g) | 18.10 | 7.10 | 6.70 | 6.90 |
| K-40 Counting Error | 0.90 | 0.60 | 0.50 | 0.50 |
| U-235 (pCi/g) | <0.14 | <0.14 | <0.14 | <0.14 |
| U-235 Counting Error | . | . | . | . |
| U-238 (pCi/g) | <3.00 | 6.20 | 4.00 | <3.00 |
| U-238 Counting Error | . | 1.90 | 1.50 | . |
| Σ Uranium | 13.00 | 4.40 | 6.20 | 24.00 |
| TCE | <0.01 | <0.01 | <0.01 | <0.01 |
| PCE | <0.01 | <0.01 | <0.01 | <0.01 |
| PCBs | 4.17 | . | 0.05 | 0.05 |
| Ag | <2.50 | <2.50 | <2.50 | <2.50 |
| Al | 39000.00 | 19000.00 | 16000.00 | 15000.00 |
| As | <5.00 | <5.00 | <5.00 | <5.00 |
| Ba | 140.00 | 120.00 | 120.00 | 120.00 |
| Be | 1.90 | 1.50 | 1.30 | 1.20 |
| Ca | 14000.00 | 2400.00 | 1400.00 | 1300.00 |
| Cd | 0.90 | 1.30 | 0.25 | <0.24 |
| Co | 19.00 | 18.00 | 16.00 | 15.00 |
| Cr | 36.00 | 18.00 | 16.00 | 16.00 |
| Cu | 41.00 | 15.00 | 8.40 | 6.30 |
| Fe | 35000.00 | 17000.00 | 19000.00 | 18000.00 |
| Ga | <15.00 | <14.00 | <15.00 | <15.00 |
| Hf | . | . | . | . |
| Li | 58.00 | 19.00 | 14.00 | 13.00 |
| Mg | 4100.00 | 1200.00 | 870.00 | 880.00 |
| Mn | 910.00 | 1800.00 | 1800.00 | 1400.00 |
| Mo | <2.00 | <2.00 | <2.00 | <2.00 |
| Na | 98.00 | 56.00 | 47.00 | 51.00 |
| Ni | 39.00 | 23.00 | 16.00 | 14.00 |
| P | 480.00 | 360.00 | 300.00 | 270.00 |
| Pb | 90.00 | 58.00 | 40.00 | 33.00 |
| Sb | 17.00 | 12.00 | 11.00 | 11.00 |
| Se | <10.00 | <10.00 | <10.00 | <10.00 |
| Sr | 16.00 | 7.60 | 5.40 | 5.30 |
| Ti | 44.00 | 50.00 | 41.00 | 49.00 |
| V | 41.00 | 24.00 | 19.00 | 18.00 |
| Zn | 130.00 | 59.00 | 35.00 | 25.00 |
| Zr | 4.70 | 2.10 | 1.10 | 2.20 |

# APPENDIX J. RESULTS OF SEDIMENT AND FLOODPLAIN SOIL SAMPLING AND ANALYSIS AT BCK-9.42

MARTIN MARIETTA

# Internal Correspondence

MARTIN MARIETTA ENERGY SYSTEMS, INC.

November 18, 1985

C. Kimbrough

Sampling at BCK 9.42 for bridge repair

As per our agreement, I collected soil and sediment samples at BCK 9.42 (bridge crossing near SS5 spring) on November 14, 1985. The locations of samples and field descriptions are given in the attached sketch and table. All samples are composites, either of cores or surface grabs. Composites were homogenized in a stainless steel tray in the field and placed in large-mouth glass jars with Al-foil lined lids. Samples C1 and C2 were sediment from the culverts and were field-sieved through a 2 mm stainless steel screen. On return to the laboratory, one-half the contents of each jar was dried in a forced-air oven at 50 °C overnight and then crushed in a mullite mortar and pestle. Material coarser than 2 mm was screened out of samples C3, C4, C5, and C6 using a stainless steel sieve. Sample aliquots of the dried material have been submitted for the following analyses:

Gross alpha and gross beta activity
Gamma-ray spectrometry
PCBs
Total uranium
ICP metals

Ralph R. Turner

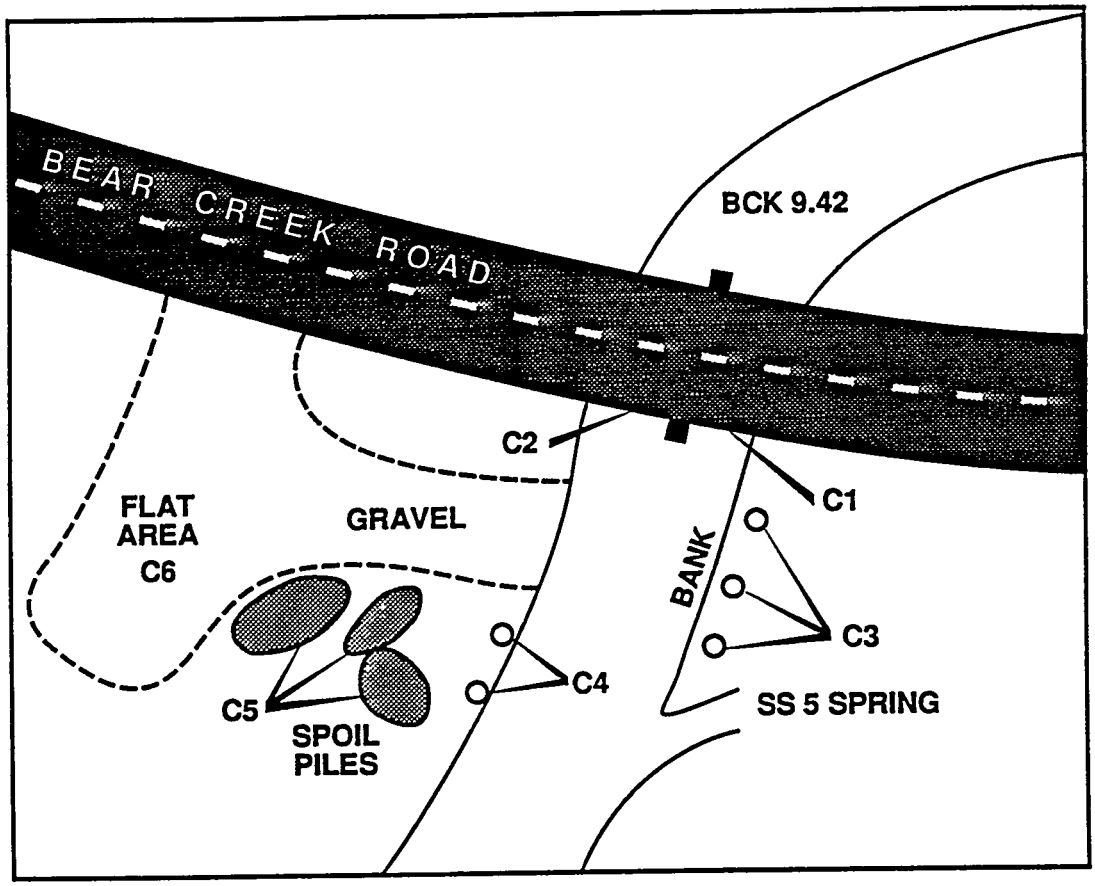
R. R. Turner, 1505, MS-2, ORNL (4-7856)

RRT/cf

Attachment

cc: N. H. Cutshall
J. M. Loar

ORNL-DWG 88M-16792




| Sample ID | Location | Description | Remarks |
|---|---|---|---|
| C1 | East culvert | Clayey sandy gravel | Field sieved to remove > 2 mm |
| C2 | West culvert | Clayey sandy gravel | Field sieved to remove > 2 mm |
| C3 | Bank SE of bridge | Sandy alluvium | Cored, 1" x 16" |
| C4 | Remnants of bank SW of bridge | Rocky alluvium | Channel-sampled |
| C5 | Spoil piles SW of bridge | Mixture of sandy gravel and loam | Surface grabs |
| C6 | Flat area SW of bridge | Gravelly loam | Surface grabs |

December 6, 1985

C. W. Kimbrough

Results of Analyses of Soil/Sediment Samples from BCK 9.42

Attached are the complete results of analyses performed on samples collected November 14, 1985, at the bridge repair site at BCK 9.42. My earlier memo (dated November 18, 1985) documents sampling locations and methods.

The results show generally similar levels of contamination for recent sediment deposits (C1, C2) and historical floodplain deposits (C3, C4). Thus no 'mother lode' of historical contamination appears to have been breached, or will be breached, by the bridge repair. Uranium levels are high relative to uncontaminated areas in Bear Creek but are similar to levels observed previously in surface sediments and floodplain deposits upstream and downstream of the bridge site. PCB levels are also elevated and are somewhat higher than observed previously in this area for creek sediments. The ICP metal scan revealed slightly elevated levels for certain metals, such as Cd, but these levels are also similar to previously measured levels upstream and downstream of the site.

It is noteworthy that the flat area (C6) proposed by Loar and myself (memo dated November 18, 1985) as a spoil storage area appears to be relatively free of surface soil contamination. This may indicate that floodwaters rarely, or never, reached this area to deposit contaminants and thus the area may be a suitable spoil storage site. On the other hand, if the prevailing philosophy is to avoid mixing contaminated material with clean material, the area should probably not be used for contaminated spoil storage. In this case, the advantages of the site for protection against erosion by the creek seem to outweigh any advantage gained by not mixing (actually overlaying) clean and contaminated material.

