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# Active Sites Environmental Monitoring Program: Mid–FY 1991 Report

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Environmental Sciences Division
Publication No. 3700

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Environmental Sciences Division

# ACTIVE SITES ENVIRONMENTAL MONITORING PROGRAM: MID-FY 1991 REPORT

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## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| ACD | Analytical Chemistry Division |
| ASEMP | Active Sites Environmental Monitoring Program |
| BMP | Best Management Practices |
| DOE | Department of Energy |
| ESD | Environmental Sciences Division |
| HDTF | Hillcut Disposal Test Facility |
| IT | Intratrench |
| LLW | Low-Level Waste |
| NPDES | National Pollutant Discharge Elimination System |
| ORNL | Oak Ridge National Laboratory |
| PVC | Polyvinyl chloride |
| PWT | Perched water table |
| RCRA | Resource Conservation and Recovery Act |
| SWSA | Solid Waste Storage Area |
| TMOI | Tumulus I |
| TMOII | Tumulus II |
| TOC | Total organic carbon |
| TRU | Transuranic |
| UND | Underpad drain |
| WOC | White Oak Creek |

# EXECUTIVE SUMMARY

This report summarizes the activities of the Active Sites Environmental Monitoring Program (ASEMP) from October 1990 through March 1991. The ASEMP was established in 1989 by Solid Waste Operations and the Environmental Sciences Division to provide early detection and performance monitoring at active low-level radioactive waste (LLW) disposal sites in Solid Waste Storage Area (SWSA) 6 and transuranic (TRU) waste storage sites in SWSA 5 as required by chapters II and III of U.S. Department of Energy Order 5820.2A.

Monitoring results continue to demonstrate that no LLW is being leached from the storage vaults on the tumulus pads. Loading of vaults on Tumulus II began during this reporting period, and 115 vaults had been loaded by the end of March 1991.

Tumulus I was covered throughout the period of this report; however, the cover leaks, and as much as 2000 gal of water can accumulate on the pad during a prolonged rain event. This accumulated water has a pH of ~10 and contains gross beta concentrations that exceed the 5.0 Bq/L ASEMP action level (up to 25 Bq/L). Gross beta concentrations, which are primarily derived from $^{40}K$, are strongly correlated with specific conductance. Elevated values for pH, gross beta concentrations ($^{40}K$), and specific conductance all suggest that concrete in the vaults and/or pad is being leached by accumulating rain water. The impact of such leaching on the long-term performance of the concrete should be evaluated.

Continuous-reading pH probes were installed in the tumulus monitoring shed flume and in the small receiving stream about 50 m downstream from the discharge of the monitoring shed. Data from these probes indicate the pH of the stream increased to more than 10 when the runoff from Tumulus I was discharged. Seven-day toxicity tests using *Ceriodaphnia spp.* were conducted on the Tumulus I runoff. These tests showed the high-pH water was toxic; however, a biological survey of the stream indicated the benthic invertebrate fauna below the Tumulus discharge point was not adversely affected by the relatively short duration pH excursions.

The runoff from Tumulus II has shown an increasing trend in pH, but all composite samples have been at or below 9. The continuous-reading probe in the flume, however, indicates that instantaneous pH values from Tumulus II runoff exceeded 9 on at least two occasions. Stream pH was not significantly impacted because there was sufficient flow in the stream to dilute the effect of the runoff. Gross beta concentrations in composite samples of Tumulus II runoff have remained below the 5.0-Bq/L action level.

Groundwater monitoring data from the tumulus wells continue to show the plume of tritium believed to originate from the discharge of the 49-Trench area French drain. This problem was reported in FY 1990, and corrective actions were taken then. However, it will be several more months before the effectiveness of those actions can be assessed.

Monitoring results from the intratrench wells around LLW silos and the wells around auger holes, asbestos silos, and fissile wells continue to show that no LLW is being leached from grouted silos. Intratrench well 19 contained water with elevated gross beta concentrations (30–85 Bq/L), primarily caused by $^{90}Sr$. This well is in a trench where the silos were not filled with grout.

An expanded investigation of radioactive contamination in ground water under SWSA 5 North was completed. Curium-244 and $^{241}Am$ appear to have been leached from

TRU burial trenches and transported to White Oak Creek (WOC). Curium-244 concentrations approaching 70 Bq/L and $^{241}Am$ concentrations of 1 Bq/L were measured in a water sample from one seep (in the bank of WOC) that is along geologic strike with the burial trenches.

Well 516, just down slope from the SWSA 5 North trenches, continues to show variable levels of $^{244}Cm$ and $^{241}Am$. No other ASEMP-monitored wells in or around SWSA 5 North have been found to contain measurable levels of alpha-emitting radionuclides. However, a sample from well 982 (monitored by another group) was reported to contain 1 Bq/L of gross alpha contamination. Well 982 is located southwest of SWSA 5 North and is not along the presumed geologic strike with the burial trenches although it is topographically down slope from the trenches.

Previously measured gross alpha contamination in the small tributary south of SWSA 5 North was confirmed. No transuranic isotopes were detected in the most recent samples from this stream, which suggests that the alpha-emitting contamination does not originate in SWSA 5 North. The stream is also topographically down slope from LLW burial areas in SWSA 5.

# 1. INTRODUCTION

Chapter III of U.S. Department of Energy (DOE) Order 5820.2A (USDOE 1988) sets forth requirements for management of the facilities in Solid Waste Storage Area (SWSA) 6 (Fig. A.1) that were used for disposal of solid low-level radioactive waste (LLW) on or after the date of the order (September 26, 1988). The transuranic (TRU) waste storage areas in SWSA 5 North (Fig. A.2) are covered by Chapter II of the order. Both chapters require environmental monitoring to provide early warning of leaks before those leaks pose a threat to human health or the environment. Chapter III also requires that monitoring be conducted to evaluate the short- and long-term performance of LLW disposal facilities. In accordance with this order, the Solid Waste Operations Department at Oak Ridge National Laboratory (ORNL) has established an Active Sites Environmental Monitoring Program (ASEMP) that is implemented by staff of the Environmental Sciences Division (ESD) at Oak Ridge National Laboratory (ORNL).

This report summarizes data from ASEMP activities for the first 6 months of FY 1991. The monitoring methodology is described in the ASEMP program plan (Ashwood et al. 1990a).

# 2. SWSA 6 LOW-LEVEL WASTE FACILITIES

## 2.1 TUMULUS FACILITIES

Environmental monitoring of the tumulus facilities (Fig. A.3) consists of groundwater monitoring, pad runoff sampling, sampling of water from the underpad drain, and measurement of meteorological parameters.

Tumulus I is completely loaded and is covered by a plastic tarp, although the cover leaks, resulting in substantial amounts of water (as much as 2000 gal) reaching the concrete vaults and pad. Loading of Tumulus II began in October 1990, and the pad was approximately 70% loaded as of 31 March 1991.

### 2.1.1 Pad Runoff

#### 2.1.1.1 Methodology

Samples of runoff from the Tumulus II pad are collected by a flow proportional sampler such that a 500-mL sample is collected for every 500 L of flow that passes through the Parshall flume in the monitoring shed. A portion of the composite sample is used to measure pH and specific conductance in the laboratory, and appropriate volumes are sent to the Analytical Chemistry Division (ACD) at ORNL for gross alpha, gross beta, gamma scan, and total organic carbon (TOC) analyses.

Tumulus I pad drain lines are normally valved closed. Samples of accumulated water on the Tumulus I pad are collected (after the composite sampler is emptied of pad II runoff water) by opening the Tumulus I pad drain lines and manually operating the sampler.

In March 1991, two continuous-reading pH probes were installed to quantify the pH changes that occur during pad runoff and to identify any pH fluctuations in the stream that accepts Tumulus drainage. One probe was installed in the monitoring shed flume, and the second probe was installed in the stream approximately 150 ft downstream of the Tumulus

outfall (Fig. A.3). Both probes are connected to the same data logging system (located in the monitoring shed) that records flow through the flume and rainfall. Average pH values are recorded at 5-min intervals.

Periodic samples are also collected from the underpad drains from both pads and from the Tumulus I construction base drain. These samples are analyzed by ACD for tritium and the same parameters as the pad runoff samples.

### 2.1.1.2 Tumulus II Results

Twenty-three composite samples of runoff from pad II and two samples from the underpad drain were collected during this six-month reporting period (Table B.1). Data from the composite samples indicate a rapid rise in pH after the first 50 vaults were loaded and then a more gradual and variable rise to the end of this reporting period at which time there were 115 vaults on the pad (Fig. A.4).

The maximum pH observed in the composite samples was 9.0 (Fig. A.5 and Table B.1), which is the maximum allowable pH under the National Pollutant Discharge Elimination System (NPDES) permit for the Tumulus area discharge. More recent data, obtained by the continuous-reading pH probe in the monitoring shed, show that the instantaneous pH of the runoff from Tumulus II often rises above 9 (Fig. A.6). Fluctuations in the pH of Tumulus II runoff produce only small pH perturbations in West Tributary (Fig. A.6) probably because the runoff is diluted by relatively high rain-induced flow in the stream. On the other hand, high pH runoff from Tumulus I has a significant impact on the pH in West Tributary because Tumulus I runoff is not released until sometime after rainfall has stopped and the stream has begun to return to base flow.

Gross beta concentrations in the Tumulus II runoff have increased slightly since loading began (Fig. A.7), but only one sample has exceeded the first action level of 5 Bq/L, apparently due to $^{40}K$ (Table B.1). Other radionuclides were at or below minimum detectable concentrations in all samples (Table B.1).

TOC levels have decreased substantially since the early samples (Fig. A.8), probably due to the washing off of residual sealant that was applied to the pad before loading began.

Specific conductance (Fig. A.9) has fluctuated considerably, but there appears to be a correlation between higher specific conductance and elevated gross beta concentrations (Fig. A.10a). Leaching of concrete from the pad and/or vaults may result in increased dissolved ions (including K), which increases specific conductance, causing a corresponding increase in $^{40}K$ and gross beta concentrations.

The most recent sample of the Tumulus II underpad drain water contained a high concentration of tritium (Table B.1). The cause of this elevated tritium concentration is unknown, and samples will be taken more frequently from the underpad drain in order to determine if this is a recurrent phenomenon.

### 2.1.1.3 Tumulus I Results

Twenty-five samples of water were collected from Tumulus I during this reporting period (Table B.1). Twenty-three of these samples were collected as grab samples as described above, while samples 364 and 366 were collected as composite samples before Tumulus II operations began. Calculations based on flow rate through the monitoring shed flume when water is released from pad I indicate that ~2000 gal of water may accumulate on the pad during heavy or prolonged rainfall.

Nineteen samples of pad runoff had a pH greater than 10.0 (Table B.1). A sample of Tumulus I pad runoff was tested for toxicity using a 7-d *Ceriodaphnia* test (Appendix C). Results of this test indicated that the runoff is toxic. In addition, a survey was conducted of benthic invertebrates above and below the tumulus discharge into West Tributary. Results of this survey (Appendix C) indicate that the stream fauna is not impacted by the relatively short duration episodes of high pH.

Twenty-three of the 25 samples contained gross beta concentrations greater than the 5-Bq/L action level, with a maximum concentration of 25 ± 4 Bq/L (Fig. A.11 and Table B.1). Gross beta concentrations were accompanied by elevated $^{40}K$ concentration (Fig. A.12). All other radionuclide parameters in all samples of pad water were at or below minimum detectable concentrations.

TOC concentrations declined substantially over this reporting period (Fig. A.13). This may be the result of decreased algal growth on the covered pad. Considerable algal growth was apparent during the previous reporting period.

Specific conductance levels varied throughout the period, but generally remained above 1000 µS/cm (Table B.1 and Fig. A.14). As was the case with Tumulus II, higher specific conductance appears to correlate with elevated gross beta concentrations, probably due to ions leached from the concrete (Fig. A.10b).

The most recent samples from the perched water table and the Tumulus I underpad drain indicate slightly elevated tritium concentrations (Table B.1). Further investigation of the cause of the elevated concentrations is needed.

## 2.1.2 Groundwater Monitoring

### 2.1.2.1 Methodology

The Tumulus pads are encircled by twelve monitoring wells (Fig. A.3) that were drilled to auger refusal and are finished in zones of permanent groundwater (Wickliff et al. 1991b). Exact construction details of well 381 are uncertain because this well was drilled prior to the start of Tumulus activities. All of the wells contain a pressure transducer (either Druck series 830 or 930) for continuous monitoring of water levels. Each transducer is connected to an Omnidata EZLogger or Datapod II, and water levels are recorded at 15-min intervals as the average of instantaneous levels recorded at 5-min intervals.

Each well (excluding 381) contains a dedicated bladder pump and is sampled on a quarterly basis for radiological and field parameters (e.g., pH and specific conductance). Field parameters are measured using a Hydrolab Model II sample analyzer equipped with a flow through cell. Samples from selected wells are collected on an annual basis for cation, anion, TOC, volatile, and semivolatile organic analyses.

### 2.1.2.2 Results

Figure A.15 displays approximate groundwater elevation contours in the Tumulus area during a relatively dry period (27 November 1990) and during a relatively wet period (21 December 1990). The contours suggest that groundwater flow is generally to the south toward White Oak Lake and to the southwest (particularly during high water periods) toward West Tributary. However, these contours provide only a general indication of groundwater flow in the area because there are too few wells to show detailed flow paths. As suggested by the tritium plume that intersects wells 1036 and 1039 (Table B.2), movement of groundwater along geologic strike (west–southwest) is probably more important than indicated by the contours.

Only partial analytical results from one round of sampling are available (Table B.2). Tritium concentrations in well 1036 have increased since the last sampling (Fig. A.16a), while tritium concentrations in well 1039 have decreased during the same period (Fig. A.16b). Th source of this tritium is believed to be the old outfall from the French drain that drains the 49-trench area (Davis et al. 1985). All other radionuclide parameters reported to date are below minimum detectable concentrations.

### 2.1.3 Meteorological Conditions

### 2.1.3.1 Methodology

A meteorological station equipped with instrumentation to measure wind speed and direction, air temperature, relative humidity, and solar irradiation is positioned just to the south of the Tumulus area near well 1037 (Fig. A.3). Data is recorded from each of the sensors at 15-min intervals and is reported as an hourly average. Also, a tipping bucket rain gage is mounted atop the Tumulus monitoring shed and is connected to the shed data logging system. Rainfall is recorded as the total received during a 15-min interval.

### 2.1.3.2 Results

Data for this 6-month reporting period indicate that the prevailing winds were mainly from the southwest in the Tumulus area. Table B.3 provides the monthly rainfall, average temperatures, average relative humidity, and average solar irradiation for this reporting period.