Lastly, I think it should continue to be required for Rust to steam clean their equipment before moving it after completion of the repairs. We need to minimize the spreading of contaminated soil by vehicles. Although one incident such as this may represent only a trivial dispersal, the increasing

vehicular activity in the creek floodplain could lead, in the aggregate of all such incidents, to non-trivial dispersal.

R. R. Turner, 1505, MS-2, ORNL (4-7856) /RRT

RRT/cf

cc: N. H. Cutshall
J. M. Loar

Table J.1. Results of analyses of sediment and floodplain soils from BCK 9.42. Samples were collected November 1985. Units are $\mu g/g$ dry weight except as noted.

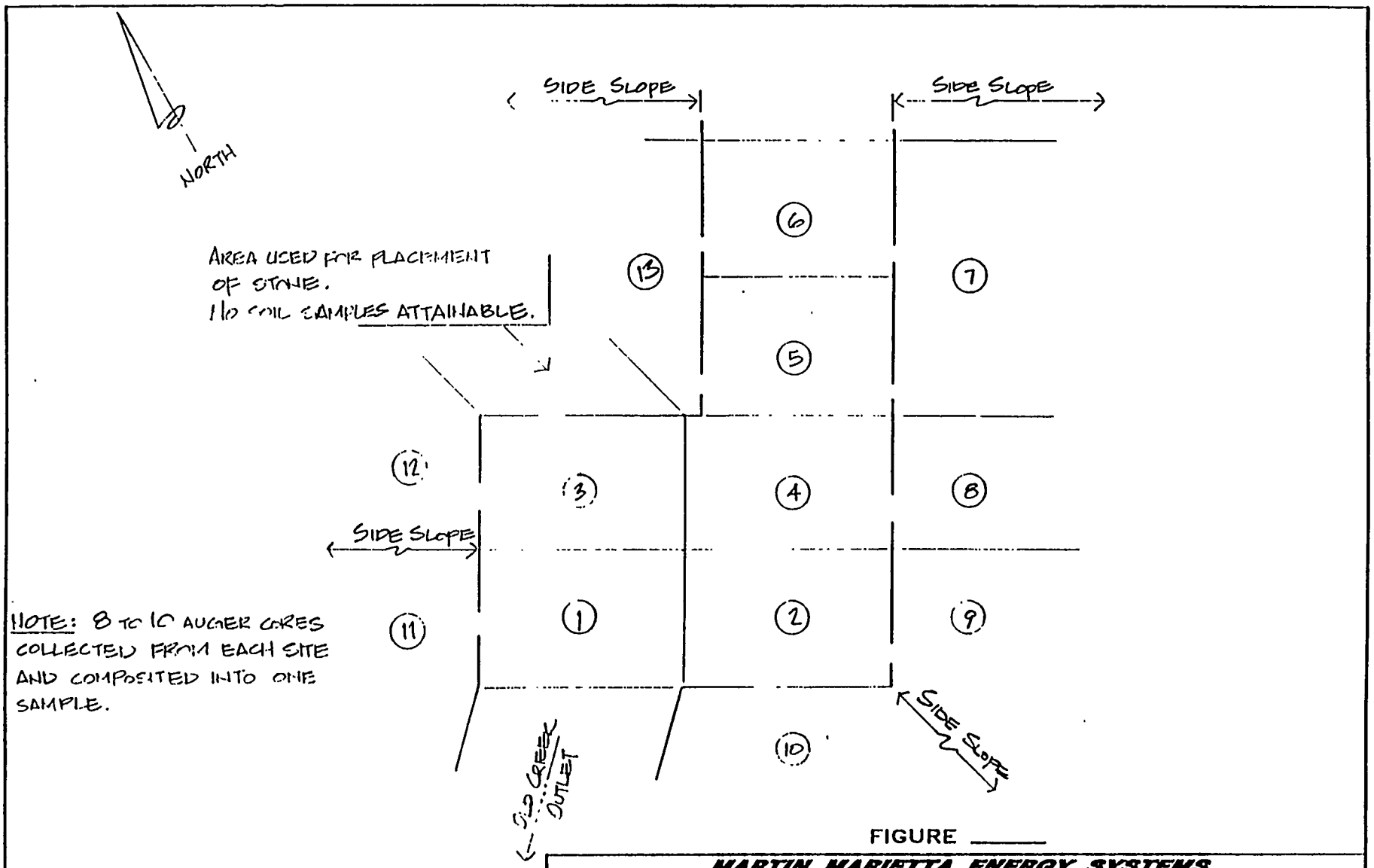
| SITE | C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|---|
| Aluminum | 6400 | 4300 | 4300 | 3300 | 4100 | 2500 |
| Antimony | 7.7 | 8.5 | 7.8 | 7.6 | 6.8 | <29 |
| Arsenic | <2.5 | <2.5 | <2.4 | <2.5 | <2.5 | <15 |
| Barium | 210 | 140 | 120 | 110 | 120 | 77 |
| Beryllium | 1.6 | 1.3 | 0.94 | 0.86 | 1.1 | 0.74 |
| Boron | 13 | 5.3 | <2.0 | 3.0 | 4.5 | <12 |
| Cadmium | 14 | 7.4 | 8.6 | 5.7 | 6.8 | 3.4 |
| Calcium | 22000 | 22000 | 2800 | 4900 | 7300 | 65000 |
| Chromium | 6.1 | 5.7 | 3.9 | 4.1 | 4.5 | <5.8 |
| Cobalt | 32 | 22 | 19 | 14 | 18 | 7.9 |
| Copper | 12 | 6.9 | 10 | 9.5 | 11. | 3.7 |
| Gallium | <7.5 | 7.5 | <7.3 | <7.4 | <7.4 | <44 |
| Iron | 5500 | 4900 | 3700 | 3800 | 3900 | 4200 |
| Lead | 25 | 23 | 25 | 24 | 26 | 47 |
| Lithium | 120 | 66. | 20 | 17 | 33 | <29 |
| Magnesium | 2400 | 2200 | 750 | 1700 | 2000 | 29000 |
| Manganese | >350 | >350 | >340 | >340 | >340 | 1100 |
| Molybdenum | 1.0 | <1.0 | <0.98 | <0.99 | <0.98 | <5.8 |
| Nickel | 71 | 34 | 34 | 16 | 28 | <8.7 |
| Phosphorus | 98 | 87 | 58 | 70 | 83 | 270 |
| Selenium | <5.0 | <5.0 | <4.9 | <5.0 | <4.9 | <29 |
| Silicon | 720 | 420 | 330 | 260 | 340 | 530 |
| Silver | <1.2 | <1.2 | <1.2 | <1.2 | <1.2 | 8.2 |
| Sodium | <12 | <12 | <12 | <12 | <12 | <73 |
| Strontium | 13 | 12 | 4.9 | 4.4 | 5.4 | <0.73 |
| Titanium | 14 | 12 | 14 | 15 | 14 | 36 |
| Uranium | 126 | 94 | 105 | 96 | 127 | 7.5 |
| Vanadium | 9.0 | 9.0 | 6.8 | 7.0 | 7.5 | <1.5 |
| Zinc | 44 | 30 | 28 | 120 | 60 | 940 |
| Zirconium | <0.50 | 0.52 | <0.49 | <0.50 | <0.49 | <2.9 |
| PCB-1254 | 1.32 | 1.92 | 2.21 | 0.89 | 2.17 | <0.10 |
| PCB-1260 | 0.89 | 1.52 | 1.01 | 0.65 | 0.99 | <0.10 |
| Gross $\alpha$ (pCi/g) | 37.8 | 35.1 | 59.4 | 37.8 | 51.3 | 18.9 |
| $\alpha$ counting error | 24.3 | 24.3 | 29.7 | 24.3 | 27. | 16.2 |
| Gross $\beta$ (pCi/g) | 70.2 | 72.9 | 89.1 | 94.5 | 113.4 | 32.4 |
| $\beta$ counting error | 21.6 | 21.6 | 21.6 | 21.6 | 24.3 | 16.2 |

Table J.2. Results[1] of gamma ray spectrometry on sediment and floodplain soils from BCK 9.42. Units are pCi/g ± 1 S.D.

| | Cs-137 | K-40 | U-238 | U-235 |
|---|---|---|---|---|
| C1 | 0.18 ± 0.04 | 10.0 ± 0.9 | 41.3 ± 4.9 | 0.5 ± 0.2 |
| C2 | 0.16 ± 0.04 | 11.8 ± 0.9 | 40.2 ± 4.8 | 0.3 ± 0.2 |
| C3 | 0.35 ± 0.04 | 13.1 ± 0.8 | 32.6 ± 4.2 | 0.8 ± 0.2 |
| C4 | 0.29 ± 0.05 | 8.6 ± 1.0 | 33.4 ± 5.4 | 0.7 ± 0.3 |
| C5 | 0.61 ± 0.06 | 9.2 ± 0.9 | 50.5 ± 5.6 | 1.5 ± 0.3 |
| C6 | 2.61 ± 0.11 | 5.4 ± 0.9 | N.D. | N.D. |

[1]Transmitted to R. R. Turner from I. L. Larsen (ESD) on November 27, 1985.

# APPENDIX K. ANALYTICAL RESULTS AND MAPS OF SAMPLING LOCATIONS FOR BLUE LAGOON EXCAVATION, APRIL-JUNE 1988




NOTE: 8 TO 10 AUGER CORES COLLECTED FROM EACH SITE AND COMPOSITED INTO ONE SAMPLE.

FIGURE _____

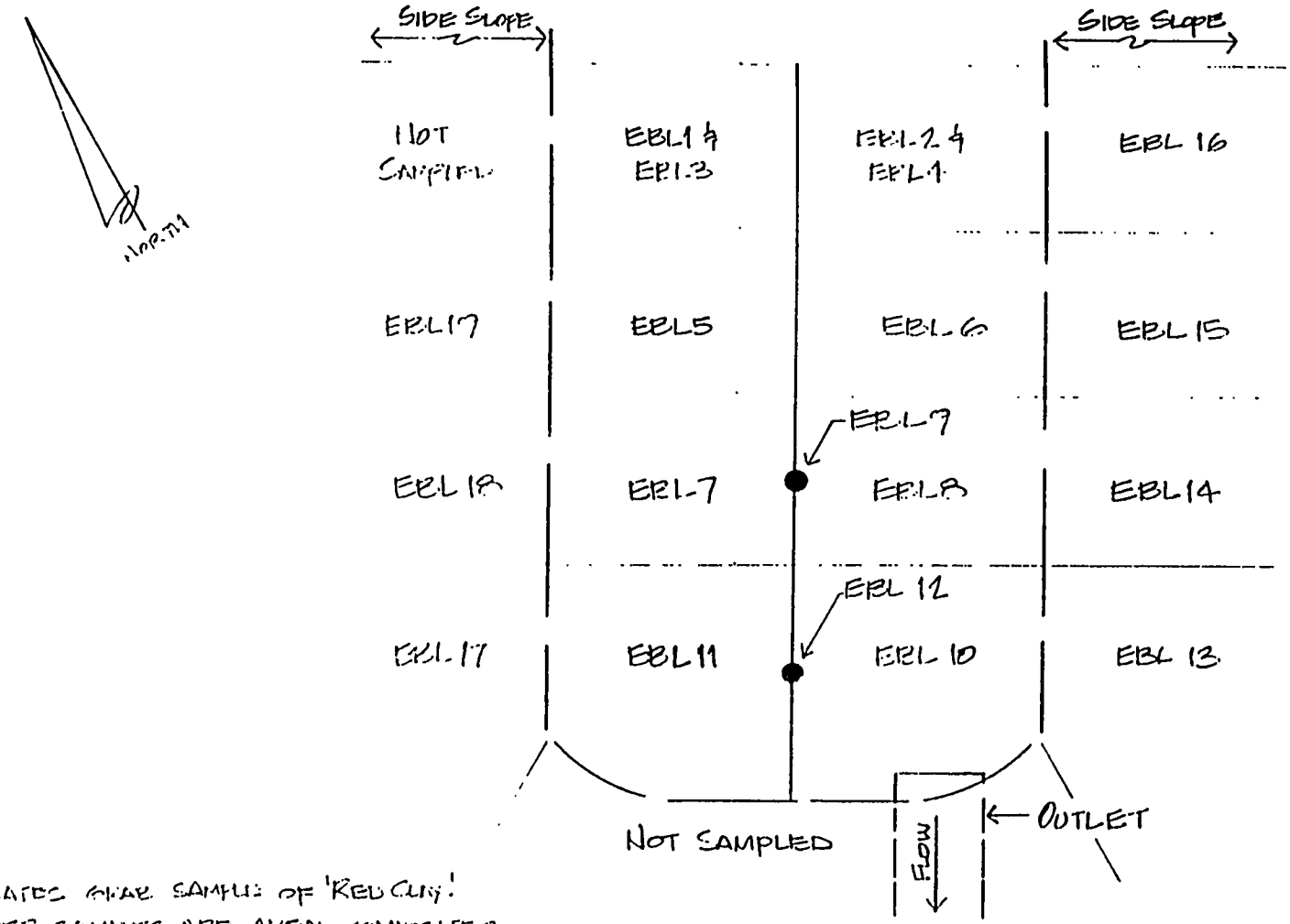
**MARTIN MARIETTA ENERGY SYSTEMS**

**ENVIRONMENTAL MGT. DEPT.– ASSESSMENT & REMEDIATION**

WEST BLUE LAGOON SAMPLING

SITES 1 THRU 5 - MAY 1988; SITES 6 THRU 13 - JUNE 1988

**Scale:** 1" = (NO SCALE) **Date:** NOVEMBER 1988




NOTES:
1. ● INDICATES GRAB SAMPLE OF 'RED CLAY'. ALL OTHER SAMPLES ARE AREAL COMPOSITES.
2. EBL1 & EBL2 COLLECTED 4/11/88.
3. EBL3 & EBL4 COLLECTED 4/12/88 AFTER ADDITIONAL SLUDGE REMOVAL.

FIGURE _____

9/21/88
RALPH R. TURNER

**MARTIN MARIETTA ENERGY SYSTEMS**
**ENVIRONMENTAL MGT. DEPT.– ASSESSMENT & REMEDIATION**

EAST BLUE LAGOON SAMPLING
- APRIL 1988 -

Scale: 1"=(NO SCALE)  Date: NOVEMBER 1988

Table K.1. Post-Excavation Analytical Results for East Blue Lagoon. "N/A" indicates analysis was not performed. Units are for metals (µg/g), total uranium (µg/g), % U-235 (% of total U), volatile organics (µg/kg), and radionuclides (pCi/g) unless noted otherwise in footnote.

| | A07147 EBL-1 | A07147 EBL-2 | A14386 EBL-3 | A14386 EBL-4 | A14389 EBL-5 | A14389 EBL-6 | A14854 EBL-7 | A14854 EBL-8 | A14854 EBL-9 | A14855 EBL-10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Inorganics** | | | | | | | | | | |
| Se | <0.1 | <0.1 | <0.1(1) | <0.1(1) | <0.1 | <0.1 | <0.1 | 0.74 | <0.1 | <0.1 |
| Hg | 2.6 | 11 | 1.3 | 2.6 | 2 | 1.3 | 0.8 | 1 | <0.2 | 2.3 |
| Gross Alpha | 66 | 210 | 82 | 100 | 98 | 230 | 89 | 100 | 140 | 76 |
| Gross Beta | 84 | 260 | 130 | 140 | 150 | 270 | 110 | 150 | 220 | 140 |
| Am-241 | 0.05 | 0.13 | 0.04(2) | 0 | 0.01 | 0.03 | 0.02 | 0.01 | 0 | 0.02 |
| Np-237 | 0 | 0 | 0.12 | 0.51 | 0 | 0.12 | 0 | 0.11 | 0 | 0.26 |
| Pu-238 | 0 | 0 | 0 | 0.004 | 0 | 0.005 | 0 | 0 | 0 | 0 |
| Pu-239/240 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tc-99 | 78 | 130 | 130(3) | 180(3) | 120 | 340 | 22 | 32 | 30 | 21 |
| Tritium | <0.23 | 0.39 | 0 | 2 | 4.3 | 2.8 | 13 | <0.84 | 3.8 | 10 |
| U-234 | 19 | 90 | 42(2) | 37(2) | 21 | 59 | 32 | 40 | 5.3 | 24 |
| U-235 | 0.23 | 1.3 | 1.4(2) | 0.59(2) | 0.51 | 1.5 | 1.4 | 2.4 | 0.89 | 0.45 |
| % U-235 | 0.32 | 0.42 | 0.37 | 0.33 | 0.39 | 0.39 | 0.3 | 0.33 | 0.27 | 0.35 |
| U-236 | 0.47 | 1.3 | 0.74(2) | 0.82(2) | 0.33 | 1.9 | 0.52 | 0.82 | 0.83 | 0.36 |
| U-238 | 47 | 52 | 121(2) | 77(2) | 8.6 | 150 | 62 | 77 | 73 | 75 |
| Total U | 164 | 406 | 24.5(1) | 30.8(1) | 262 | 354 | 168 | 206 | 223 | 31.8 |
| Sr-90 | <0.13 | 0.06 | 0 | <0.11 | 0.55 | 0.08 | | | | 0.65 |
| Al | 48200 | 67700 | 52300 | 47300 | 42000 | 50800 | 53100 | 44900 | 46000 | 57000 |
| As | <33 | <30 | <35 | <33 | <32 | <30 | <38 | <32 | <29 | <39 |
| Ba | 205 | 839 | 259 | 588 | 287 | 799 | 183 | 198 | 189 | 249 |
| Be | 1.1 | 1.9 | 1.4 | 1.6 | 1.2 | 1.6 | 1.3 | 1.3 | 1.4 | 1.9 |
| Ca | 1120 | 2730 | 3710 | 3010 | 2650 | 970 | 25600 | 2390 | 560 | 4670 |
| Cd | <2.5 | 3 | <2.7 | <2.5 | <2.4 | <2.3 | <2.9 | <2.4 | <2.2 | 11 |
| Cr | 36 | 53 | 41 | 50 | 38 | 62 | 50 | 45 | 48 | 60 |
| Fe | 18300 | 21500 | 22000 | 28800 | 19500 | 38600 | 26500 | 28700 | 38300 | 22500 |
| Pb | 20 | 30 | 30 | 20 | <16 | 20 | 30 | 40 | 20 | <20 |
| Mg | 2610 | 3170 | 4050 | 2690 | 2440 | 2830 | 4400 | 3080 | 2640 | 4180 |
| Mn | 209 | 249 | 247 | 282 | 182 | 294 | 197 | 390 | 337 | 513 |
| Ni | 56 | 80 | 58 | 48 | 44 | 68 | 28 | 29 | 31 | 41 |
| K | 9900 | 10600 | 11100 | 11300 | 11000 | 14000 | 17200 | 13300 | 12500 | 20900 |
| Ag | <3.3 | <3 | <3.5 | <3.3 | <3.2 | <3 | <3.8 | <3.2 | <2.9 | <3.9 |
| Na | 630 | 630 | 680 | 620 | 670 | 500 | 600 | 610 | 620 | 540 |
| Sr | 26.2 | 38.7 | 33.6 | 40.3 | 39.2 | 28.3 | 55.4 | 34.7 | 28.9 | 41.6 |
| Zr | 72 | 75 | 83 | 91 | 97 | 65 | 82 | 84 | 84 | 78 |
| **Volatile Organics ≥10** | | | | | | | | | | |
| Acetone | | | | | | | | | | 70 |