### 2.1.4 Conclusions and Recommendations

Environmental monitoring activities associated with the Tumulus disposal facility continue to show that this system is performing as an effective method of disposal for solid LLW. No releases of radioactive material from the waste have been detected in any samples to date. Elevated pH and gross beta concentrations in the pad runoff most likely result from leaching of the concrete pads and/or vaults. The short-term impact of elevated pH may be to cause potential violations of the NPDES permit at the Tumulus outfall, but this effect is controllable through proper effluent management and treatment. The long-term impact on the integrity of the containment system due to concrete leaching may be a more significant problem which requires continued observation and monitoring.

The following recommendations are offered in an attempt to eliminate or reduce specific problems or to improve the effectiveness of the monitoring activities.

1. Provide an improved temporary cover over pad I to eliminate or at least greatly reduce the volume of accumulated water with its attendant pH and gross beta problems.

2. Increase the frequency of sampling the underpad drains and the construction base drain especially during high groundwater periods due to the recent evidence of elevated tritium concentrations.

3. Check the integrity of the liner under Tumulus I and the integrity of the underpad drain line. The Tumulus I underpad drain should not be accumulating water.

## 2.2 LLW SILOS, AUGER HOLES, FISSILE WELLS, AND ASBESTOS SILOS

### 2.2.1 Methodology

LLW silos in SWSA 6 are generally installed in groups of four within a single trench. Davis et al. (1989) demonstrated that some of these silos leak. Therefore, in order to provide early contaminant detection within each trench, 2-in. drive-point monitoring wells with 5-ft screened sections were installed in May 1990 in trenches that previously were without monitoring wells. The intratrench (IT) wells are equipped with weighted sample bottles (monitored quarterly) that collect water when perched water table conditions exist within the trenches as a result of subsurface stormflow. These wells provide a way to monitor groups of silos for containment failure, leaching of wastes, and contaminant transport.

Similar drivepoint wells were installed in the backfilled soil next to high-activity auger holes, fissile wells, and asbestos silos (not in trenches), and these wells are also sampled quarterly.

Samples are prepared for analyses by acidifying the sample to pH < 2 before filtration so that contamination is detected whether it is part of the dissolved load or adsorbed on suspended sediment in the well. Quarterly samples are analyzed for gamma-emitting isotopes by ESD and ACD and for gross alpha and gross beta concentrations by ACD. Both ESD and ACD have documented QA/QC programs for their counting and analytical labs.*

### 2.2.2 Results

The first FY 1991 quarterly sampling of IT wells and of wells adjacent to asbestos silos, high-activity auger holes, and fissile wells was completed in December 1990. Conditions were fairly dry, and only 14 of the 44 IT wells had sufficient water for sample collection. Only one well in the auger hole area had sufficient water. Samples were collected from both wells next to the two asbestos silos and from both wells next to the two fissile wells.

* For details on the QA/QC programs, contact I. L. Larsen (ESD) and J. R. Stokely, Jr. (ACD).

The second FY 1991 quarterly sampling was completed in February. Samples were collected from 31 of the 44 IT wells, from both wells next to the two asbestos silos, and from both wells next to the two fissile wells. Samples were also collected from 8 of the 9 wells in the auger hole area. Many of the wells had water remaining in them even after 250 mL had been collected for the sample.

Cesium-137 and $^{60}Co$ concentrations were each near or below the minimum detectable activity (2.5 Bq/L) in IT wells and in wells next to asbestos silos, high activity auger holes, and fissile wells (Tables B.4–B.6).

Gross alpha and gross beta concentrations were below action levels of 1 Bq/L and 5 Bq/L, respectively, in wells next to the high activity auger holes, fissile wells, and asbestos silos, except for well C595 (Table B.5). The gross alpha concentration in well C595 ($1.4 \pm 0.7$ Bq/L) exceeds the action level, and future samples from this well will be analyzed for specific alpha-emitting isotopes. The gross alpha concentration in IT well 36, which was above the action level in September 1990 (Wickliff et al. 1991b: Table 6), is now at background concentrations (Table B.5).

Gross alpha and gross beta concentrations were also below action levels in the IT wells, with the exception of the gross beta activity in IT Well 19 (Tables B.4 and B.6). Samples from IT Well 19 consistently have elevated gross beta concentrations, primarily resulting from elevated $^{90}Sr$ activity. The sample from IT Well 19 from the second FY 1991 quarterly sampling was divided into two portions. One portion was acidified before filtration (sample 19A: Table B.6), and the second portion was filtered before acid was added (sample 19B: Table B.6). Each portion was submitted for $^{90}Sr$ analysis in addition to gamma, gross alpha, and gross beta analyses. Results suggest that most of the gross beta and $^{90}Sr$ activity is dissolved rather than adsorbed to sediment in the bottom of the well (Table B.6).

The $^{90}Sr$ concentration in IT Well 19 suggests one of three possible contaminant pathways: (1) one or more of the silos (Nos. 498-501) within the trench (Fig. A.17) may have containment failure that allows water to enter the waste and leach contaminants, (2) shallow storm flow entering the trench has been contaminated by shallow soil in the area, or (3) contaminated groundwater below the trench occasionally enters the trench. The silos within this trench were installed using precast concrete drainage pipes obtained from the Clinch River Breeder Reactor Project, and the wastes within the silos were not grouted. Furthermore, Davis et al. (1989) demonstrated that water can leak into and out of the silos constructed in this fashion. However, only one of the four silos within the trench has an internal polyvinyl chloride (PVC) monitoring well. A weighted sample bottle was installed in the internal well on 7 February 1991 and checked on 22 February 1991 after 7 in. of rain had been received. The bottle was dry, which suggests that no water had been present within this one silo during this wet period. Thus, at this time, we do not have sufficient information to conclusively determine the cause of the $^{90}Sr$ contamination. An action plan for further investigation will be developed.

Because most of the $^{90}Sr$ activity is associated with the dissolved phase, contaminant transport from the trench is possible. However, we have no data to confirm that such transport is actually occurring. Although this is not an active site under the definition in DOE order 5820.2A, remediation of the silos and/or trench is recommended to prevent any future release of radionuclides.

## 2.3 HILLCUT DISPOSAL TEST FACILITY

A draft of Best Management Practices (BMP) Guidelines was prepared in October 1990 to accompany a contingency plan prepared in September 1990 for the Hillcut Disposal Test Facility (HDTF). The BMP guidelines are required as part of the NPDES permitting process.

Runoff from the pad is designed to collect in an above-grade tank (tank No.1) at the HDTF. Volume measurements of pad runoff were made weekly and remained minimal through December 1990. Pad runoff samples were collected from tank No.1 on four occasions when the tank was found to be near or at its maximum capacity. After a sample was collected, the contents of tank No.1 were transferred to a holding tank until radionuclide results were received. Samples were submitted to ACD for gamma scan, gross alpha, and gross beta analyses. During the period of monitoring, October 1990 through March 1991, radionuclide concentrations in samples collected from tank No.1 were below action levels (Table B.7).

Runoff from the underpad gravel drain is also designed to collect in an above-grade tank (tank No.2). Tank No.2 remained dry during the monitoring period, except during February 1991. On 20 February 1991, tank No.2 was found full. A sample was collected, and the water was transferred to a holding tank. The tank was found full again on the 21 February 1991, and another sample was collected and the water transferred. Water collected from tank No.2 on 20 February 1991 had a gross alpha activity of $4.0 \pm 1.4$ Bq/L (Table B.7). Elevated gross alpha activity has never been found in previous samples from the pad or underpad gravel runoff, and elevated gross alpha activity was not found in the subsequent sample collected 21 February 1991 from tank No.2. The reason for the gross alpha anomaly is not known; however, the boxes of waste are not suspected to be the source of the gross alpha activity because leakage from the boxes would have included high levels of gamma-emitting radionuclides. Instead, concentrations of gamma-emitting isotopes in the runoff collected on 20 and 21 February 1991 were at or below minimum-detectable-activity levels (Table B.7).

A leak in the bottom of tank No.2 was found in February 1991, and actions were taken to reroute the water to a different holding tank. In March 1991, a temporary fix was completed by capping the 8-in. inflow pipe to tank No.2. A 2-in. flexible hose was tapped into the cap to divert groundwater runoff to a holding tank down slope from HDTF.

Two wells at HDTF (one in the gravel layer and one on the pad) were monitored weekly during the period, except from 16 January to 6 March 1991, when the well measuring device was lost and a new one was made. The well in the gravel layer around the pad remained dry except for the last week of December 1990 and the first week of January 1991. Weekly water levels in the well on the pad remained fairly constant. Water levels indicate that a small amount of standing water (depth $\leq 0.5$ in.) remained on the pad during dry periods and that water on the pad remained $< 1$ in. deep during the wetter conditions in December 1990.

Installation of four groundwater wells around the facility has been delayed until approved National Environmental Policy Act documentation is received from DOE. The wells will be used to define hydrogeology of the area and to demonstrate that no contamination is leaving the site via groundwater.

# 3. TRANSURANIC WASTE FACILITIES IN SWSA 5 NORTH

## 3.1 BACKGROUND

As part of the ASEMP, streams and groundwater wells around the TRU waste storage area in SWSA 5 North are sampled quarterly (Ashwood et al. 1990a). Well 516, immediately down-gradient from a group of TRU waste trenches (Fig. A.2), contains gross alpha activity varying from 30–150 Bq/L (Ashwood et al., 1990b; Wickliff et al. 1991a,b). Curium-244 is the dominant radionuclide, with traces of $^{241,243}Am$ having been reported from separate samples. The TRU waste trenches also contain some Resource Conservation and Recovery Act (RCRA)-regulated wastes—primarily elemental lead (Stewart et al. 1989). Samples from well 516 have not contained detectable concentrations of volatile organics. Metal concentrations have been below regulatory concern. The trenches are upgradient from White Oak Creek (WOC) which drains most of ORNL and eventually enters the Clinch River.

Because WOC represents a direct pathway off site, certain regulatory reporting and corrective action requirements may be invoked if radionuclides or heavy metals have been released to the stream. An action plan for further investigation of the extent of TRU contamination in the groundwater and possibly WOC was developed and implemented (Appendix D).

Phase 1 of the action plan involved review of existing information (primarily from RCRA groundwater wells between SWSA 5 North and WOC), water sampling along the reach of WOC adjacent to SWSA 5 North, sampling of seeps between the TRU burial trenches and WOC, sampling of wells in the vicinity of SWSA 5 North, and installation and analysis of $MnO_2$-coated fiber samplers at several locations along WOC adjacent to SWSA 5 North. The objective of Phase 1 was to determine if TRU contamination from the TRU burial trenches had reached WOC.

## 3.2 METHODS

In addition to the routine quarterly samples from wells, seeps, and streams, (Ashwood et al. 1990a, Wickliff et al. 1991a,b), water samples were collected from WOC, wells 708, 715, and 716, and several seeps not previously sampled (Table B.8). Well samples were taken after 1–3 well volumes had been evacuated from the well or after the well had been pumped dry and allowed to recover.

Gamma counting, gross alpha and gross beta analyses were performed on 1-L samples. Separate 250-mL samples were collected for $^{3}H$ and for $^{90}Sr$ analyses. A 100-mL sample was collected from well 516 for metals analysis.

All well samples were filtered through separate 0.45-micron filters and then acidified with $HNO_3$ to pH < 2 ($^{3}H$ samples were not acidified). Most WOC and other stream samples collected as part of the Phase 1 investigation were acidified, but not filtered, because we wanted to include the contribution of any activity on suspended particles. Seep samples were filtered prior to acidification. Normally, samples are filtered and acidified the day of collection; however, December 1990 seep samples were neither filtered nor acidified until several days after collection.

One round of samples from RCRA-compliance monitoring wells 982–984 were collected by ORNL Environmental Monitoring and Compliance personnel. Results of these samples (without associated counting errors) were obtained from the Consolidated Environmental Data Base.

Three 50-g $MnO_2$-coated fiber samplers were installed in well 516, and ten 100-g $MnO_2$-coated fiber samplers were installed in WOC and South Tributary (Fig. A.2). Fabrication, installation, and analysis of the fiber samplers are discussed in Appendix E. Four days after installation of the samplers in WOC, the area received rainfall equivalent to a 20-year event (D. D. Huff, ORNL, personal communication, 1991), and eight of the samplers were lost in the resultant storm. The two samplers recovered from WOC (Table B.8) had collected a large amount of sediment which was washed from the samplers with deionized water.

In order to determine how sediment might affect the results of WOC water and fiber samples, a 125-mL sample of sediment was collected at the WOC 120 site, and a second water sample was taken at WOC 120 and filtered prior to acidification. Both samples were collected on 18 January 1991.

A second round of samples from the WOC seeps was collected in January 1991 and analyzed for specific transuranic isotopes. A sample was collected from WOC 213 seep again in March 1991.

WOC samples (water, sediment, and fiber) and the fiber and water samples from well 516 were gamma-counted in ESD. All other analyses were performed by ACD. Because the samples in this investigation were considered to be for screening purposes, no special QA/QC actions were taken as part of the investigation.

## 3.3 RESULTS

Gross alpha concentrations in water samples were significantly greater than zero ($p < 0.01$) in well 516 and the two sample locations on South Tributary (Table B.9). This is consistent with previous ASEMP results (Wickliff et al. 1991a,b). The specific transuranic analysis of South Tributary samples revealed no TRU isotopes (Table B.9), suggesting that the alpha activity in this stream may be from uranium or thorium series isotopes.

December 1990 seep samples contained low gross alpha concentrations (Table B.9). However, the January and March 1991 samples from the WOC seeps revealed that two seeps contained substantial concentrations of $^{244}Cm$, and one seep had detectable $^{241}Am$ (Table B.9). RCRA-compliance well 982 had a gross alpha concentration of 1 Bq/L (Table B.9), but no determination was made of the specific isotopes.

After 14 days exposure, each of the 50-g $MnO_2$-coated fiber samplers in well 516 adsorbed approximately as much gross alpha activity as was found in a 1-L sample from that well (Table B.9). Alpha activity, including $^{244}Cm$ and $^{241}Am$, was found on $MnO_2$-coated fiber samplers at WOC 120 and 300.

Gross beta concentrations were significantly greater than zero ($p < 0.01$) throughout WOC and South Tributary, but not in North Tributary. Gross beta concentrations increased ($p < 0.001$) between 5NST 2 and the mouth of South Tributary. Although

seven wells (516, 517, 518, 519, 524, 715, and 716) have gross beta concentrations significantly greater than zero ($p < 0.01$), none of the wells approach the ASEMP action level (5 Bq/L).

One cause of the gross beta activity in WOC is $^{90}Sr$ (Table B.9). A tributary draining SWSA 4 enters WOC just below WOC 300 (Fig. A.2), and SWSA 4 is suspected to be a major source of $^{90}Sr$. Nevertheless, the difference in $^{90}Sr$ concentrations between WOC 270 and WOC 360 is only marginally greater than might be expected from random counting error ($0.01 < p < 0.05$).

Tritium concentrations were significantly greater than zero ($p < 0.01$) in wells 516, 520, 523, 524, 708, and 984, and in South Tributary (Table B.9). Tritium is not a contributor to gross beta activity because concentration procedures in the gross beta analysis cause the tritium to evaporate.