(1) mg/L
(2) pCi/L
(3) pCi/mL

Table K.1. (continued).

| | A14855 EBL-11 | A14856 EBL-12 | A14857 EBL-13 | A14857 EBL-14 | A14857 EBL-15 | A14857 EBL-16 | A14857 EBL-17 | A14857 EBL-18 | A14857 EBL-19 |
|---|---|---|---|---|---|---|---|---|---|
| **Inorganics** | | | | | | | | | |
| Se | <0.1 | <0.1 | <0.1 | <0.1 | 0.19 | <0.1 | <0.1 | <0.1 | <0.1 |
| Hg | 0.78 | <0.2 | 35 | 18 | 14 | 26 | 4.1 | 3.4 | 2.4 |
| Gross Alpha | 35 | 61 | 28 | 81 | 130 | 35 | 430 | 140 | 110 |
| Gross Beta | 61 | 130 | 56 | 110 | 340 | 65 | 750 | 170 | 190 |
| Am-241 | 0 | 0.08 | 0 | 0.03 | 0.08 | 23 | 0.03 | 0.18 | 0.06 |
| Np-237 | 0.13 | 0.17 | 0.36 | 0.29 | 0.12 | 0.39 | 1.6 | 0.56 | 0.62 |
| Pu-238 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 | 0 | 0 |
| Pu-239/240 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tc-99 | 0.13 | 26 | <0.66 | 16 | 30 | 6.1 | 78 | 29 | 18 |
| Tritium | <6.7 | 6.6 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| U-234 | 13 | 19 | 15 | 27 | 53 | 18 | 110 | 36 | 33 |
| U-235 | 0.26 | 1.0 | 0 | 1 | 1.2 | 0.44 | 5.3 | 0.88 | 0.91 |
| % U-235 | 0.37 | 0.34 | 0.51 | 0.37 | 0.44 | 0.5 | 0.34 | 0.38 | 0.37 |
| U-236 | 0.14 | 0 | 0 | 0.31 | 0.78 | 0 | 4.1 | 1.1 | 0.81 |
| U-238 | 23 | 63 | 13 | 51 | 100 | 20 | 270 | 86 | 88 |
| Total U | 53.6 | 157 | 33.6 | 110 | 246 | 47.5 | 620 | 220 | 178 |
| Sr-90 | 0.52 | 0.59 | 0.77 | 0.08 | 0.25 | 1.1 | 0.68 | 0.82 | 0.15 |
| Al | 51200 | 44600 | 46900 | 47800 | 47100 | 65200 | 57500 | 46600 | 49700 |
| As | <33 | <33 | <33 | <32 | <40 | <37 | <40 | <40 | <38 |
| Ba | 229 | 175 | 187 | 301 | 180 | 271 | 200 | 110 | 263 |
| Be | 1.5 | 1.6 | 1.3 | 1.4 | 1 | 1.5 | 2 | 2 | 1.3 |
| Ca | 2460 | 1040 | 43000 | 54000 | 117000 | 44500 | 48600 | 92700 | 40400 |
| Cd | <2.5 | <2.5 | <2.5 | <2.4 | <3 | <2.8 | <3 | <3 | <2.9 |
| Cr | 54 | 52 | 54 | 43 | 40 | 56 | 50 | 30 | 38 |
| Fe | 30500 | 30000 | 24700 | 21600 | 18800 | 27900 | 22100 | 13200 | 20100 |
| Pb | <16 | 30 | 30 | 40 | 40 | 30 | 20 | <20 | 20 |
| Mg | 3900 | 2500 | 10500 | 12300 | 15800 | 8500 | 8180 | 7910 | 5810 |
| Mn | 330 | 238 | 726 | 407 | 314 | 543 | 587 | 359 | 374 |
| Ni | 21 | 37 | 35 | 46 | 35 | 29 | 50 | 42 | 38 |
| K | 22300 | 11600 | 12800 | 12800 | 11500 | 22100 | 18900 | 10200 | 14600 |
| Ag | <3.3 | <3.3 | <3.3 | <3.2 | <4 | <3.7 | <4 | <4 | <3.8 |
| Na | 500 | 610 | 750 | 820 | 1080 | 1500 | 1090 | 690 | 1010 |
| Sr | 29.1 | 32.7 | 78.5 | 95.8 | 147 | 89.2 | 117 | 136 | 96.9 |
| Zr | 60 | 104 | 64 | 65 | 47 | 67 | 66 | 35 | 96 |
| **Volatile Organics ≥10** | | | | | | | | | |
| Acetone | 180 | | | | | | | | |

(1) mg/L
(2) pCi/L
(3) pCi/mL

Table K.2. Post-Excavation Analytical Results for West Blue Lagoon. "N/A" indicates analysis was not performed. Units are for metals (µg/g), total uranium (µg/g), % U-235 (% of total U), volatile organics (µg/kg), and radionuclides (pCi/g) unless noted otherwise in footnote.

| | A14862 WBL-1 | A14862 WBL-2 | A14862 WBL-3 | A14862 WBL-4 | A14862 WBL-5 | A14868 WBL-6 | A14868 WBL-7 | A14868 WBL-8 | A14868 WBL-9 | A14868 WBL-10 | A14868 WBL-11 | A14868 WBL-12 | A14868 WBL-13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Inorganics** | | | | | | | | | | | | | |
| Se | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Hg | 0.77 | 0.28 | 0.3 | 0.29 | 0.81 | 1.3(1) | 0.2(1) | 0.3(1) | 0.4(1) | 0.4(1) | 0.4(1) | <0.2(1) | 4.8(1) |
| Gross Alpha | 31 | 29 | 10 | 46 | 42 | 25 | 73 | 130 | 61 | 79 | 18 | 8.8 | 26 |
| Gross Beta | 21 | 18 | 8.8 | 61 | 38 | 45 | 75 | 140 | 61 | 92 | 23 | 11 | 27 |
| Am-241 | 0.01 | 0 | 0 | 0 | 0 | 0.04 | 0.03 | 0 | 0.05 | 0.04 | 0 | 0.01 | 0.01 |
| Np-237 | 0.05 | 0.34 | 0 | 0.66 | 0.16 | 0.02(2) | 0.06(2) | 0.11 | 0 | 0.05(2) | 0.04(2) | 0.02(2) | 0 |
| Pu-238 | 0 | 0 | 0 | 0 | 0.01 | 0 | 0.04(2) | 0 | 0.03(1) | 0.12(2) | 0.01(2) | 0 | 0.09(2) |
| Pu-239/240 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tc-99 | <2.1 | 15 | <4.2 | 5.9 | 21 | 7.1 | 12 | 23 | 2.3 | 13 | 11 | 0 | 0 |
| Tritium | 3.3 | <0.09 | 0.73 | 11 | 2 | 2.1 | <7.3 | 0.75 | <2.5 | 7.3 | <0.09 | 4.6 | 1.3 |
| U-234 | 73 | 18 | 0.33 | 17 | 18 | 11(2) | 22(2) | 40 | 22(2) | 6.9(2) | 6.6(2) | 1.3(2) | 9.6(2) |
| U-235 | 0 | 0.38 | 0 | 0.37 | 0 | 0.18(2) | 0.28(2) | 2 | 0.6(2) | 0.22(2) | 0.16(2) | 0 | 0 |
| % U-235 | 0.35 | 0.32 | 0.35 | 0.35 | 0.33 | 0.38 | 0.31 | 0.36 | 0.35 | 0.29 | 0.34 | 0.4 | 0.38 |
| U-236 | 0 | 0.37 | 0 | 0.15 | 0.3 | 0 | 0 | 1.6 | 0 | 1.4(2) | 0.1(2) | 0.05(2) | 0.04(2) |
| U-238 | 14 | 41 | 1.1 | 32 | 42 | 22(2) | 40(2) | 85 | 38(2) | 65(2) | 12(2) | 3.9(2) | 13(2) |
| Total U | 36.4 | 101 | 8.16 | 78.9 | 91.7 | 56.2(1) | 111(1) | 174(1) | 90.6(1) | 138(1) | 47.8(1) | 12.3(1) | 36.9(1) |
| Sr-90 | 0.34 | 0.4 | 0.12 | 0.59 | 0.62 | 0.27 | 0.42 | 0.19 | 0.22 | 0.11 | 0 | 0.47 | 0.17 |
| Al | 65000 | 37300 | 75600 | 46200 | 44000 | 40500 | 33000 | 24900 | 41900 | 48400 | 54500 | 42900 | 58300 |
| As | <35 | <37 | <36 | <37 | <32 | <37 | <40 | <39 | <40 | <39 | <39 | <38 | <38 |
| Ba | 213 | 182 | 221 | 181 | 195 | 124 | 250 | 288 | 370 | 206 | 229 | 221 | 323 |
| Be | 1.5 | <0.9 | 1.3 | 1 | 0.9 | 0.9 | <1 | 1.1 | 2 | 1.3 | <1 | <0.9 | 1.5 |
| Ca | 1840 | 620 | 1430 | 620 | 1200 | 18400 | 1400 | 2340 | 61400 | 15800 | 4740 | 2090 | 27300 |
| Cd | <2.6 | <2.8 | <2.7 | <2.8 | <2.4 | <2.8 | <3 | <2.9 | <3 | <3 | <2.9 | <2.8 | <2.8 |
| Cr | 71 | 38 | 78 | 48 | 46 | 26 | 30 | 28 | 40 | 119 | 54 | 42 | 51 |
| Fe | 26700 | 25300 | 20400 | 31000 | 23200 | 19700 | 14600 | 15600 | 21500 | 35300 | 27200 | 23200 | 26400 |
| Pb | 30 | <19 | 20 | 20 | <16 | 20 | 30 | 60 | 80 | 30 | <20 | <19 | 40 |
| Mg | 4980 | 1920 | 6600 | 2490 | 2970 | 3590 | 1930 | 1090 | 7160 | 4970 | 3960 | 2990 | 6970 |
| M | 123 | 92 | 90 | 132 | 128 | 917 | 445 | 882 | 452 | 466 | 161 | 275 | 767 |
| Ni | 26 | 16 | 34 | 14 | 15 | 25 | 25 | 18 | 26 | 38 | 22 | 17 | 36 |
| K | 22100 | 8100 | 27300 | 9500 | 13100 | 6000 | 9300 | 5700 | 14500 | 14100 | 13600 | 11300 | 19900 |
| Ag | <3.5 | <3.7 | <3.6 | <3.7 | 0 | <3.7 | <4 | <3.9 | 4 | <3.9 | <3.9 | <3.8 | <3.8 |
| Na | 430 | 430 | 9880 | 490 | 450 | 470 | 530 | 460 | 980 | 770 | 980 | 790 | 790 |
| Sr | 45.7 | 30 | 46.7 | 37.7 | 36.4 | 40.7 | 41 | 45.9 | 124 | 59.5 | 52.4 | 37.6 | 72.1 |
| Zr | 85 | 110 | 68 | 123 | 103 | 66 | 103 | 66 | 72 | 112 | 134 | 101 | 89 |
| **Volatile Organics ≥10** | | | | | | | | | | | | | |
| FR113 | | | | | | | | | | | | | |
| MECL2 | 11 | 13 | 11 | 13 | 19 | | | | | | | | |
| TCEE | | | | | | | | | | | | | |
| FR11 | | | | | | | | | | | | | |