None of the wells had $^{60}Co$ or $^{137}Cs$ concentrations that were significantly greater than zero ($p < 0.01$) (Table B.10). WOC samples contained $^{137}Cs$ but no $^{60}Co$. Neither tributary contained $^{60}Co$ nor $^{137}Cs$.

Barium and chromium were the only RCRA-regulated elements detected in well 516 (Table B.11). The measured concentrations of these metals (Table B.11) are below Safe Drinking Water Act standards (1 mg/L for barium and 50 µg/l for chromium, respectively).

## 3.4 DISCUSSION

Detection of $^{244}Cm$ and $^{241}Am$ in the January and March 1991 samples from the WOC seeps strongly suggests that transuranic material is being transported from the SWSA 5 North burial trenches to WOC—especially because the trenches are along the expected geologic strike with the seeps. Failure to detect significant alpha contamination in the December 1990 samples may result from two factors: (1) the samples were neither filtered nor acidified for several days after collection, which may have resulted in some activity adsorbing to the walls of the sample containers, and (2) contamination may have been diluted by recent rainfall (although the samples were collected prior to the 20-year event).

WOC water samples did not contain statistically significant levels of alpha-emitting contamination. However, both $^{244}Cm$ and $^{241}Am$ were measured in the fiber samples from WOC 120 (upstream of the contaminated seeps) and WOC 300. The source of this contamination, particularly in the WOC 120 sample, is unclear but may result from sediment entrained in the fibers (see discussion below).

Curium-244 and $^{241}Am$ concentrations measured in the WOC fiber samplers is below the minimum statistically-quantifiable concentration for the gross alpha analysis. This analytical artifact suggests that gross alpha may be an inappropriate screening analyte in those water samples where transuranic isotopes may be present at trace levels. On the other hand, gross alpha activity in well 516 has always been of the same order of magnitude as $^{244}Cm$ activity, indicating a threshold level may exist where gross alpha activity closely approximates transuranic activity. Because it is important that this program identify all areas around SWSA 5 North where even trace levels of transuranic contamination may occur, the gross alpha analysis should be replaced, or at least supplemented, by specific analysis for transuranic isotopes—especially $^{244}Cm$.

Comparing the results from WOC 120 and WOC 120-2 water samples (Table B.10) suggests that suspended sediment contributed ~95% of the $^{137}Cs$ activity in the first sample. The importance of suspended sediment is further illustrated by the results for the sediment sample from WOC 120. Entrainment of 6.6 g of sediment in the fiber sampler at WOC 120 would account for the activity of $^{60}Co$, $^{137}Cs$, and $^{152}Eu$ measured in that sample. Although attempts were made to remove sediment from fiber samples, it is not inconceivable that a small amount remained. High $^{40}K$ activities in fiber samples should be expected because the fibers are prepared in a $KMnO_4$ solution.

South Tributary is clearly receiving some input of both alpha- and beta-emitting isotopes between 5NST 2 and the mouth. The cause of the alpha contamination is not transuranic elements, which suggests that the source is probably not in SWSA 5 North.

## 4. ACKNOWLEDGMENTS

The authors wish to thank Scott Gregory, Arnold Hunley, Lauren Larsen, Della Marshall, Tony Thomas, and Jeff Wade for valuable assistance in sampling and analysis of the data. Billy Moore (University of South Carolina) provided the $MnO_2$-coated fibers and valuable advice on the installation and analysis of the fiber samplers. Art Stewart conducted the toxicity test of Tumulus I runoff, and John G. Smith conducted the benthic invertebrate survey of West Tributary. Nic Korte and John Trabalka provided helpful comments on an early draft of this report.

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# APPENDIX A: FIGURES

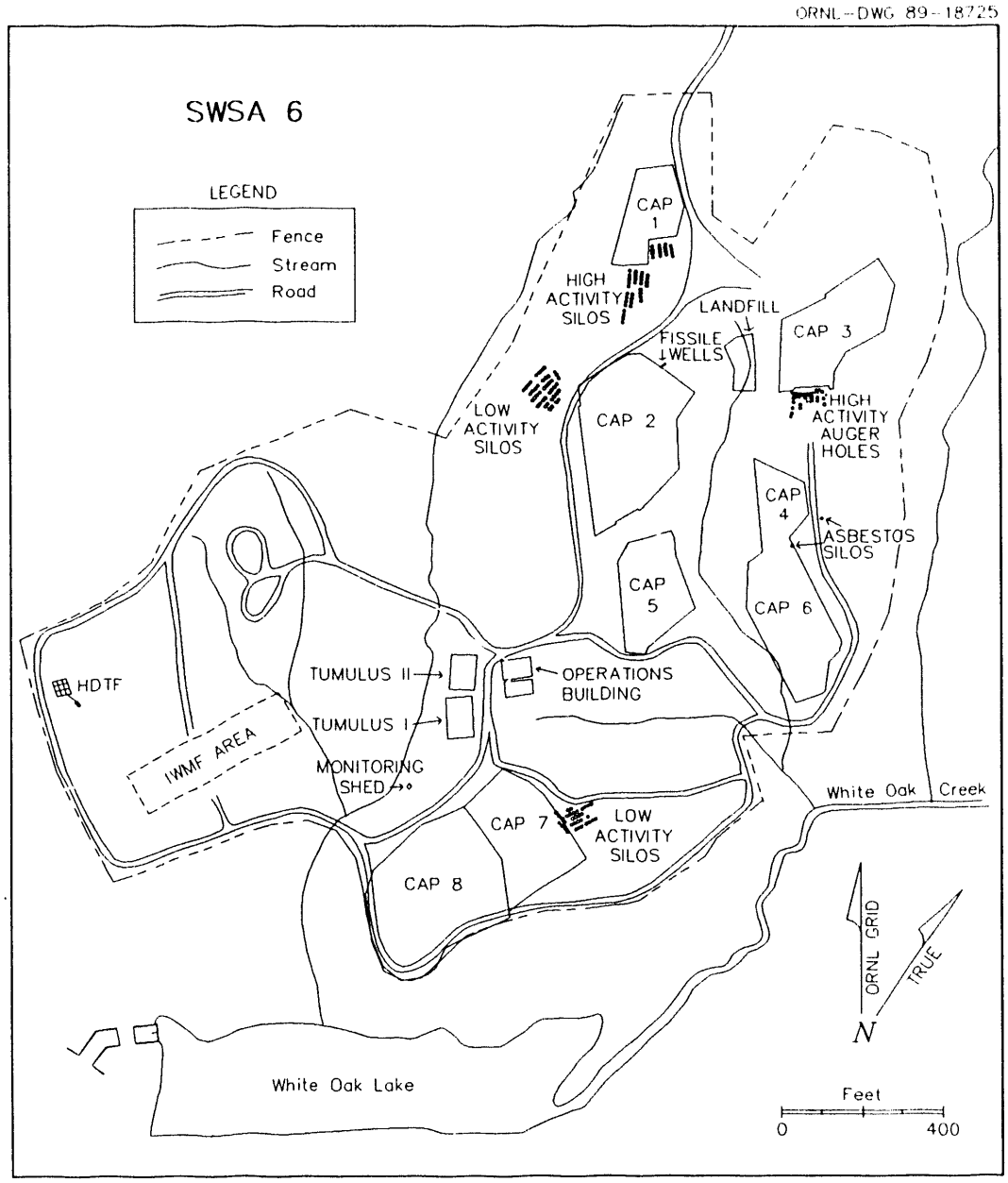



**Fig. A.1. Active low-level waste disposal sites and other major facilities in SWSA 6.**

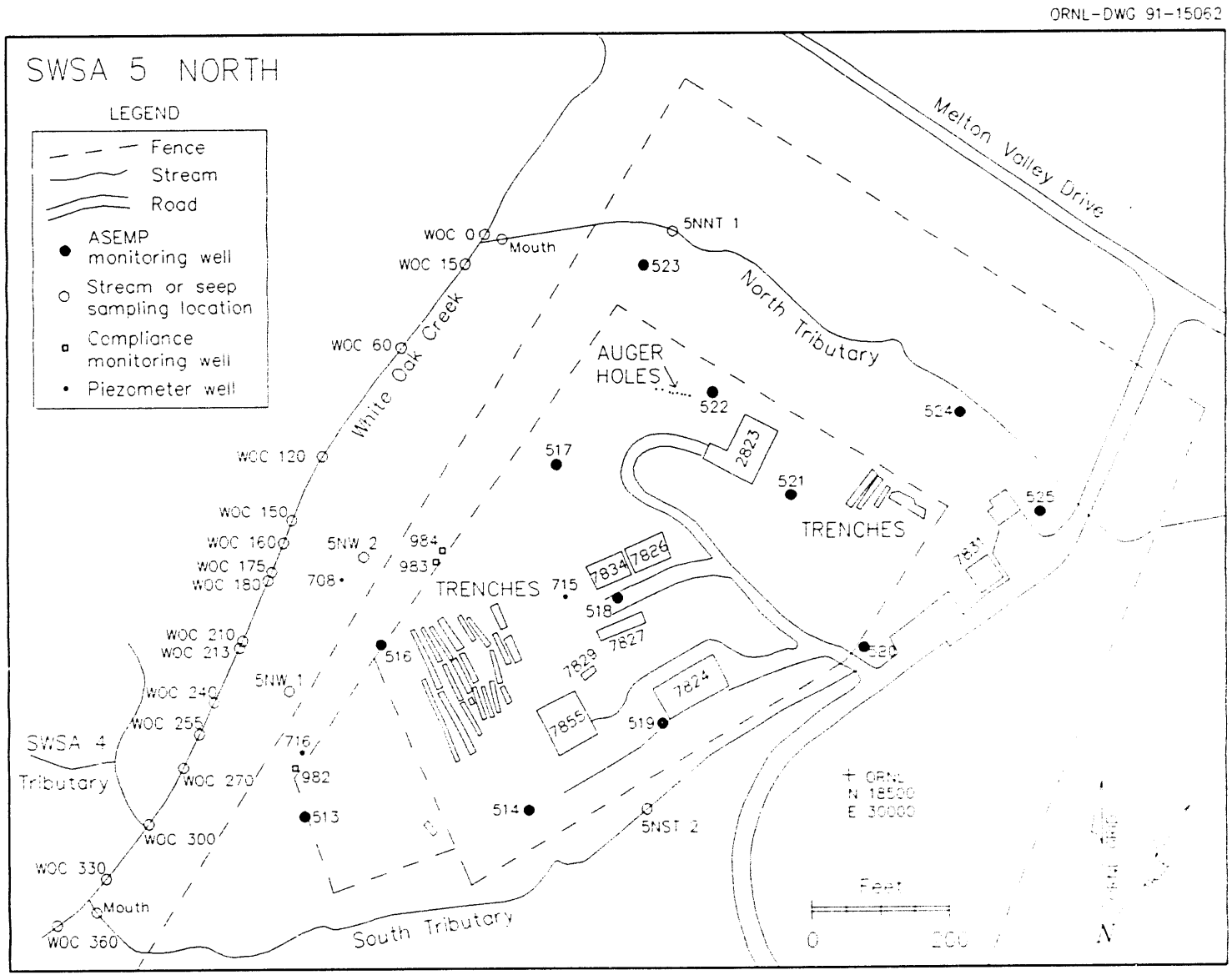



**Fig. A.2. Transuranic waste storage sites, sampling locations, and major facilities in SWSA 5 North.**

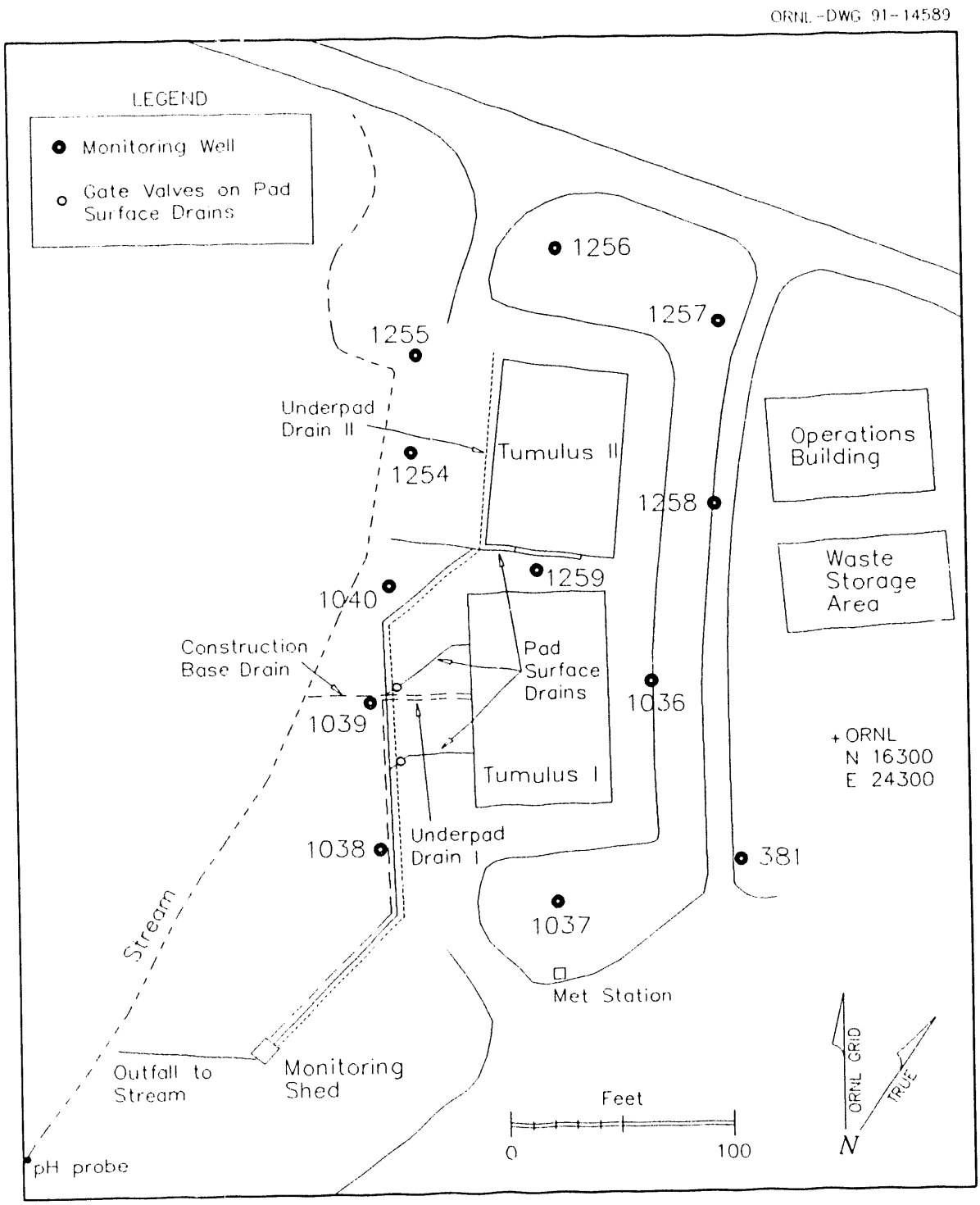



**Fig. A.3. Tumulus area in SWSA 6.**

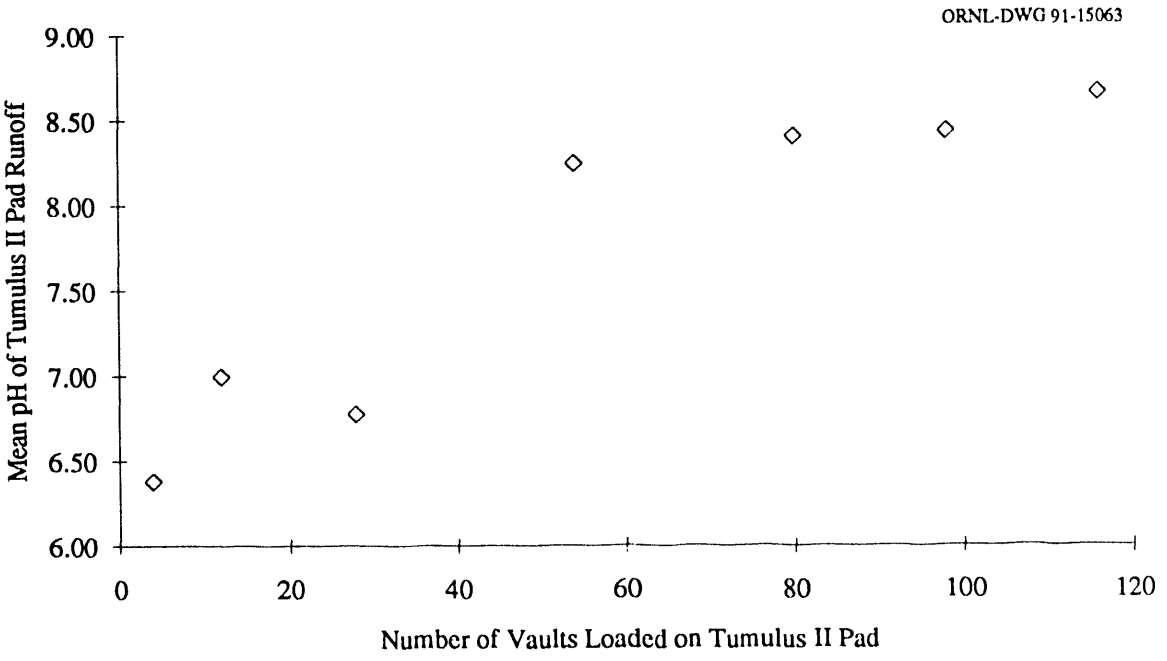



**Fig. A.4. Variation in pH of Tumulus II pad runoff with increasing number of vaults laoded on the pad.**

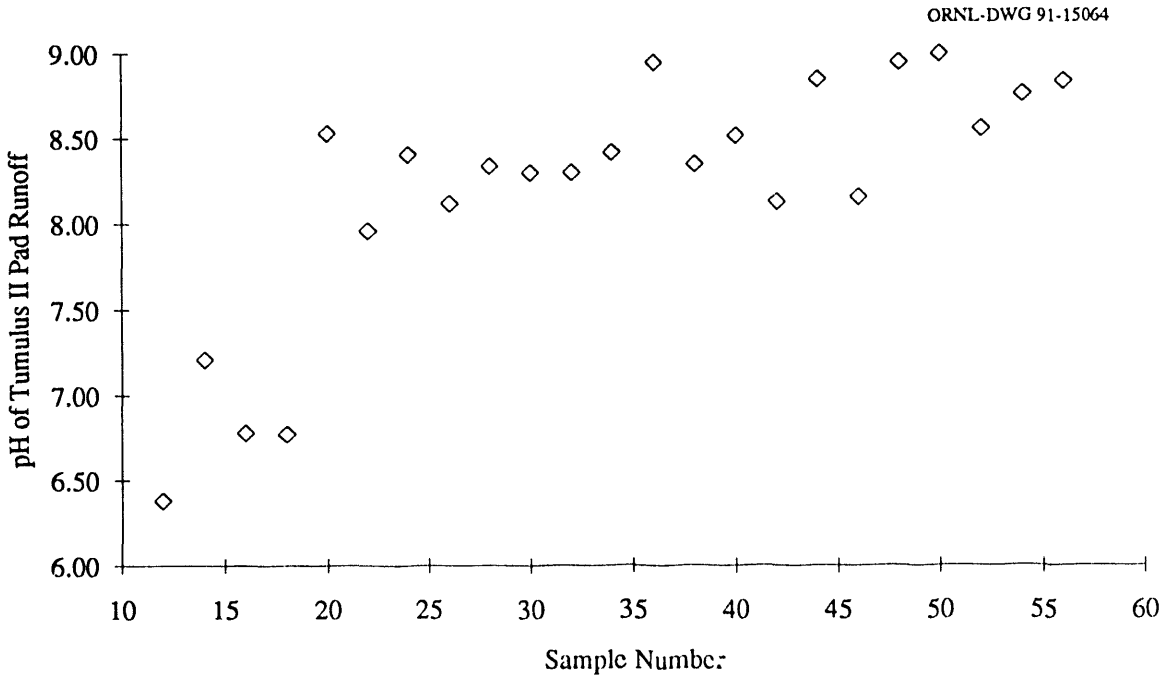



**Fig. A.5. Variation in the pH of Tumulus II pad runoff in successive samples.**

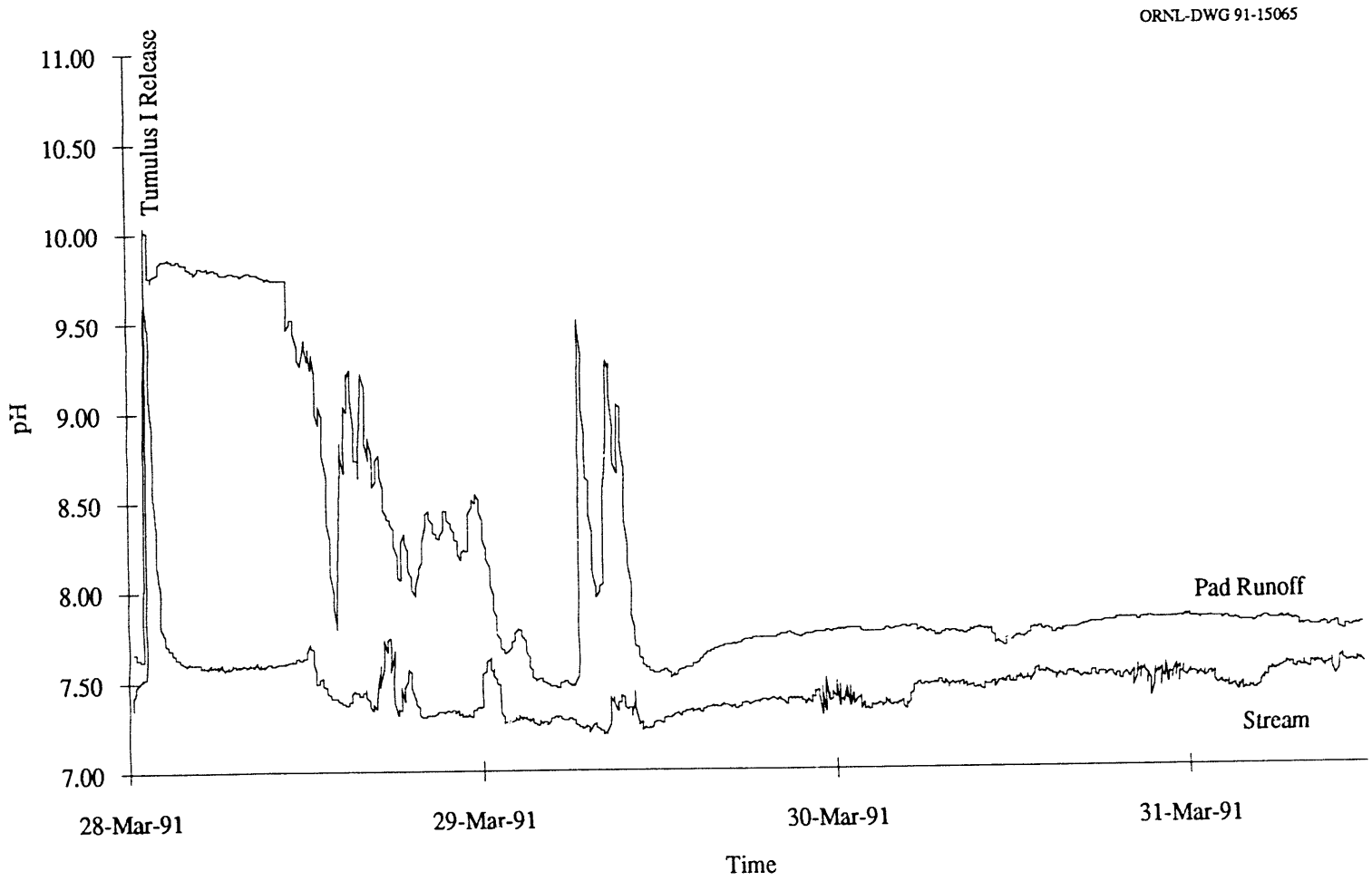