(1) mg/L
(2) pCi/L

# APPENDIX L. CHECKLISTS OF FISH AND BENTHIC MACROINVERTEBRATE SPECIES FROM BEAR CREEK REFERENCE SITES

Table L.1. Fish species composition in Bear Creek (BCK), and the reference sites, Grassy Creek (GCK) and Mill Branch (MBK) for the period May 1984 to November 1987. Numbers represent the number of sampling periods (n = 8) that a given species was collected at that site

| Species | BCK 12.36 | BCK 11.83 | BCK 11.09 | BCK 9.91 | BCK 9.40 | BCK 7.87 | BCK 3.25 | GCK 2.4 | MBK 1.6 |
|---|---|---|---|---|---|---|---|---|---|
| Cyprinidae | | | | | | | | | |
| Blacknose dace (*Rhinichthys atratulus*) | 5 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 7[a] |
| Creek chub (*Semotilus atromaculatus*) | 3 | 8 | 6 | 8 | 8 | 8 | 8 | 8 | 7 |
| Emerald shiner (*Notropis atherinoides*) | | | | | | | 1 | | |
| Mnt redbelly dace (*Phoxinus oreas*) | 1 | 7 | 6 | 8 | 8 | 8 | 2 | | 7 |
| Rosefin shiner (*Notropis ardens*) | | | | | | | 8 | | |
| Spotfin shiner (*Notropis spilopterus*) | | | | | | | 1 | | |
| Striped shiner (*Notropis chysocephalus*) | | | | 1 | 5 | 8 | 8 | 6 | 6 |
| Stoneroller (*Campostoma anomalum*) | | 2 | 6 | 7 | 7 | 7 | 8 | 3 | 6 |
| Catostomidae | | | | | | | | | |
| Northern hogsucker (*Hypentelium nigricans*) | | | | | | | 6 | | |
| White sucker (*Catostomus commersoni*) | | | | 2 | 1 | 4 | 4 | 7 | |
| Cottidae | | | | | | | | | |
| Banded sculpin (*Cottus carolinae*) | | | | 1 | 8 | | 4 | 4 | |

Table L.1 (continued)

| Species | BCK 12.36 | BCK 11.83 | BCK 11.09 | BCK 9.91 | BCK 9.40 | BCK 7.87 | BCK 3.25 | GCK 2.4 | MBK 1.6 |
|---|---|---|---|---|---|---|---|---|---|
| Centrarchidae | | | | | | | | | |
| Bluegill sunfish (*Lepomis macrochirus*) | | | | | | | | | 1 |
| Warmouth sunfish (*Lepomis gulosus*) | | | | | | | | | 1 |
| Rockbass (*Ambloplities rupestris*) | | | | | | | 8 | | |
| Percidae | | | | | | | | | |
| Stripetail darter (*Etheostoma kennicotti*) | | | | | | | 8 | | 8 |
| Tenn snubnose darter (*Etheostoma simoterum*)[b] | | | | | | | 7 | | 7 |
| Number of species (N) | 3 | 4 | 4 | 7 | 7 | 6 | 14[c] | 6 | 9 |

[a]Only seven sampling periods for this site; was not included in May 1984 sampling.

[b]May also include specimens of *Etheostoma duryi*, as these species cannot be separated in field.

[c]Species found in qualitative sampling were rebreast sunfish (*Lepomis auritus*), bluegill sunfish (*Lepomis macrochirus*), longear sunfish (*Lepomis negalotis*), green sunfish (*Lepomis cyanellus*), and bluntnose minnow (*Pimephales notatus*).

Table L.2 Checklist of benthic macroinvertebrate taxa collected from Bear Creek (BCK) and Grassy Creek (GCK), a reference stream, from June 1984 through July 1987. The '1', '2', and '3' indicate that the taxon was collected at least once in quantitative samples during sampling periods of June 1984 through May 1985, October 1985 through July 1986, and October 1986 through July 1987, respectively. Similarly, the 'Q1', 'Q2', and 'Q3' indicate the taxon was collected in the same respective years in qualitative samples only.

| | Site | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Taxon | BCK 3.25 | BCK 5.15 | BCK 7.87 | BCK 9.40 | BCK 9.91 | BCK 10.32 | BCK 11.09 | BCK 11.83 | BCK 12.36 | GCK 1.4 | GCK 2.4 | GCK 2.7 |
| Turbellaria | 3 | | 3 | 1,3 | | | | | | | 2 | |
| Tricladia | 2 | | 2 | 2 | | | | | | | 3 | |
| Planariidae | Q1,2,3 | 1 | 1,3 | 1,2,3 | | | | | | 1 | 1 | |
| Nematoda | 2 | 1 | | 2 | 2,3 | 1 | | 2 | | 1 | | |
| Annelida | | | | | | | | | | | | |
| Oligochaeta | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 1,2,3 | 1 | 1,2,3 | Q1,Q1,3 | | 1 | 1,2,3 | 1 |
| Crustacea | | | | | | | | | | | | |
| Isopoda | | | | | | | | | | | | |
| *Asellus* | | | | | | | | | | | 2 | |
| *Lirceus* | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 1,2,3 | | 2,3 | 3 | | 1 | 1,Q2 | |
| Amphipoda | | | | | | | | | | | | |
| Gammaridae | | | | | | | | | | | | |
| *Crangonyx* | 2 | 1 | 1,2,3 | 1,2,3 | 1,2,3 | | 1Q2,3 | 2,3 | | 1 | 1,2,3 | |
| Talitridae | | | | | | | | | | | | |
| *Hyallela azteca* | | | | | 1 | | | | | | | |
| Decapoda | 2,3 | | 2,3 | 2,3 | 2,3 | | 2 | 3 | | | 2,3 | |
| *Cambarus* | 1,2,3 | 1 | 1,2 | 1,2,3 | 1,2 | | Q3 | 1,Q2 | 1 | 1 | 1,2,3 | |
| Hydracarina | | | | | | | | | | | | |
| Parasitengona | | | | 3 | | | | | | | 2 | |