**Fig. A.6. Fluctuations in pH of runoff from both pads and corresponding fluctuations in receiving stream pH.**

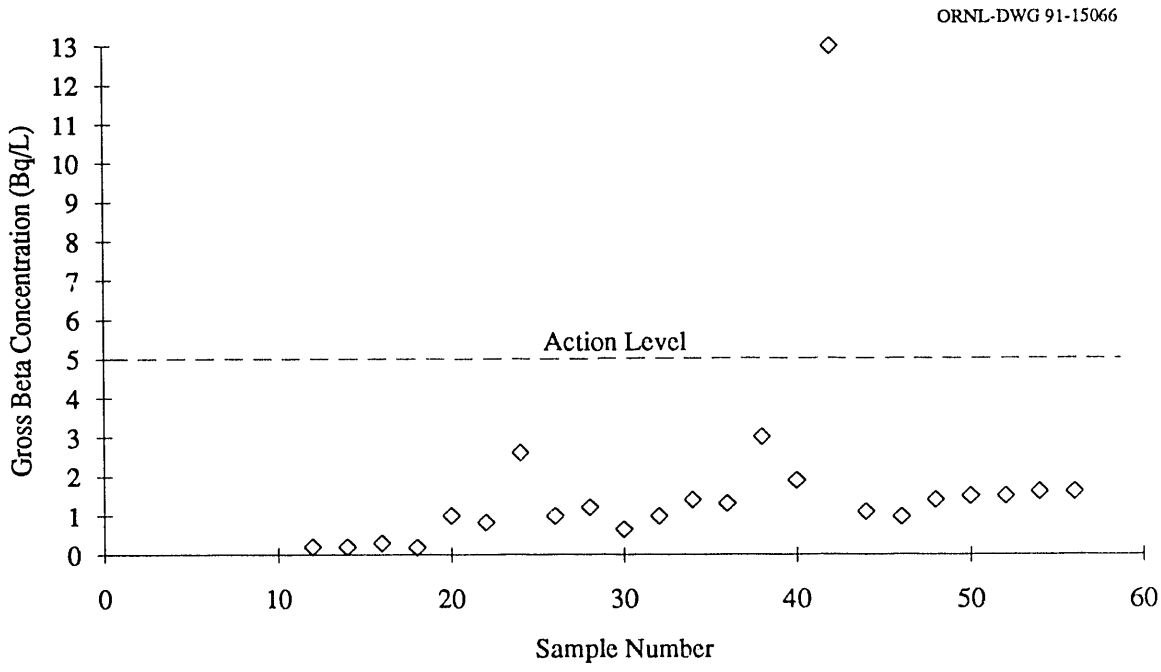



**Fig. A.7. Variation in gross beta concentration of Tumulus II pad runoff in successive samples.**

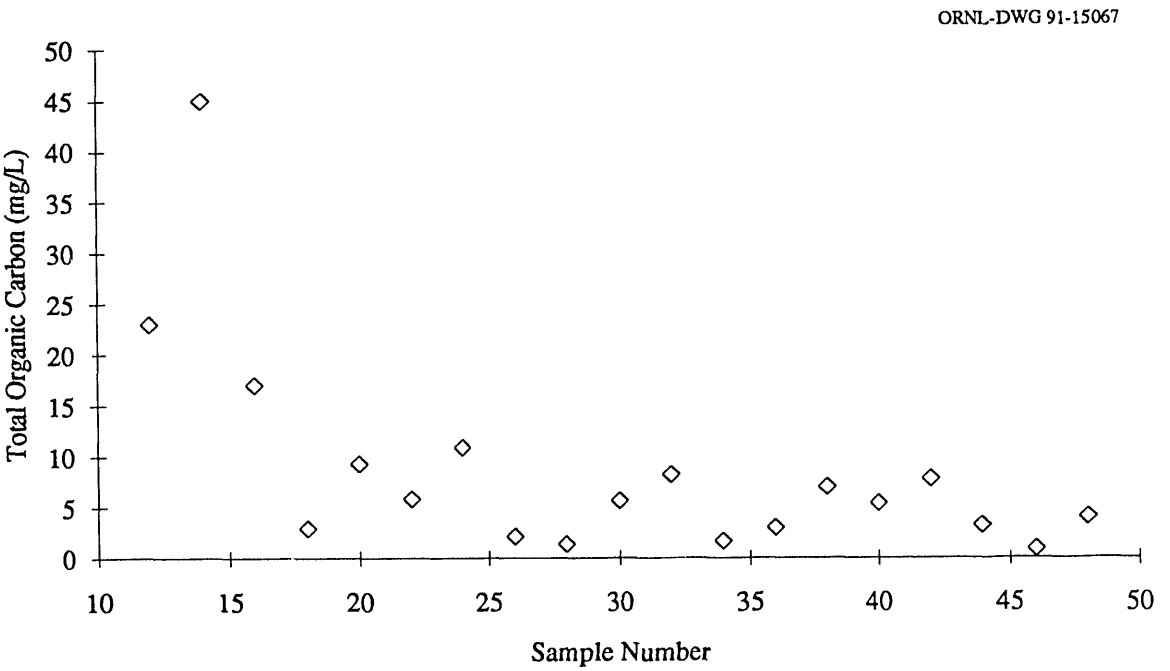



**Fig. A.8. Total organic carbon in composite samples of Tumulus II pad runoff.**

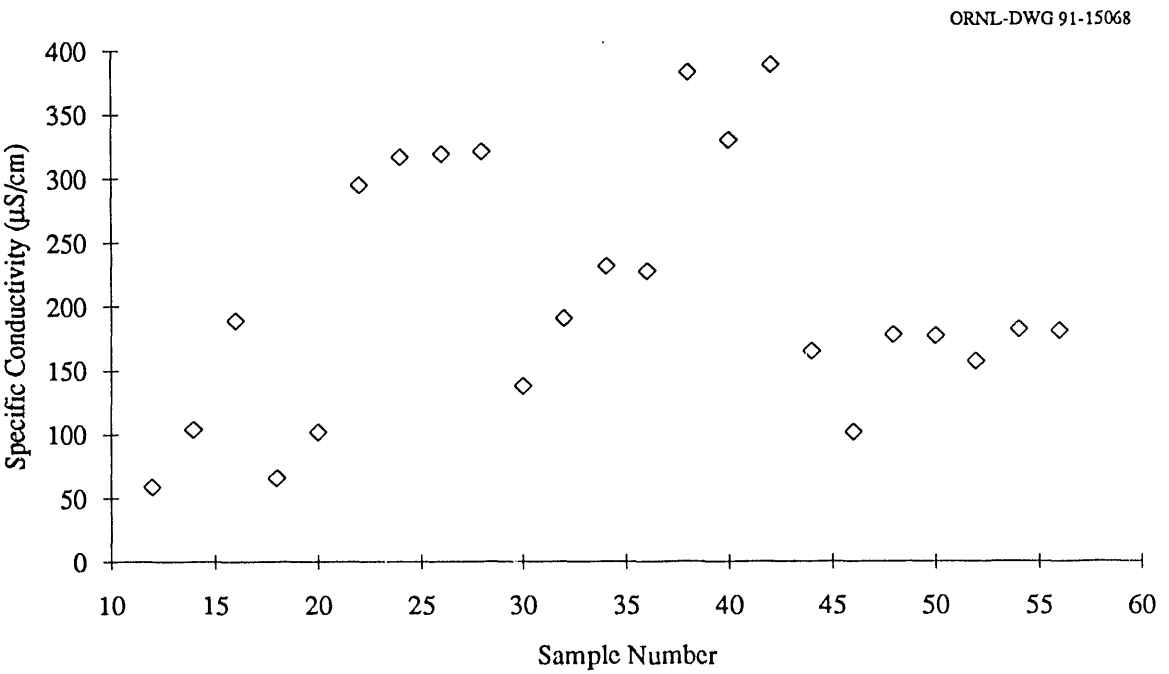
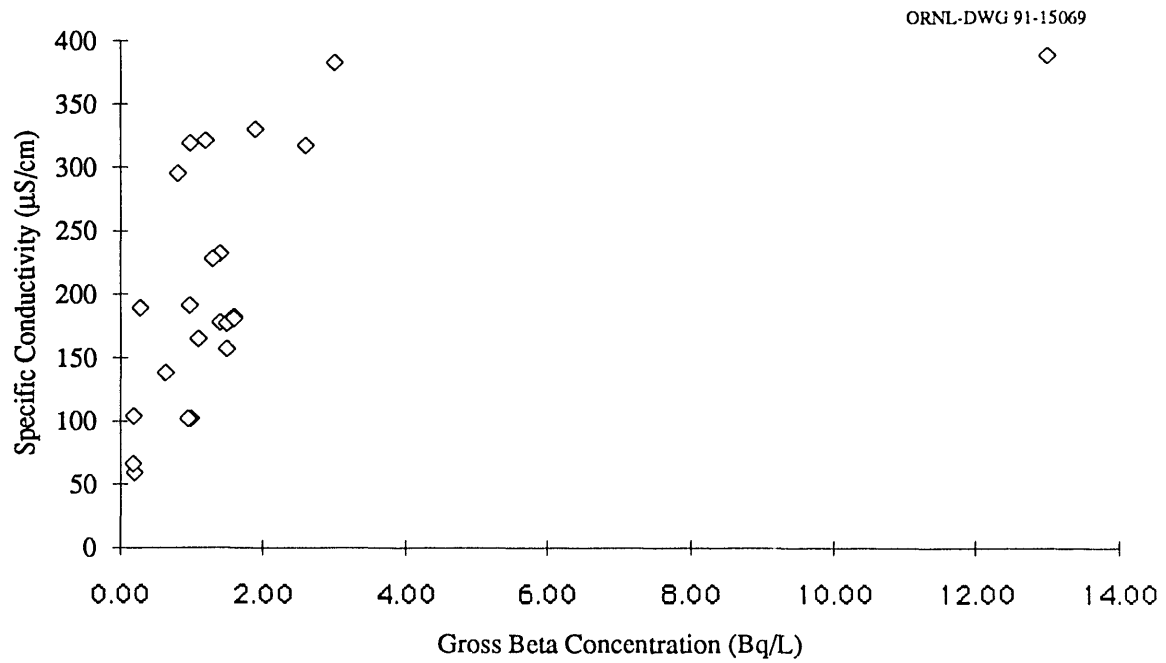
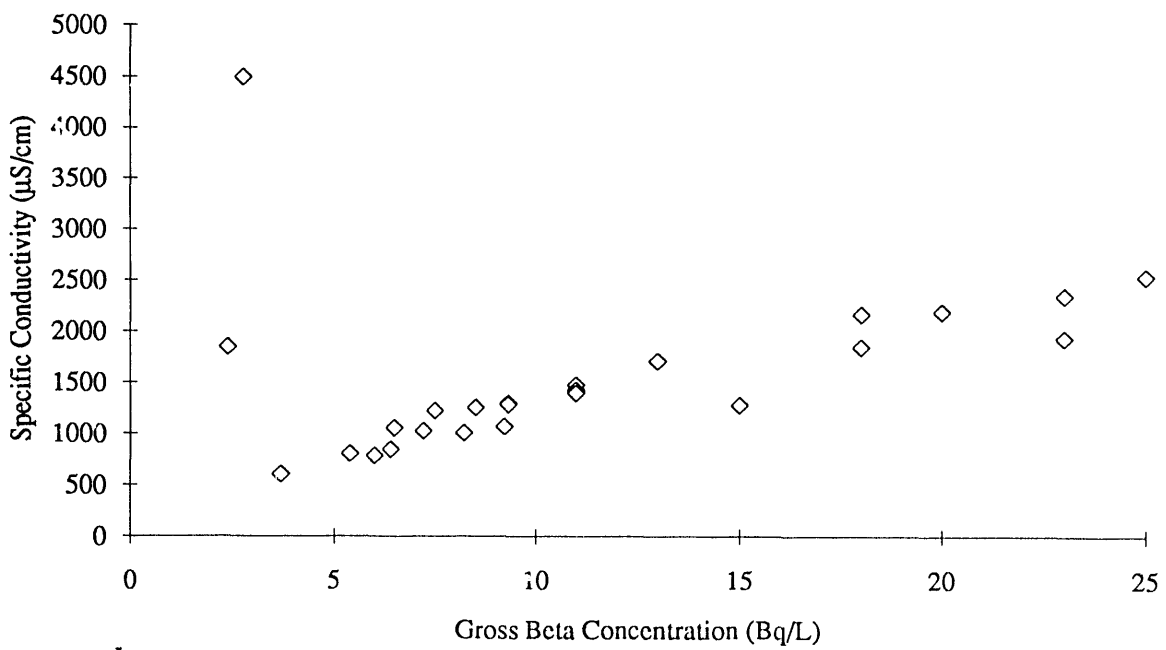



**Fig. A.9. Specific conductance of composite samples of Tumulus II pad runoff.**




*a*.




*b*.

**Fig. A.10. Specific conductance and gross beta concentrations in samples of pad runoff from (*a*) Tumulus II and (*b*) Tumulus I.**

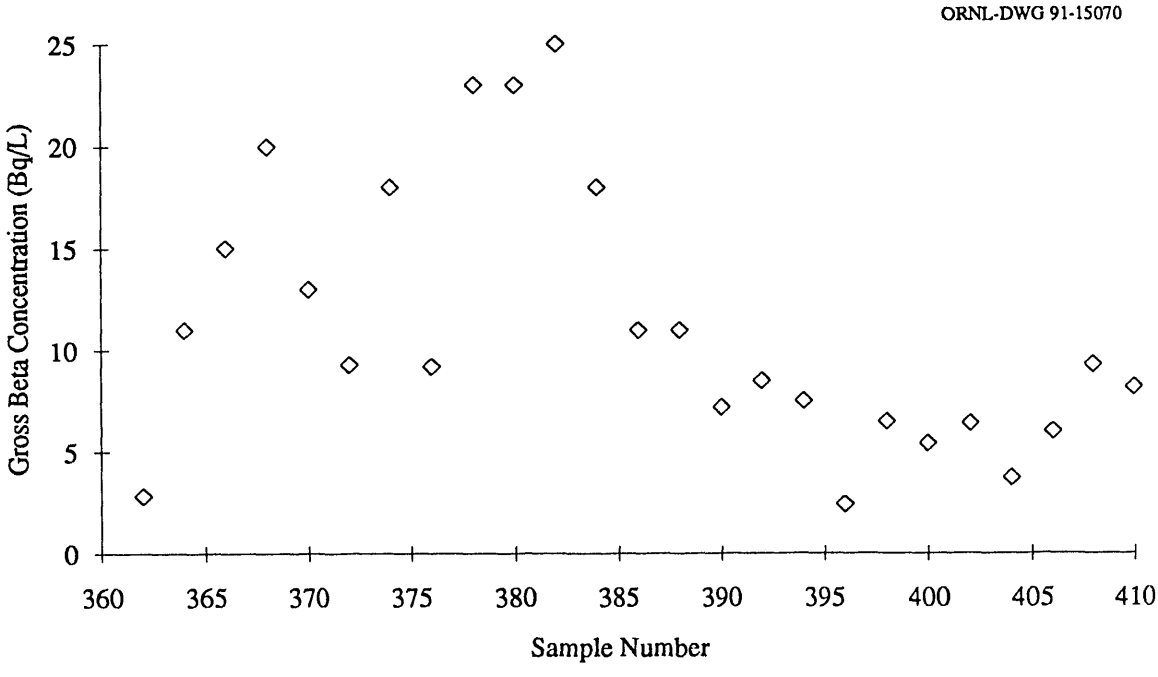



**Fig. A.11. Gross beta concentrations in grab samples of Tumulus I pad runoff.**

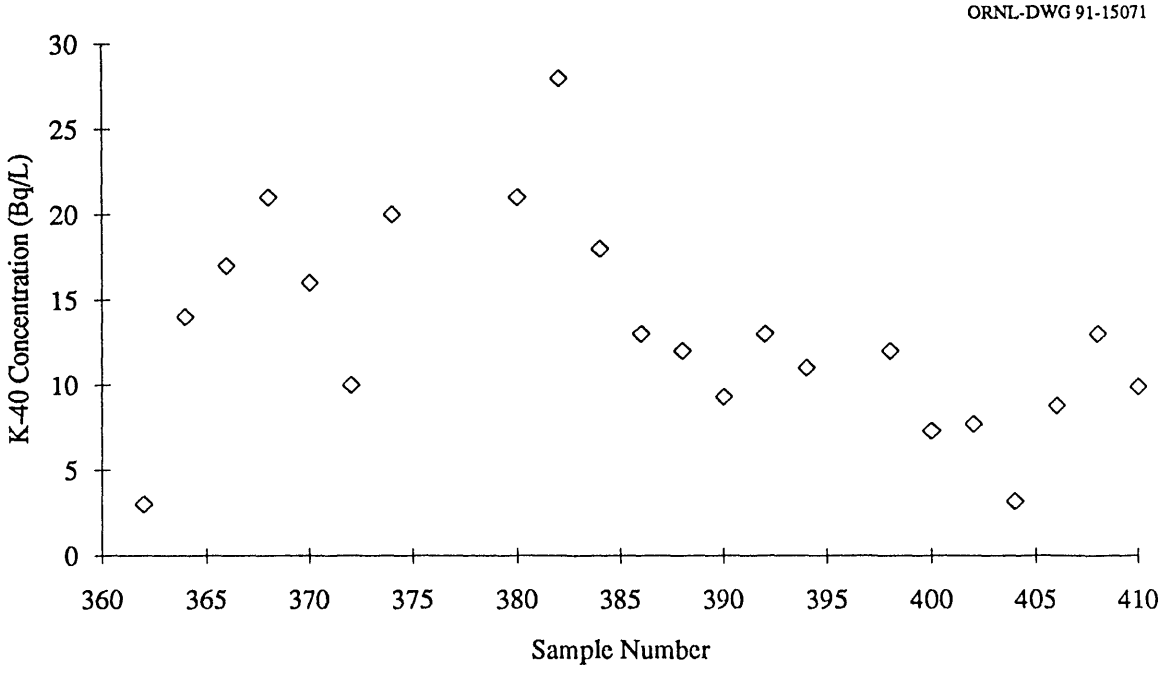



**Fig. A.12. Potassium-40 concentrations in grab samples of Tumulus I pad runoff.**

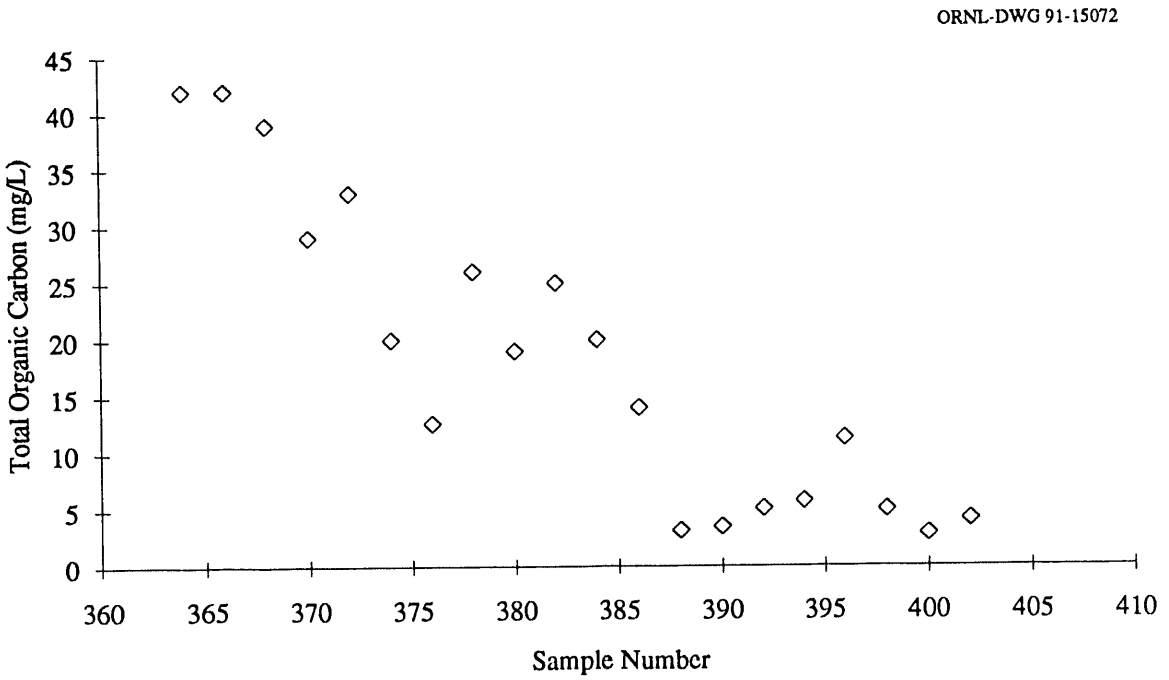



**Fig. A.13. Total organic carbon in grab samples of Tumulus I pad runoff.**

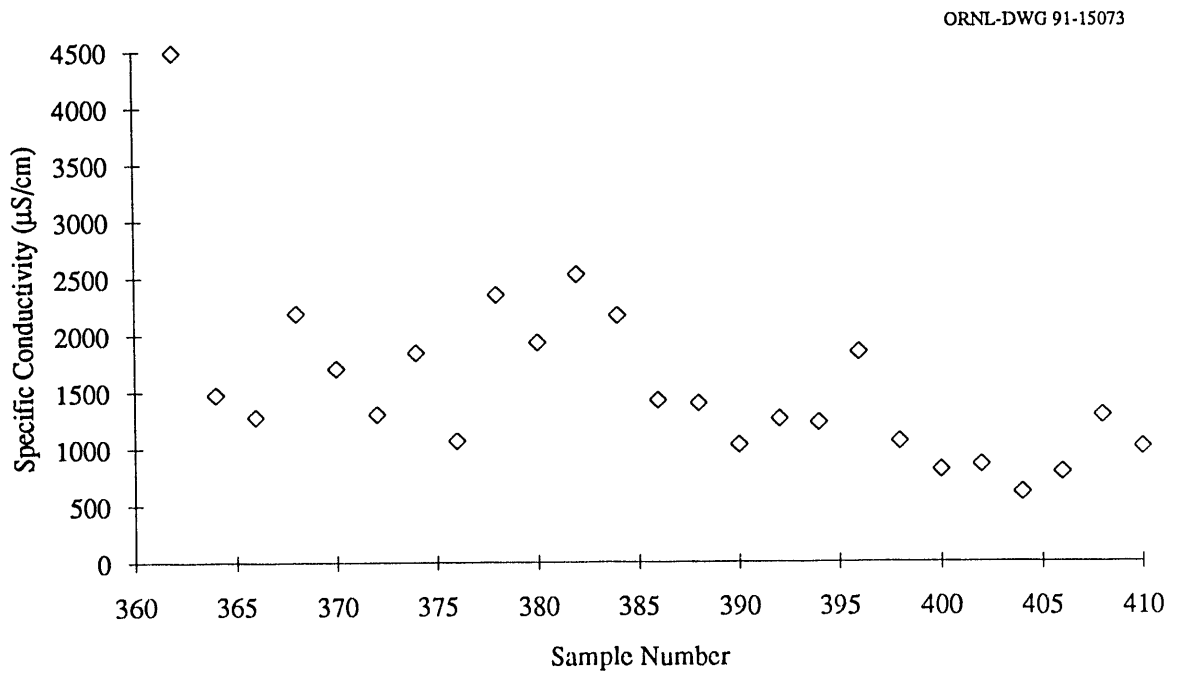



**Fig. A.14. Specific conductance of grab samples of Tumulus I pad runoff.**

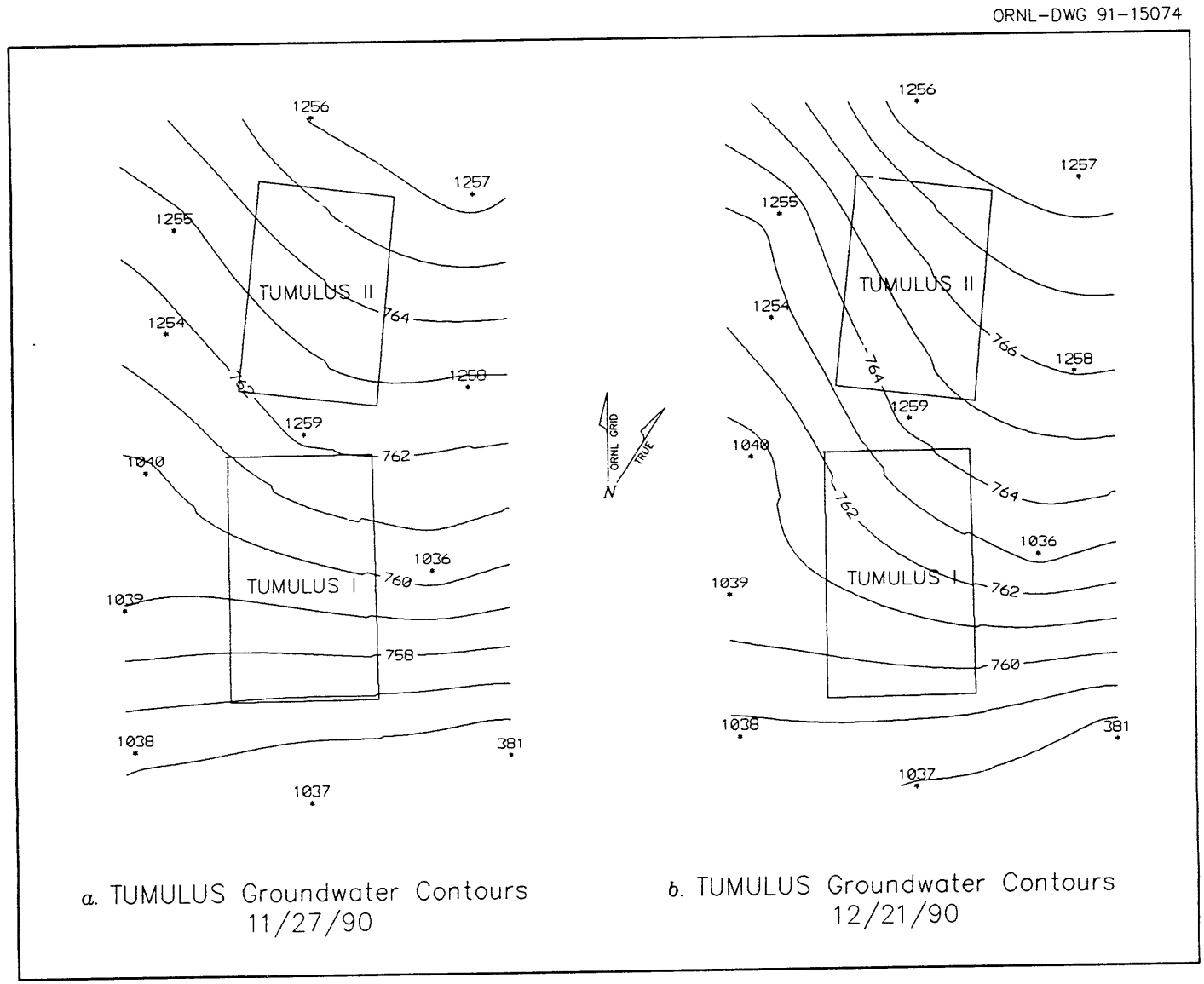



**Fig. A.15. Groundwater contours of the tumuus area on (*a*) 27 November 1990 and (*b*) 21 December 1990.**

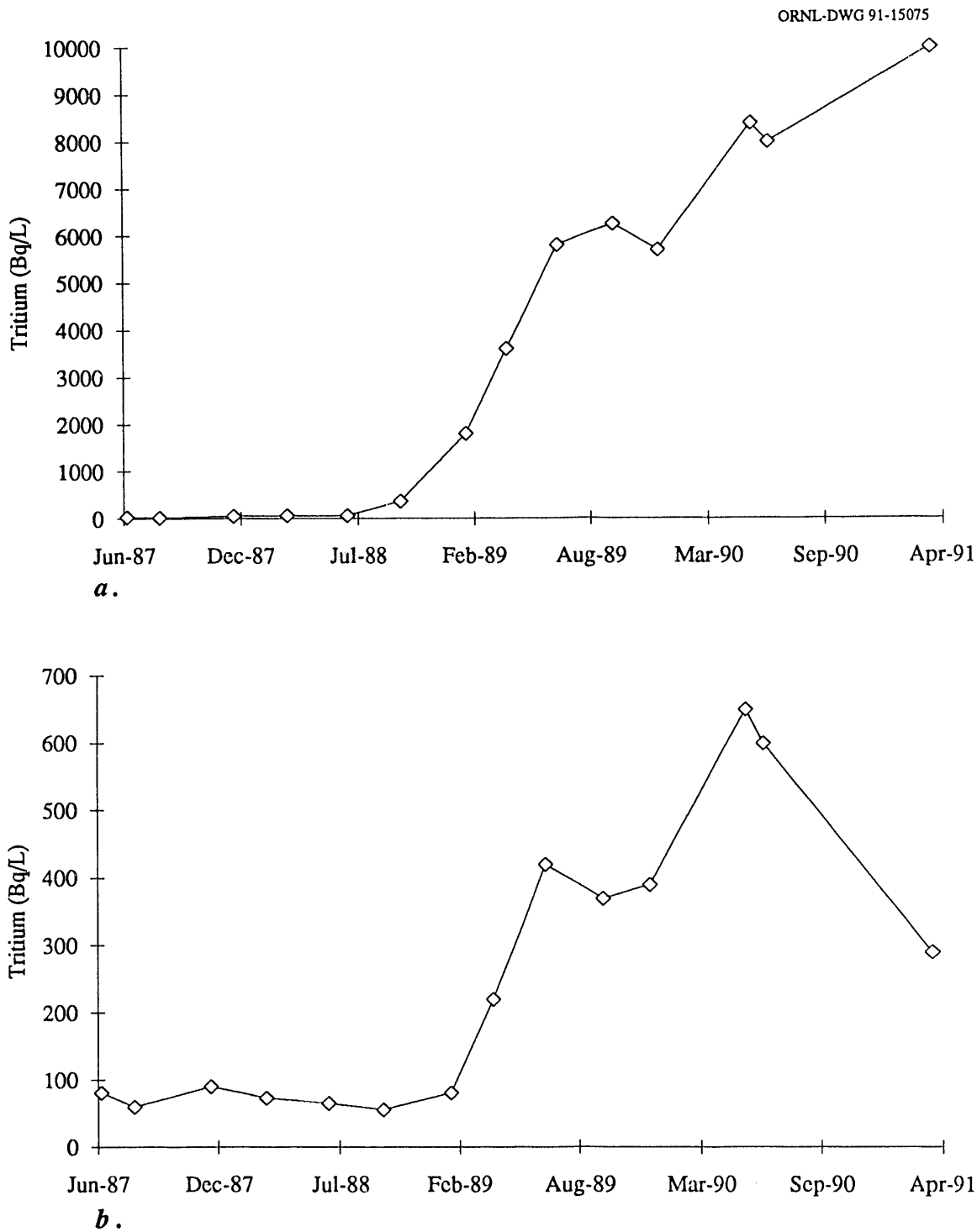



**Fig. A.16. Tritium concentrations since the beginning of tumulus operations in (*a*) well 1036 and (*b*) well 1039.**

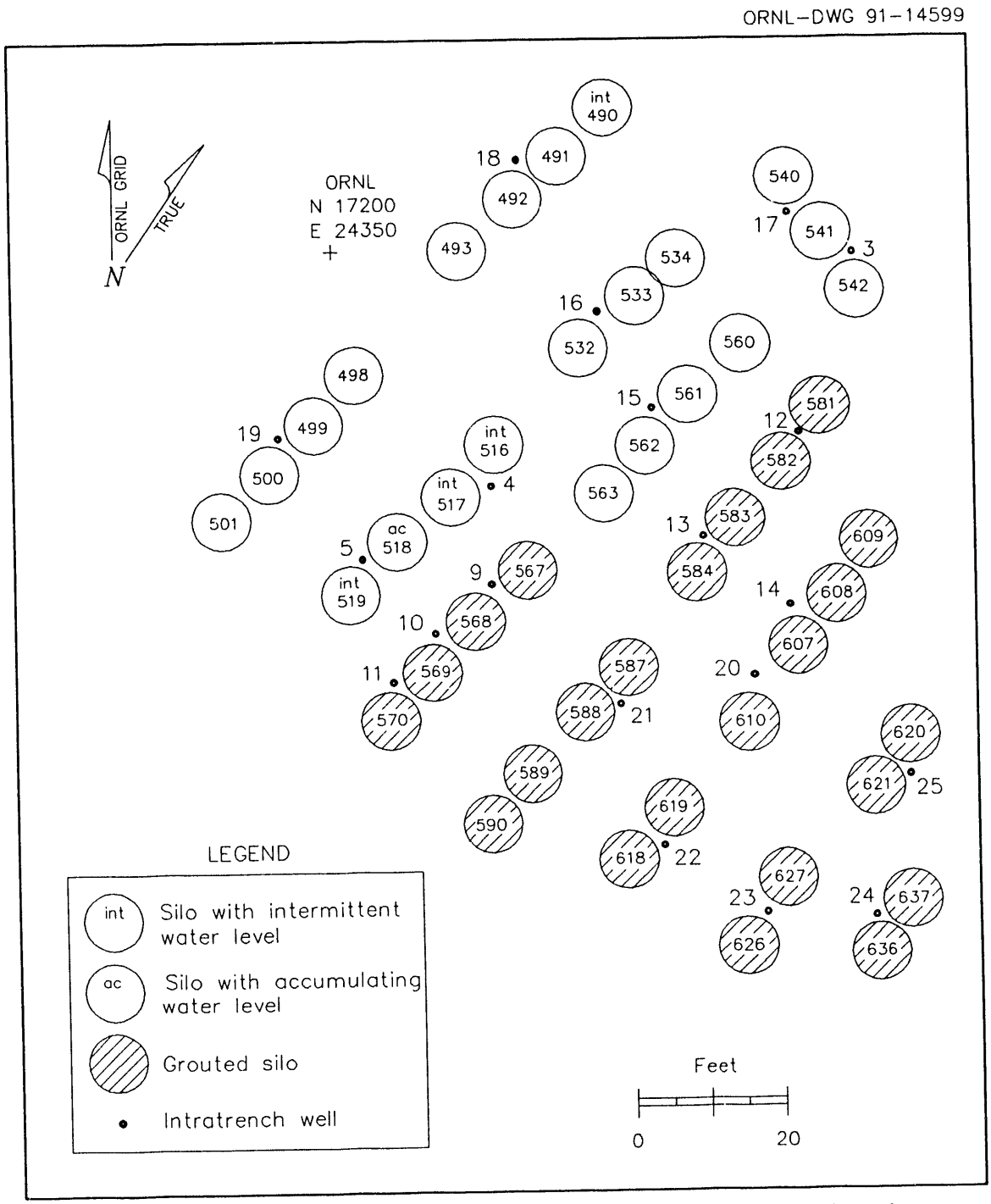



**Fig. A.17. Intratrench well locations around low-activity silos area north in SWSA 6.**

# APPENDIX B: TABLES

## Table B.1. Field parameters, radionuclide concentrations, and total organic carbon in samples from Tumulus I and II

| Sample no.[a] | Date | pH | Specific conductance (µS/cm) | Gross alpha (Bq/L) | Gross beta (Bq/L) | $^{3}H$ (Bq/L)[b] | $^{40}K$ (Bq/L)[c] | $^{60}Co$ (Bq/L) | $^{137}Cs$ (Bq/L) | Total organic carbon (Bq/L)[f] |
|---|---|---|---|---|---|---|---|---|---|---|
| TMOI-362 | 10/04/90 | 9.98 | 4490 | -0.005 ± 0.054 | 2.8 ± 0.4 | | 3 ± 2.5 | 0.27 ± 0.38 | 0.1[illegible] ± 0.31 | 17 |
| TMOI-CS-364 | 10/05/90 | 9.53 | 1476 | -0.029 ± 0.076 | 11 ± 1 | | 14 ± 3 | 0.12 ± 0.12 | 0.04 ± 0.12 | 42 |
| TMOI-CS-366 | 10/15/90 | 9.14 | 1280 | 0.05 ± 0.68 | 15 ± 4 | | 17 ± 3 | 0 ± 0.23 | -0.01 ± 0.21 | 42 |
| TMOI-368 | 10/19/90 | 10.20 | 2190 | 0.02 ± 0.47 | 20 ± 4 | | 21 ± 3 | -0.1 ± 0.26 | -0.06 ± 0.23 | 39 |
| TMOI-370 | 10/23/90 | 10.36 | 1710 | 0.43 ± 0.84 | 13 ± 4 | | 16 ± 3 | 0.1 ± 0.26 | 0.15 ± 0.16 | 29 |
| TMOI-372 | 11/06/90 | 10.54 | 1300 | 0.17 ± 0.17 | 9.3 ± 0.8 | | 10 ± 3 | -0.1 ± 0.3 | -0.01 ± 0.28 | 33 |
| TMOI-374 | 11/06/90 | 10.57 | 1849 | 0.35 ± 0.71 | 18 ± 4 | | 20 ± 2 | 0.07 ± 0.13 | 0.04 ± 0.12 | 20 |
| TMOI-376 | 11/29/90 | 10.42 | 1070 | 0.004 ± 0.079 | 9.2 ± 0.8 | | | 0.01 ± 0.26 | 0.18 ± 0.21 | 12.6 |
| TMOI-378 | 12/05/80 | 10.28 | 2350 | -0.22 ± 0.08 | 23 ± 4 | | | 0.02 ± 0.21 | -0.02 ± 0.19 | 26.0 |
| TMOI-380 | 12/18/90 | 10.08 | 1934 | -0.26 ± 0.09 | 23 ± 4 | | 21 ± 3 | 0.04 ± 0.20 | 0.03 ± 0.18 | 19 |
| TMOI-382 | 12/21/90 | 10.15 | 2530 | 0.42 ± 0.81 | 25 ± 4 | | 28 ± 2 | 0 ± 0.12 | -0.01 ± 0.11 | 25 |
| TMOI-384 | 12/31/90 | 10.61 | 2170 | -0.22 ± 0.08 | 18 ± 4 | | 18 ± 3 | 0.02 ± 0.25 | -0.02 ± 0.26 | 20 |
| TMOI-386 | 01/08/91 | 10.36 | 1425 | -0.28 ± 0.09 | 11 ± 3 | | 13 ± 2 | 0.14 ± 0.16 | -0.02 ± 0.20 | 14 |
| TMOI-388 | 01/14/91 | 10.35 | 1398 | -0.020 ± 0.080 | 11 ± 1 | | 12 ± 2 | 0.11 ± 0.19 | 0.09 ± 0.16 | 3.2 |
| TMOI-390 | 01/17/91 | 10.33 | 1026 | 0.03 ± 0.056 | 7.2 ± 0.5 | | 9 ± 3 | 0.24 ± 0.24 | 0.08 ± 0.26 | 3.5 |
| TMOI-392 | 01/23/91 | 10.35 | 1255 | 0.097 ± 0.089 | 8.5 ± 0.5 | | 13 ± 2 | 0.03 ± 0.17 | 0.08 ± 0.15 | 5.1 |
| TMOI-394 | 02/01/91 | 10.21 | 1225 | -0.04 ± 0.01 | 7.5 ± 0.5 | | 11 ± 3 | -0.1 ± 0.28 | 0.06 ± 0.28 | 5.8 |
| TMOI-396 | 02/12/91 | 10.18 | 1848 | 0.028 ± 0.052 | 2.4 ± 0.3 | | | 0.07 ± 0.2 | 0.05 ± 0.24 | 11.3 |
| TMOI-398 | 02/19/91 | 10.64 | 1059 | -0.018 ± 0.008 | 6.5 ± 0.5 | | 12 ± 3 | 0.05 ± 0.25 | -0.05 ± 0.24 | 5.0 |
| TMOI-400 | 02/25/91 | 10.49 | 805 | -0.006 ± 0.042 | 5.4 ± 0.4 | | 7 ± 3 | -0.2 ± 0.25 | -0.13 ± 0.25 | 2.9 |
| TMOI-402 | 03/06/91 | 10.43 | 849 | -0.031 ± 0.010 | 6.4 ± 0.5 | | 7 ± 2 | -0.1 ± 0.17 | 0.02 ± 0.17 | 4.2 |
| TMOI-404 | 03/13/91 | 10.18 | 609 | -0.008 ± 0.050 | 3.7 ± 0.4 | | 3 ± 2 | 0.02 ± 0.18 | -0.02 ± 0.23 | |
| TMOI-406 | 03/18/91 | 9.53 | 786 | -0.005 ± 0.054 | 6.0 ± 0.6 | | 9 ± 1 | -0.1 ± 0.15 | 0.01 ± 0.15 | |
| TMOI-408 | 03/25/91 | 9.80 | 1284 | 0.12 ± 0.15 | 9.3 ± 0.8 | | 13 ± 3 | 0.08 ± 0.24 | 0.01 ± 0.22 | |
| TMOI-410 | 03/28/91 | 9.88 | 1006 | -0.030 ± 0.012 | 8.2 ± 0.8 | | 10 ± 3 | -0.1 ± 0.23 | 0.11 ± 0.18 | |

## Table B.1 (continued).

| Sample no.[a] | Date | pH | Specific conductance (µS/cm) | Gross alpha (Bq/L) | Gross beta (Bq/L) | $^{3}H$ (Bq/L)[b] | $^{40}K$ (Bq/L)[c] | $^{60}Co$ (Bq/L) | $^{137}Cs$ (Bq/L) | Total organic carbon (Bq/L)[c] |
|---|---|---|---|---|---|---|---|---|---|---|
| TMOI-PWT | 10/04/90 | 7.07 | 192 | -0.019 ± 0.048 | 4.1 ± 0.5 | | | -0.1 ± 0.32 | 0.04 ± 0.27 | |
| TMOI-PWT | 03/13/91 | | | 0.019 ± 0.048 | 0.17 ± 0.13 | 680 ± 60 | | 0.05 ± 0.14 | 0.01 ± 0.16 | d |