Table L.2 (continued)

| Taxon | Site | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BCK 3.25 | BCK 5.15 | BCK 7.87 | BCK 9.40 | BCK 9.91 | BCK 10.32 | BCK 11.09 | BCK 11.83 | BCK 12.36 | GCK 1.4 | GCK 2.4 | GCK 2.7 |
| Insecta | | | | | | | | | | | | |
| Colleabola | 3 | | 3 | | 3 | | 3 | 2,3 | 3 | | 3 | |
| Anthropleona | | | | | | | | | | | | |
| Entomobryomorpha | | | | 3 | | | | | | | 2 | |
| Isotomidae | | 1 | | | | | | 1 | | 1 | | |
| Symphypleona | | | | | | | | | | | | |
| Sminthuridae | | | | | | | | | | | 1 | |
| Ephemeroptera | | | | | | | | | | | | |
| Baetidae | 1,Q2 | | 2 | 1,2,3 | Q2,Q3 | | 1 | | | | 1,2 | |
| Baetis | 1,2,3 | | 2,3 | 2,3 | 2 | | | | | 1 | 1,2,3 | |
| Baetis? | | | | | | | | | | | 1 | |
| Callibaetis | | | Q2 | | | | Q2 | | | | | |
| Cloeon | | | | | | | | | | | Q2 | |
| Pseudocloeon | 1,2,Q3 | 1 | 1 | 1,2 | | | 1 | | | | | 1 |
| Caenidae | | | | | | | | | | | | |
| Caenis | 1,2,3 | | | | | | | | | | | |
| Ephemerellidae | | | | | | | | | | | | |
| Ephemerella | 1,2,3 | | | | | | | | | 1 | 1,Q2 | |
| Eurylophella | 2,3 | | | | | | | | | | 1,Q2,3 | 1 |
| Ephemeridae | | | | | | | | | | | | |
| Ephemera | | | | | | | | | 1 | 1 | 1,2,3 | |
| Heptageniidae | 1 | | | | | | | | | 1 | 1 | |
| Cinygmula | | | | | | | | | | | 2 | |
| Heptagenia | | | | | | | | | | 1 | | |
| Leucrocuta | | | | | | | | | | 1 | 1,3 | |
| Stenacron | 3 | | 3 | | | | | | | 1 | 1,2,3 | |
| Stenonema | 1,Q2,3 | | Q2 | | | | | | | 1 | 3 | |

Table L.2 (continued)

| Taxon | Site | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BCK 3.25 | BCK 5.15 | BCK 7.87 | BCK 9.40 | BCK 9.91 | BCK 10.32 | BCK 11.09 | BCK 11.83 | BCK 12.36 | GCK 1.4 | GCK 2.4 | GCK 2.7 |
| Ephemeroptera (cont.) | | | | | | | | | | | | |
| Leptophlebiidae | | | | | | | | | | 1 | 1,2,3 | 1 |
| Habrophlebeiodes | 3 | | | | | | 3 | | | 1 | 1,2,3 | |
| Leptophlebia | | | | | | | | | | | 2,3 | |
| Paraleptophlebia | | | | | | | | | | 1 | 1,2,3 | |
| Oligoneuriidae | | | | | | | | | | | | |
| Isonychia | 1,2,3 | | | | | | | | | | 1 | |
| Siphlonuridae | | | | | | | | | | | | |
| Ameletus | 2 | | | | | | | | | | | 1 |
| Odonata | | | | | | | | | | | | |
| Anisoptera | | | | | | | | | | | | |
| Aeshnidae | | | | | 1 | | | | | | | |
| Aeshna umbrosa | | | | | | | | | | | Q2 | |
| Basiaeschna janata | | | | | | | | | | | 3 | |
| Boyeria | Q2,Q3 | | | 3 | 2 | | | | | | 2,3 | |
| Boyeria grafiana | | | | | | | | | | | Q3 | |
| Boyeria vinosa | | | | Q2,Q3 | | | | | | | 3 | |
| Cordulegastridae | | | | | | | | | | | | |
| Cordulegaster | | | 2 | Q2,3 | Q3 | | | | | | 3 | |
| Cordulegaster maculata | | | | | | | | | | | 2 | |
| Corduliidae | | | | | | | | | | | | |
| Somatrochlora | | | Q2,Q3 | Q1,Q2,Q3 | Q2,Q3 | | | | | | Q2,Q3 | |
| Gomphidae | 2 | | 2,3 | | | | 3 | | | | 2,3 | |
| Gomphus | Q2 | | Q1 | | | | | | | | | |
| Lanthus vernalis | 1 | 1 | 1 | | | | | | | 1 | | |
| Stylogomphus Albistylus | 1,2,3 | 1 | 1,2,3 | | | | | | | 1 | 1,2,3 | |

Table L.2 (continued)

| Taxon | Site | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BCK 3.25 | BCK 5.15 | BCK 7.87 | BCK 9.40 | BCK 9.91 | BCK 10.32 | BCK 11.09 | BCK 11.83 | BCK 12.36 | GCK 1.4 | GCK 2.4 | GCK 2.7 |
| Odonata (cont.) | | | | | | | | | | | | |
| Libellulidae | | | | | | | | | | | | |
| Plathemis lydia | | | | | Q1 | | | | | | | |
| Zygoptera | | | | 3 | | | | | | | | |
| Calopterygidae | | | 3 | | | | | | | | | |
| Calopteryx | Q2 | Q2,Q3 | | | 2 | | Q2 | | | | 2 | |
| Calopteryx maculata | | | 3 | Q,23 | Q1,Q2 | | 1 | | | Q1 | 3 | |
| Coenagrionidae | | | 3 | 3 | | | | | | | 2 | |
| Argia | Q2 | | Q2 | | | | Q2 | 3 | | | | |
| Argia fummipennis | | | | | 1 | | | | | | | |
| Orthoptera | | | | | | | 2 | | | | | |
| Plecoptera | 2 | | 2,3 | | | | | | | | | |
| Capniidae | 2,3 | | 2,3 | 2,3 | 2 | | | | | | 2,3 | |
| Allocapnia | 2 | | 1,2 | 2 | | | | | | 1 | 2 | |
| Chloroperlidae | 1,2,3 | 1 | 1,3 | 2,3 | 1,2 | 1 | Q3 | 1 | | 1 | 2 | |
| Haploperla | 1,3 | | | | | | | | | 1 | 2 | |
| Sweltsa | | | | | | | | | | | 2 | |
| Leuctridae | 2,3 | | | 3 | | | | | | | 2 | |
| Leuctra | 1,2,3 | 1 | 1,3 | 1,3 | Q1 | | | 1 | | 1 | 1,3 | |
| Nemouridae | | | | | | | | | | | | |
| Amphinemura | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 1,2,3 | | 1,2,3 | 2,3 | 1,2 | 1 | 1,2,3 | 1 |
| Nemoura | | | | | | | | | | 1 | | |
| Shipsa | 2 | | | | | | | | | | | |
| Peltoperlida | 2,3 | | | | | | | | | | | |
| Tallaperla | 1,Q3 | | | | | | | | | | | |

Table L.2 (continued)

| Taxon | Site | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BCK 3.25 | BCK 5.15 | BCK 7.87 | BCK 9.40 | BCK 9.91 | BCK 10.32 | BCK 11.09 | BCK 11.83 | BCK 12.36 | GCK 1.4 | GCK 2.4 | GCK 2.7 |
| Plecoptera (cont.) | | | | | | | | | | | | |
| Perlidae | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 3 | 1 | 1,2,3 | | 1 | 1 | 1,2,3 | |
| *Acroneuria* | | 1 | | | | | | | | | | |
| *Beloneuria* | | | | | | | | | | | 2 | |
| *Eccoptura xanthenes* | 1,2,Q3 | 1 | 1,Q2,Q3 | 1,Q2,3 | | | | | | 1 | 1,2,3 | |
| *Perlesta* | | | 1 | | | | | | | | 1 | |
| Perlodidae | 2 | | 2,Q3 | | 1 | 1 | | | | | Q3 | |
| *Clioperla clio* | | | | Q3 | Q3 | | 3 | Q3 | | | | |
| *Isoperla* | 3 | 1 | Q3 | 1,3 | 3 | 1 | 1,2,3 | 3 | | | | 1 |
| *Yogus* | | | | 2 | | | 2 | | | | | |
| Taeniopterygidae | 1 | 1 | | | | | 1 | | | | | |
| *Taeniopteryx* | 1,2 | | | 2 | | | 2 | | | 1 | | |
| Hemiptera | | | | | | | | | | | | |
| Gerridae | | | | 3 | | | | 2,3 | 2 | | | |
| *Trepobates* | | | | | 1 | | | | | 1 | 1 | |
| Veliidae | | | 2 | | 2,3 | | | Q2,3 | 3 | | 3 | |
| *Rhagovelia* | | 1 | 1 | 1,2,3 | | | | | | 1 | 2,3 | |
| Megaloptera | | | | | | | | | | | | |
| Corydalidae | | | | | | | | | | | | |
| *Nigronia* | | | | | | | | | | 1 | | |
| *Nigronia fasciatus* | | | Q2,3 | 3 | | | | | | 1 | 1,2,3 | |
| *Nigronia serricornis* | 1,2,3 | 1 | 2 | 1,2,3 | | | | | | 1 | 1,2,3 | |
| Sialidae | | | | | | | | | | | | |
| *Sialis* | 1,2,3 | 1 | 1,2,3 | 1,3 | Q2 | | 2,Q3 | 2,3 | | | 1,2,3 | |