| TMOI-UND | 02/19/91 | | | 0.076 ± 0.07 | 1 ± 0.2 | 110 ± 40 | | -0.1 ± 0.28 | 0.13 ± 0.22 | d |
| TMOII-CS-012 | 10/19/90 | 6.38 | 58.9 | -0.2 ± 0.08 | 0.2 ± 1.5 | | | 0 ± 0.19 | -0.03 ± 0.16 | 23 |
| TMOII-CS-014 | 10/23/90 | 7.21 | 104 | -0.004 ± 0.044 | 0.19 ± 0.19 | | | -0.1 ± 0.3 | -0.01 ± 0.3 | 45 |
| TMOII-CS-016 | 11/06/90 | 6.78 | 189 | 0.03 ± 0.07 | 0.29 ± 0.20 | | | 0.02 ± 0.21 | -0.02 ± 0.18 | 17 |
| TMOII-CS-018 | 11/13/90 | 6.77 | 66 | -0.1 ± 0.01 | 0.18 ± 0.22 | | | 0.10 ± 0.15 | 0.01 ± 0.17 | 2.9 |
| TMOII-CS-020 | 11/29/90 | 8.53 | 102 | 0.12 ± 0.11 | 1.0 ± 0.3 | | | 0.06 ± 0.17 | -0.11 ± 0.20 | 9.3 |
| TMOII-CS-022 | 12/05/90 | 7.96 | 295 | 0.010 ± 0.051 | 0.82 ± 0.29 | | | 0.06 ± 0.19 | 0.04 ± 0.16 | 5.8 |
| TMOII-CS-024 | 12/17/90 | 8.41 | 317 | 0.12 ± 0.13 | 2.6 ± 0.4 | | | 0.10 ± 0.16 | 0.02 ± 0.17 | 10.9 |
| TMOII-CS-026 | 12/18/90 | 8.12 | 319 | 0.020 ± 0.070 | 0.99 ± 0.29 | | | 0.09 ± 0.18 | 0.02 ± 0.17 | 2.1 |
| TMOII-CS-028 | 12/21/90 | 8.34 | 321 | 0.027 ± 0.070 | 1.2 ± 0.3 | | | 0.11 ± 0.24 | -0.09 ± 0.28 | 1.4 |
| TMOII-CS-030 | 12/31/90 | 8.30 | 138 | 0.017 ± 0.049 | 0.64 ± 0.26 | | | -0.1 ± 0.20 | 0.02 ± 0.17 | 5.6 |
| TMOII-CS-032 | 01/08/91 | 8.30 | 191 | -0.022 ± 0.008 | 0.98 ± 0.29 | | | -0.1 ± 0.29 | 0.11 ± 0.23 | 8.2 |
| TMOII-CS-034 | 01/14/91 | 8.42 | 232 | 0.050 ± 0.086 | 1.4 ± 0.4 | | | 0.06 ± 0.15 | -0.02 ± 0.17 | 1.7 |
| TMOII-CS-036 | 01/17/91 | 8.95 | 228 | 0.01 ± 0.04 | 1.3 ± 0.2 | | | -0.1 ± 0.29 | 0.06 ± 0.28 | 3.0 |
| TMOII-CS-038 | 01/23/91 | 8.35 | 383 | 0.14 ± 0.13 | 3 ± 0.5 | | | 0.1 ± 0.21 | 0.18 ± 0.2 | 7.0 |
| TMOII-CS-040 | 02/01/91 | 8.52 | 330 | 0.008 ± 0.044 | 1.9 ± 0.3 | | | 0.11 ± 0.17 | 0.09 ± 0.17 | 5.4 |
| TMOII-CS-042 | 02/12/91 | 8.13 | 389 | -0.005 ± 0.051 | 13 ± 1 | | 20 ± 3 | 0 ± 0.16 | 0.03 ± 0.17 | 7.8 |
| TMOII-CS-044 | 02/19/91 | 8.85 | 165 | 0.03 ± 0.05 | 1.1 ± 0.2 | | | 0.01 ± 0.3 | -0.02 ± 0.28 | 3.2 |
| TMOII-CS-046 | 02/25/91 | 8.16 | 102 | 0.007 ± 0.04 | 0.96 ± 0.20 | | | 0.13 ± 0.25 | -0.9 ± 0.23 | 0.9 |
| TMOII-CS-048 | 03/06/91 | 8.95 | 178 | -0.010 ± 0.026 | 1.4 ± 0.2 | | | * ± 0.26 | 0.01 ± 0.21 | 4.0 |
| TMOII-CS-050 | 03/13/91 | 9.00 | 177 | 0.035 ± 0.050 | 1.5 ± 0.2 | | | 0.19 ± 0.20 | -0.06 ± 0.23 | |
| TMOII-CS-052 | 03/18/91 | 8.56 | 157 | 0.17 ± 0.14 | 1.5 ± 0.4 | | | 0.01 ± 0.23 | 0.08 ± 0.22 | |
| TMOII-CS-054 | 03/25/91 | 8.76 | 182 | -0.014 ± 0.007 | 1.6 ± 0.4 | | | 0.01 ± 0.28 | 0.07 ± 0.21 | |

## Table B.1 (continued).

| Sample no.[a] | Date | pH | Specific conductance (µS/cm) | Gross alpha (Bq/L) | Gross beta (Bq/L) | $^{3}H$ (Bq/L)[b] | $^{40}K$ (Bq/L)[c] | $^{60}Co$ (Bq/L) | $^{137}Cs$ (Bq/L) | Total organic carbon (Bq/L)[f] |
|---|---|---|---|---|---|---|---|---|---|---|
| TMOII-CS-056 | 03/28/91 | 8.84 | 181 | 0.14 ± 0.13 | 1.6 ± 0.4 | | | 0.01 ± 0.22 | -0.06 ± 0.24 | |
| TMOII-UND | 12/19/90 | 7.48 | 977 | 0.20 ± 0.18 | 0.28 ± 0.23 | | | -0.1 ± 0.20 | 0.02 ± 0.17 | d |
| TMOII-UND | 02/19/91 | | | 0.05 ± 0.06 | 0.3 ± 0.1 | 5200 ±100 | | 0 ± 0.26 | 0.09 ± 0.22 | d |

[a] TMOI = Tumulus I; TMOII = Tumulus II; CS = composite sample; UND = underpad drain; PWT = perched water table.

[b] Blanks indicate parameter not measured.

[c] Blanks indicate data not reported by Analytical Chemistry Division.

[d] Data not received at time of report.

**Table B.2. Field parameters and radionuclide concentrations in tumulus area wells**

| Well No. | Date | pH | Temperature (° C) | Specific conductance (uS/cm) | Gross Alpha (Bq/L)[a] | Gross Beta (Bq/L)[a] | $^{3}H$ (Bq/L)[a] | $^{60}Co$ (Bq/L)[a] | $^{137}Cs$ (Bq/L)[a] |
|---|---|---|---|---|---|---|---|---|---|
| 1036 | 03/28/91 | 6.3 | 15.6 | 351 | 0.06 ± 0.10 | 0.17 ± 0.18 | 10000 ± 1000 | 0.09 ± 0.10 | 0.01 ± 0.14 |
| 1037 | 03/28/91 | 5.6 | 15.7 | 172 | | | | | |
| 1038 | 03/28/91 | 6.1 | 14.4 | 613 | 0.18 ± 0.15 | 0.47 ± 0.26 | 99 ± 39 | 0.15 ± 0.21 | -0.01 ± 0.20 |
| 1039 | 03/28/91 | 6.1 | 14.2 | 686 | 0.18 ± 0.15 | 0.16 ± 0.22 | 290 ± 50 | 0.01 ± 0.25 | -0.07 ± 0.24 |
| 1040 | 03/28/91 | 6.4 | 13.6 | 384 | 0.00 ± 0.05 | 0.11 ± 0.17 | 83 ± 38 | 0.08 ± 0.21 | 0.01 ± 0.26 |
| 1254 | 03/28/91 | 7.0 | 14.4 | 406 | | | | | |
| 1255 | 03/28/91 | 6.8 | 14.2 | 443 | | | | | |
| 1256 | 03/28/91 | 6.5 | 14.5 | 625 | | | | | |
| 1257 | 03/28/91 | 6.8 | 16.2 | 464 | | | | | |
| 1258 | 03/28/91 | 6.3 | 15.9 | 349 | | | | | |
| 1259 | 03/28/91 | 5.6 | 15.8 | 202 | | | | | |

[a] Blanks indicate data not received from Analytical Chemistry Division at the time of this report.