Table L.2 (continued)

| Taxon | Site | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BCK 3.25 | BCK 5.15 | BCK 7.87 | BCK 9.40 | BCK 9.91 | BCK 10.32 | BCK 11.09 | BCK 11.83 | BCK 12.36 | GCK 1.4 | GCK 2.4 | GCK 2.7 |
| Trichoptera | | | | | | | | 1 | | | 2 | |
| Brachycentridae | | | | | | | | | | | | |
| *Micrasema* | | | | 3 | | | | | | | | |
| Glossosomatidae | | | | | | | | | | | 3 | |
| *Agapetus* | | | | | | | | | | 1 | | |
| *Glossosoma* | 1,2 | | | | | | | | | | | |
| Hydropsychidae | | | | 3 | | | | | | | | |
| *Cheumatopsyche* | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 1,2,3 | | 1,2,3 | 2,3 | | 1 | 1,2,3 | |
| *Diplectrona modesta* | 1,3 | | Q2 | 1,2,3 | 1 | | 1,2 | | | 1 | 1,2,3 | |
| *Hydropsyche* | 1,2,3 | | 2,3 | 1,2,3 | 1,2 | | 2 | 2 | | 1 | | |
| Hydroptilidae | 2,3 | | | 2,3 | | | 3 | | | | | |
| *Hydroptila* | | | | 1,2,3 | | | 2 | | | | | |
| *Ochrotrichia* | | | | 3 | 3 | | 3 | 3 | 3 | | | |
| *Oxyethira* | | | | 3 | | | | | | | | |
| Leptoceridae | | | | | | | | | | | 2,Q3 | |
| *Triaenodes* | Q2 | | | | | | | | | | 2 | |
| Limnephilidae | 2 | | | 3 | | | | | | | 2,3 | |
| *Hydatophylax* | Q2,Q3 | | 2,3 | Q3 | | | | Q3 | Q2 | | | |
| *Ironoquia* | Q3 | | 2 | 2,3 | 3 | | | 3 | 1 | 1 | 1,2,3 | |
| *Neophylax* | 1,2,3 | | Q2,3 | 1,2,3 | 3 | | | Q2 | | 1 | 1 | |
| *Pycnopsyche* | 1,Q2,Q3 | | Q2,Q3 | Q1,2,3 | | | | | | | 1 | |
| Odontoceridae | | | | | | | | | | 1 | 1,2,3 | |
| *Psilotreta* | 2,3 | | | | | | | | | | | |
| Philopotamidae | | | | | | | | | | | | |
| *Chimarra* | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 1,2,3 | | 1,2,3 | 1,2,3 | | 1 | 1,2,3 | 1 |
| *Dolophilodes distinctus* | | | | 3 | | | | | | | | |

Table L.2 (continued)

| Taxon | Site | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BCK 3.25 | BCK 5.15 | BCK 7.87 | BCK 9.40 | BCK 9.91 | BCK 10.32 | BCK 11.09 | BCK 11.83 | BCK 12.36 | GCK 1.4 | GCK 2.4 | GCK 2.7 |
| Trichoptera (cont.) | | | | | | | | | | | | |
| Phryganeidae | | | | | | | | | | | | |
| *Ptilostomis* | | | | Q2 | | 1 | Q2,3 | | | | | |
| Polycentropodidae | | | | | | | | | | | | |
| *Polycentropus* | 1,3 | | | | | 1 | | | | | | |
| Psychomyiidae | | | | | | | | | | | | |
| *Lype diversa* | | | | 2 | | | | | | | | |
| Rhyacophilidae | | | | | | | | | | | | |
| *Rhyacophila* | 1,2,3 | 1 | 1,2,3 | 2,3 | 3 | 1 | Q2 | 3 | | 1 | 1,2,3 | |
| Lepidoptera | | | | | 1 | | | | | | 1 | |
| Coleoptera | | | | | | | | | | | | |
| Dryopidae | | | | | | | | | | | | |
| *Helichus* | 2 | | 1 | | | | Q2 | | | | | |
| Dytiscidae | | | | | | | Q1 | | | | | |
| Elmidae | | 1 | 1 | 1,2,3 | | | | | | | 1 | |
| *Dubiraphia* | 2,3 | | | 3 | | | 3 | | | | 1,Q2,3 | |
| *Optioservus* | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 1,2,3 | | 2,3 | 1,2,3 | | 1 | 1,2,3 | |
| *Stenelmis* | 1,2,3 | 1 | 1,2,3 | 2,3 | 2,3 | | 1,2,3 | 1,2,3 | 3 | 1 | 1,2,3 | |
| Eubriidae | | | | | | | | | | | | |
| *Ectopria* | 1,2 | | | 3 | | | | | | | 1,2,3 | |
| Hydrophilidae | | | | | | | | | | 1 | | |
| Psephenidae | | | | | | | | | | | | |
| *Psephenus herricki* | 1,2,3 | 1 | 2,3 | | 1,2 | | | | | 1 | 1,2,3 | |
| Ptilodactylidae | | | | | | | | | | | | |
| *Anchytarsus bicolor* | 3 | | | | | | 3 | | | 1 | 1,2,3 | |

Table L.2 (continued)

| Taxon | Site | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BCK 3.25 | BCK 5.15 | BCK 7.87 | BCK 9.40 | BCK 9.91 | BCK 10.32 | BCK 11.09 | BCK 11.83 | BCK 12.36 | GCK 1.4 | GCK 2.4 | GCK 2.7 |
| Diptera | | | | 3 | | | | | | | 2 | |
| Ceratopogonidae | 3 | 1 | 1,2,3 | 1,2,3 | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 1,2,3 | 1 | 1,2,3 | 1 |
| Chaoboridae | | | | | | | | | | | | |
| Chaoborus | | | | | 2 | | | | | | | |
| Chironomidae | | | | | | | | | | | | |
| Tanypodinae | 2,3 | | 2,3 | 2,3 | Q1,2,3 | | 2,3 | 2 | Q2 | | | |
| Ablabesmyia | 1 | | 2,3 | Q2,3 | 1,Q2 | 1 | 1,Q3 | | | | | |
| Coelotanypus? | | | | | | | | 3 | | | | |
| Labrundinia | | | | | | | | | | | 2,3 | |
| Labrundinia? | | | | | | | 2 | | | | | |
| Larsia | | 1 | | 1,2 | 1,2,3 | | 1,2,3 | 1,2,3 | | 1 | 1,2 | |
| Larsia? | | | | 3 | 1 | 1 | 1,2,3 | 1,3 | 1 | | 1,2 | |
| Natarsia | 2,3 | | 2 | 1,2,3 | 3 | | 1 | 2,3 | | | 1,2,3 | 1 |
| Nilotanypus | 2,3 | | 3 | | | | | | | 1 | 2,3 | |
| Nilotanypus? | | | 3 | | | | | | | | | |
| Paramerina | | | | | | | | | 1 | | | |
| Procladius | | | | | | | | | | | 2,3 | |
| Rheopelopia? | 1 | | 1 | | | | | | | | | |
| Thienemannimyia gp | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 1,2 | 1 | 1,2,3 | 1 |
| Thienemannimyia? | | | | | | 1 | | | | | | |
| Trissopelopia ogemawi | | | 2 | Q3 | Q2 | | Q2 | | | 1 | 1,2,3 | |
| Trissopelopia? | | | | | | | | | | | 2 | |
| Zavrelimyia | Q2 | 1 | 2 | 2,Q3 | 1,2,3 | | 2,3 | 2,3 | | | 1,2,3 | 1 |
| Zavrelimyia? | | | Q2 | 3 | 2,Q3 | | | 3 | | | 2 | |
| Diamesinae | | | | | | | | | | | | |
| Diamesa | 1 | 1 | 1,3 | 1 | 1,3 | 1 | 1 | | 1 | | | |
| Diamesa? | | | | | | | | | | | 3 | |

Table L.2 (continued)

| Taxon | Site | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BCK 3.25 | BCK 5.15 | BCK 7.87 | BCK 9.40 | BCK 9.91 | BCK 10.32 | BCK 11.09 | BCK 11.83 | BCK 12.36 | GCK 1.4 | GCK 2.4 | GCK 2.7 |
| Chironomidae (cont.) | | | | | | | | | | | | |
| Orthocladiinae | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 1,2,3 | 1 | 1,2,3 | 1,3 | 1,3 | | | |
| Orthocladini | | | | | | | | | | | | |
| Acricotopus | | | | | | | | | 3 | | | |
| Brillia | 2 | Q1 | 1,2 | 2 | 2 | | 1 | | | | | |
| Chaetocladius | | | 2,3 | 1,2,3 | 2 | | | 3 | 1,3 | | 3 | |
| Chaetocladius? | | | 2,3 | 3 | 2,3 | 2 | 3 | | | | | |
| Chaetocladius?? | | | 3 | | | | | | | | | |
| Corynoneura | 1,2,3 | 1 | 2,3 | 1,2,3 | 1,3 | 1 | 2,3 | 2,3 | 1 | | 2,3 | 1 |
| Cricotopus/ Orthocladius | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 1,2,3 | | 3 | 1 |
| Cricotopus/ Orthocladius? | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | |
| Diplocladius | | | 1 | 1,2 | 1,2,3 | 1 | 1,2 | 1 | | 1 | | |
| Eukiefferiella | 1,2,3 | | 1 | 1,2,3 | 1 | | 3 | 3 | | | 1,3 | |
| Heleniella | | | | 1,2,3 | | | 2 | | | | 1,2,3 | |
| Heleniella? | | | | | 2 | | | | | | | |
| Heterotrissocladius | 3 | 1 | Q2 | 2,3 | | | Q3 | | | | 1,2,3 | |
| Hydrobaenus | | | Q2 | | | 1 | | | Q3 | | | |
| Hydrobaenus? | | | | | | 1 | | | | | | |
| Nanocladius | 2,3 | | 2,3 | 2,3 | 1,3 | | 3 | | | 1 | 2 | |
| Orthocladius | 1 | | 1 | | 1 | | | | | | | |
| Parachaetocladius | 1 | | | | | | | | | | 1,2,3 | |
| Paracladius | | 1 | 1 | 1 | | | | | | | | |
| Paracladius? | 1 | | 1,3 | 1 | 1 | 1 | 1 | 1 | 1 | | | 1 |
| Paracricotopus | | | | | | | | | | | 3 | |
| Parakiefferiella | | | 2 | 3 | | | | | 1 | | 2,3 | |
| Parakiefferiella? | | 1 | 2 | | | | | | | | | |
| Parametriocnemus | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 1,2,3 | 1 | 1,2,3 | 3 | 1,3 | 1 | 1,2,3 | 1 |
| Parametriocnemus? | | | 2 | | | | | | | | | |

Table L.2 (continued)

| Taxon | Site | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BCK 3.25 | BCK 5.15 | BCK 7.87 | BCK 9.40 | BCK 9.91 | BCK 10.32 | BCK 11.09 | BCK 11.83 | BCK 12.36 | GCK 1.4 | GCK 2.4 | GCK 2.7 |
| Chironomidae (cont.) | | | | | | | | | | | | |
| Paraphaenocladius | | | | Q1 | | | | Q1 | | 1 | | |
| Paratrichocladius | | | | 1 | 1 | 1 | 1 | 1 | 1 | | | |
| Paratrichocladius? | | | | | 3 | | | | | | | |
| Psectrocladius | | 1 | 1 | 1 | | | | 1,3 | 3 | | | |
| Pseudorthocladius | | | 1,3 | 3 | 3 | | 2,3 | | | | | |
| Pseudorthocladius? | | | 2 | | | | | | | | | |
| Pseudosmittia | | | | | | | 1,2 | | | | | |
| Pseudosmittia? | | | | | | | | | 3 | | | |
| Psilometriocnemus | | | | | | | | | 1 | | 3 | |
| Rheocricotopus | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 1,2,3 | 1 | 1,2,3 | 3 | 1 | | 3 | |
| Smittia | | | | | 1 | | | | | | | |
| Symposiocladius | | | | | Q2,3 | | | | | | | |
| Symposiocladius lignicola | | | 1 | | | | | | | 1 | | |
| Synorthocladius | 1,2 | | | | | | | | | | | |
| Thienemanniella | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 2,3 | 1 | 1,2,3 | | | 1 | 2,3 | 1 |
| Trissocladius | | | | | | | | | | | 3 | |
| Tvetenia | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 1,2,3 | 1 | 1,2,3 | 1,3 | | 1 | 2,3 | 1 |
| Tvetenia? | 2 | | | | | | | | | | | |
| Xylotopus par | | | 1 | | | | | | | | 1,2 | |
| Chironominae | | | | | | | | | | | | |
| Chironomini | | | 2 | | | | 3 | | | | 2,3 | |
| Chironomus | | | | | 2 | | | | | | Q1,Q2,3 | |
| Cladopelma | | | | | | | | | | | 2,3 | |
| Cryptochironomus | 1,2 | | Q2 | 1,Q2 | 1,Q3 | | | 2 | | Q1 | 1,2,3 | |
| Dicrotendipes | | | | 1 | | | 2 | | | | | |
| Dicrotendipes? | | | | 3 | | | | | | | | |

Table L.2 (continued)

| Taxon | Site | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BCK 3.25 | BCK 5.15 | BCK 7.87 | BCK 9.40 | BCK 9.91 | BCK 10.32 | BCK 11.09 | BCK 11.83 | BCK 12.36 | GCK 1.4 | GCK 2.4 | GCK 2.7 |
| Chironomidae (cont.) | | | | | | | | | | | | |
| Goeldichironomus | | | | | | | | 3 | | | | |
| Goeldichironomus holoprasinus | | | | | | | | | 1 | | | |
| Microtendipes | 3 | | | | | | | | | 1 | 1,2,3 | |
| Paralauterborniella | | | | 3 | 2 | | | | | | 2,3 | |
| Paratendipes | 2 | | | Q2,3 | | | | | | | 3 | |
| Phaenopsectra | 1 | | 2,3 | 3 | | | | | | 1 | | |
| Polypedilum | 1,2,3 | 1 | 2,3 | 1,2,3 | 1,Q2,3 | | | 1,3 | | 1 | 1,2,3 | |
| Stenochironomus | 1 | | | | | | | | | | 2 | |
| Stictochironomus | | | | | | | | | | | Q2 | |
| Tribelos | Q2 | | | | | | | | | | 1,2,3 | |
| Tribelos? | | | | | | | | | | | 2 | |
| Tanytarsini | 2,3 | | 2,3 | 2,3 | 2,3 | | 3 | | | | | |
| Krenosectra? | | | | | | | 1 | | | | | |
| Micropsectra | Q2,3 | | 2 | 1 | 2,3 | | 2 | | | | 2,3 | 1 |
| Micropsectra? | | | | 2,3 | | | | | | | | |
| Paratanytarsus | | | 2,3 | 2 | 2 | | | | | | | |
| Paratanytarsus? | | | 2,3 | | | | | | | | | |
| Rheotanytarsus | 2 | | 1,2,3 | | 2 | | | | | 1 | 2,3 | |
| Stempellina | | | | | | | | | | | 2,3 | |
| Stempellinella | 3 | 1 | | | 2 | | | | | 1 | 1,2,3 | |
| Tanytarsus | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 2,3 | | Q2 | | | 1 | 1,2,3 | |
| Tanytarsus? | | | 2 | 3 | 3 | | | | | | | |
| Culicidae | | | | | | | | | | | | |
| Anopheles | | | | | | | 1,2 | | | | | |
| Dixidae | | | | | | | | | | | | |
| Dixa | Q2,3 | | | | | | | | | 1 | 1,2,3 | |
| Empididae | | 1 | 1 | 1,3 | | 1 | | | | 1 | | |
| Hemerodromia | 2,3 | | 2,3 | 2,3 | 2 | | | 1,2 | | | | |

Table L.2 (continued)

| Taxon | Site | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BCK 3.25 | BCK 5.15 | BCK 7.87 | BCK 9.40 | BCK 9.91 | BCK 10.32 | BCK 11.09 | BCK 11.83 | BCK 12.36 | GCK 1.4 | GCK 2.4 | GCK 2.7 |
| Diptera (cont.) | | | | | | | | | | | | |
| Ephydridae | | | | | | | 2 | | | | | |
| Psychodidae | | | | | | | | | | | | |
| *Pericoma* | | | | | | | | | | | 3 | |
| Simuliidae | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 2,3 | | 1,2 | 1,2 | 1,2 | 1 | 1,3 | 1 |
| Stratiomyidae | | | | 3 | 3 | | 3 | Q2 | | | | |
| *Stratiomys* | | | | 3 | | | | | | | | |
| Tabanidae | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 1,2,3 | 1 | 1,2,3 | 1,2,3 | | 1 | 1,2,3 | |
| *Chrysops* | | 1 | | 1 | | | | 1 | | | 1 | |
| *Chrysops*? | | | | | | | | | | | 1 | |
| *Tabanus* | | | 1 | | | | | | | | | |
| Tipulidae | 2 | 1 | 1,Q3 | 1,3 | 1 | | 3 | 3 | | 1 | 1,2,3 | 1 |
| *Antocha* | 1,2,3 | | | | | | | | | 1 | | |
| *Hexatoma* | Q2 | | | | | | | | | 1 | 1,3 | |
| *Pseudolimnophila* | 1 | 1 | 1 | | | | | | | 1 | 1,Q2,Q3 | 1 |
| *Tipula* | 1,2,3 | 1 | 1,2,3 | 1,2,3 | 1,2,3 | 1 | 1,2,Q3 | 1,3 | | 1 | 1,2,Q3 | |
| Mollusca | | | | | | | | | | | | |
| Gastropoda | | | | | | | | | | | | |
| Ancylidae | | | | | | | | | | | | |
| *Ferrissia* | 3 | | | | | | | | | | | |
| Bithyniidae | | | | | | | | | | 1 | | 1 |
| Hydrobiidae | | | | | | | | | | | | |
| *Amnicola* | | | | 3 | | | | | | | | |
| Lyanaeidae | | | 3 | Q2 | 3 | | 3 | | | | | |
| Lymnaeinae | | | | | 1 | | | | | | | |
| *Fossaria* | | | | 3 | | | Q2,3 | | | | | |
| *Lymnaea* | | | | | | | 1 | | | | | |
| Physidae | | | | | | | | | | | | |
| *Physella* | 1,2,3 | | | 3 | Q2,3 | 1 | 2,3 | 2,3 | 3 | | Q2,3 | |

Table L.2 (continued)

| Taxon | Site | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BCK 3.25 | BCK 5.15 | BCK 7.87 | BCK 9.40 | BCK 9.91 | BCK 10.32 | BCK 11.09 | BCK 11.83 | BCK 12.36 | GCK 1.4 | GCK 2.4 | GCK 2.7 |
| Mollusca (cont.) | | | | | | | | | | | | |
| Pleuroceridae | | | | | | | | | | | | |
| *Elimia* | 1,2,3 | | 3 | 1 | | | Q3 | | | 1 | 1,2,3 | |
| *Pleurocera* | 1,2,3 | | | | | | | | | Q1 | | |
| Pelecypoda | | | | | | | | | | | | |
| Sphaeriidae | | | | | | | | | | | | |
| *Pisidium* | Q1 | | | | | | | | | | 3 | |
| *Sphaerium* | | | | | | | | | | 1 | 1 | |

APPENDIX M. TOPOGRAPHIC MAP SET (1:100/2 FT CONTOUR INTERVAL) OF BEAR CREEK AREA WITH RFI PLAN SAMPLING/MONITORING LOCATIONS

## DISTRIBUTION

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