**Table B.3. Meteorological data from tumulus area meteorological station[a]**

| Month | Rainfall (mm) | Average temperature (°C) | Average relative humidity (%) | Average solar irradiation (ly/m)[a] | Average wind speed (m/s) |
|---|---|---|---|---|---|
| October 1990 | 106.7 | 14.0 | 94.5 | 0.37 | 1.1 |
| November 1990 | 58.93 | 9.3 | 87.7 | 0.28 | 1.2 |
| December 1990 | 225.27 | 5.8 | 95.6 | 0.15 | 1.5 |
| January 1991 | 53.34 | 0.7 | 77.6 | 0.15 | 2.1 |
| February 1991 | 182.63 | | | | |
| March 1991 | | 10.7 | 75.6 | 0.41 | 2.6 |

[a] Blanks indicate data not available due to instrument malfunction.
[b] 1 ly (langley) = 1 gram-calorie per square centimeter of irradiated surface.

**Table B.4. Radionuclide concentrations in samples from intratrench wells in SWSA 6 during December 1990**

| Well No. | Date | GrossAlpha (Bq/L) | GrossBeta[a] (Bq/L) | $^{137}Cs$ (Bq/L)[b] | $^{60}Co$ (Bq/L)[b] | $^{90}Sr$ (Bq/L) |
|---|---|---|---|---|---|---|
| 8 | 12/07/90 | 0.06 ± 0.09 | 0.90 ± 0.28 | -0.2 ± 1.8 | 0.1 ± 2.0 | |
| 11 | 12/07/90 | 0.13 ± 0.12 | 0.66 ± 0.25 | | | |
| 15 | 12/07/90 | 0.24 ± 0.20 | 0.22 ± 0.21 | | | |
| 19 | 12/07/90 | 0.09 ± 0.12 | 85 ± 2 | | | 51 ± 5 |
| 25 | 12/07/90 | 0.04 ± 0.08 | 1.3 ± 0.3 | | | |
| 27 | 12/12/90 | 0.25 ± 0.27 | 0.51 ± 0.40 | | | |
| 28 | 12/12/90 | -0.02 ± 0.01 | 1.4 ± 0.3 | -0.1 ± 2.0 | 1.2 ± 2.3 | |
| 30 | 12/12/90 | 0.01 ± 0.05 | 0.26 ± 0.20 | | | |
| 32 | 12/12/90 | -0.73 ± 0.66 | 1.9 ± 0.4 | 0.7 ± 2.8 | -0.2 ± 4.1 | |
| 35 | 12/12/90 | 0.10 ± 0.16 | 0.80 ± 0.30 | | | |
| 38 | 12/12/90 | 0.06 ± 0.12 | 1.5 ± 0.3 | | | |
| 40 | 12/12/90 | 0.01 ± 0.06 | 0.28 ± 0.21 | | | |
| 42 | 12/12/90 | -0.01 ± 0.10 | 2.1 ± 0.5 | 1.1 ± 2.6 | 0.8 ± 2.9 | |
| 43 | 12/12/90 | 0.16 ± 0.16 | 0.09 ± 0.21 | | | |

[a] Does not include tritium activity.

[b] Blanks denote concentration below minimum detectable activity of ~2.5 Bq/L.

**Table B.5. Radionuclide concentrations in samples from wells near high-activity auger holes, asbestos silos, and fissile wells in SWSA 6**

| Well No. | Date | Gross Alpha[a] (Bq/L) | Gross Beta [a,b] (Bq/L) | $^{137}Cs$[c] (Bq/L) | $^{60}Co$[c] (Bq/L) |
|---|---|---|---|---|---|
| AUG 48 | 12/12/90 | 0.06± 0.10 | 0.17± 0.18 | | |
| C520 | 12/12/90 | 0.21± 0.16 | 1.1 ± 0.3 | -0.34± 0.97 | -0.4 ± 1.1 |
| C595 | 12/12/90 | 0.29± 0.20 | 0.80± 0.29 | -0.1 ± 1.3 | 0.4 ± 1.4 |
| FIS 102 | 12/12/90 | 0.18± 0.14 | 1.2 ± 0.3 | 0.3 ± 1.3 | 1.6 ± 1.0 |
| FIS ? | 12/12/90 | 0.09± 0.11 | 0.69± 0.29 | -0.01± 0.97 | -0.3 ± 1.3 |
| C520 | 02/07/91 | -0.02± 0.17 | 0.35± 0.75 | | |
| C595 | 02/07/91 | 1.4 ± 0.7 | 0.47± 0.80 | | |
| FIS 102 | 02/07/91 | 0.04± 0.20 | 1.6 ± 0.9 | | |
| FIS ? | 02/07/91 | -0.01± 0.13 | 1.0 ± 0.5 | | |
| AUG 48 | 02/22/91 | | | | |
| AUG 49 | 02/22/91 | | | | |
| AUG 50 | 02/22/91 | | | | |
| AUG 51 | 02/22/91 | 0.00± 0.11 | 2.6 ± 0.6 | | |
| AUG W536 | 02/22/91 | 0.01± 0.12 | 0.73± 0.52 | | |
| AUG W540 | 02/22/91 | 0.06± 0.15 | 0.16± 0.34 | | |
| AUG W559 | 02/22/91 | -0.06± 0.02 | 0.07± 0.31 | | |
| AUG W? | 02/22/91 | 0.15± 0.14 | 0.49± 0.35 | | |

[a] Blanks indicate analysis not completed.

[b] Does not include tritium activity.

[c] Blanks denote concentration below minimum detectable activity of ~2.5 Bq/L.

**Table B.6. Radionuclide concentrations in samples from intratrench wells in SWSA 6 during February 1991**

| Well No. | Date | Gross Alpha (Bq/L) | Gross Beta[a] (Bq/L) | Cs-137[b] (Bq/L) | Sr-90[c] (Bq/L) |
|---|---|---|---|---|---|
| 4 | 02/07/91 | 0.26 ± 0.30 | 0.89 ± 0.68 | | |
| 5 | 02/07/91 | -0.11 ± 0.04 | 0.32 ± 0.67 | | |
| 6 | 02/07/91 | -0.840± 0.032 | 2.7 ± 1.0 | | |
| 8 | 02/07/91 | 0.07 ± 0.25 | 0.75 ± 0.79 | | |
| 9 | 02/07/91 | 0.08 ± 0.27 | 2.1 ± 0.9 | | |
| 10 | 02/07/91 | 0.06 ± 0.16 | 0.01 ± 0.37 | | |
| 11 | 02/07/91 | 0.16 ± 0.31 | 0.77 ± 0.75 | 1.8 ± 0.4 | |
| 12 | 02/07/91 | 0.28 ± 0.24 | 0.64 ± 0.43 | 1.1 ± 0.4 | |
| 15 | 02/07/91 | 0.35 ± 0.45 | 0.80 ± 0.86 | | |
| 18 | 02/07/91 | 0.11 ± 0.16 | 0.61 ± 0.42 | | |
| 19A | 02/22/91 | 0.07 ± 0.15 | 44 ± 2 | | 28 ± 4 |
| 19B | 02/22/91 | -0.06 ± 0.02 | 32 ± 2 | | 21 ± 3 |
| 20 | 02/07/91 | 0.10 ± 0.27 | 0.39 ± 0.69 | | |
| 22 | 02/07/91 | 0.08 ± 0.18 | 0.40 ± 0.39 | | |
| 23 | 02/07/91 | 0.04 ± 0.13 | 0.40 ± 0.40 | 1.4 ± 0.4 | |
| 24 | 02/07/91 | -0.08 ± 0.21 | 0.20 ± 0.79 | | |
| 25 | 02/22/91 | -0.02 ± 0.20 | 0.50 ± 0.69 | | |
| 26 | 02/07/91 | 0.05 ± 0.14 | 0.68 ± 0.50 | | |
| 27 | 02/22/91 | 0.04 ± 0.14 | -0.05 ± 0.31 | | |
| 28 | 02/07/91 | -0.02 ± 0.20 | 0.86 ± 0.79 | | |
| 30 | 02/07/91 | -0.08 ± 0.03 | 0.11 ± 0.57 | | |
| 32 | 02/07/91 | -0.05 ± 0.02 | 0.55 ± 0.41 | | |
| 36 | 02/07/91 | 0.0 ± 0.2 | 0.67 ± 0.95 | 0.3 ± 0.8 | |
| 38 | 02/07/91 | 0.28 ± 0.36 | 2.0 ± 1.0 | | |
| 39 | 02/07/91 | -0.06 ± 0.02 | -0.11 ± 0.28 | | |
| 40 | 02/07/91 | -0.10 ± 0.19 | 0.24 ± 0.70 | | |
| 41 | 02/07/91 | 0.10 ± 0.26 | -0.03 ± 0.62 | | |
| 42 | 02/07/91 | -0.088± 0.034 | 0.46 ± 0.86 | | |
| 43 | 02/07/91 | 0.12 ± 0.21 | 0.76 ± 0.53 | | |
| 44 | 02/07/91 | 0.17 ± 0.33 | 0.14 ± 0.63 | | |
| 45 | 02/07/91 | -0.02 ± 0.11 | 2.5 ± 0.6 | 2.5 ± 1.1 | |
| 46 | 02/07/91 | 0.10 ± 0.27 | 0.57 ± 0.71 | | |

[a] Does not include tritium activity.

[b] Blanks indicate concentration below minimum detectable activity of ~2.5 Bq/L.

[c] Blanks denote analysis not performed.

**Table B.7. Radionuclide concentrations in samples from hillcut disposal test facility in SWSA 6**

| Sample Collection Date | Tank No. of Sample | $^{60}Co$ (Bq/L) | $^{137}Cs$ (Bq/L) | Gross Alpha (Bq/L) | Gross Beta[a] (Bq/L) |
|---|---|---|---|---|---|
| 12/28/90 | 1 | 0.02± 0.31 | 0.07± 0.29 | 0.20 ± 0.24 | 1.3 ± 0.5 |
| 01/22/91 | 1 | 0.03 | ± 0.360.007 | ± 0.058 | 0.26± 0.23 |
| 02/20/91 | 1 | 0.15± 0.57 | 0.10± 0.66 | 0.49 ± 0.57 | 1.2 ± 1.4 |
| 03/06/91 | 1 | -0.09± 0.26 | 0.22± 0.26 | 0.07 ± 0.11 | 0.66± 0.26 |
| 02/20/91 | 2 | -0.29± 0.86 | -0.22± 0.61 | 4.0 ± 1.4 | 4.8 ± 1.6 |
| 02/21/91 | 2 | 0.11± 0.22 | 0.23± 0.19 | 0.47 ± 0.12 | 1.5 ± 0.2 |

[a] Does not include tritium activity.

**Table B.8. Samples collected and analyses performed during Phase 1 investigation in SWSA 5 North**

| Sample Location[a] | Media Sampled | Analyses[b] |
|---|---|---|
| WOC 0 | Water | Gross alpha, gross beta, gamma scan, $^{90}Sr$ |
| WOC 30 | Water | Gross alpha, gross beta, gamma scan |
| WOC 15 | Water | Gross alpha, gross beta, gamma scan |
| WOC 60 | Water | Gross alpha, gross beta, gamma scan |
| WOC 120 | Water | Gross alpha, gross beta, gamma scan |
| WOC 150 | Water | Gross alpha, gross beta, gamma scan |
| WOC 180 | Water | Gross alpha, gross beta, gamma scan |
| WOC 210 | Water | Gross alpha, gross beta, gamma scan |
| WOC 240 | Water | Gross alpha, gross beta, gamma scan |
| WOC 270 | Water | Gross alpha, gross beta, gamma scan, $^{90}Sr$ |
| WOC 300 | Water | Gross alpha, gross beta, gamma scan |
| WOC 330 | Water | Gross alpha, gross beta, gamma scan |
| WOC 360 | Water | Gross alpha, gross beta, gamma scan, $^{90}Sr$ |
| 5NST 2 | Water | Gross alpha, gross beta, gamma scan, $^{3}H$ |
| South Tributary Mouth | Water | Gross alpha, gross beta, gamma scan |
| 5NNT 1 | Water | Gross alpha, gross beta, gamma scan, $^{3}H$ |
| North Tributary Mouth | Water | Gross alpha, gross beta, gamma scan |
| Well 513 | Water | Gross alpha, gross beta, gamma scan, $^{3}H$ |
| Well 514 | Water | Gross alpha, gross beta, gamma scan, $^{3}H$ |
| Well 516 | Water | Gross alpha, gross beta, gamma scan, $^{3}H$, $^{90}Sr$, ICP[c] |
| Well 517 | Water | Gross alpha, gross beta, gamma scan, $^{3}H$ |
| Well 518 | Water | Gross alpha, gross beta, gamma scan, $^{3}H$ |
| Well 519 | Water | Gross alpha, gross beta, gamma scan, $^{3}H$ |
| Well 520 | Water | Gross alpha, gross beta, gamma scan, $^{3}H$ |
| Well 521 | Water | Gross alpha, gross beta, gamma scan, $^{3}H$ |
| Well 523 | Water | Gross alpha, gross beta, gamma scan, $^{3}H$ |
| Well 524 | Water | Gross alpha, gross beta, gamma scan, $^{3}H$ |
| Well 525 | Water | Gross alpha, gross beta, gamma scan, $^{3}H$ |
| Well 708 | Water | Gross alpha, gross beta, gamma scan, $^{3}H$ |
| Well 715 | Water | Gross alpha, gross beta, gamma scan, $^{3}H$ |
| Well 716 | Water | Gross alpha, gross beta, gamma scan, $^{3}H$ |
| Seep 5NW 1 | Water | Gross alpha, gross beta, gamma scan, $^{3}H$ |
| Seep 5NW 2 | Water | Gross alpha, gross beta, gamma scan, $^{3}H$ |
| WOC Seeps (4) | Water | Gross alpha, gross beta, gamma scan, $^{3}H$ |
| WOC 120 | $MnO_2$-coated Fiber | Gross alpha, gross beta, gamma scan |

**Table B.8 (continued).**

| Sample Location[a] | Media Sampled | Analyses[b] |
|---|---|---|
| WOC 300 | $MnO_2$-coated Fiber | Gross alpha, gross beta, gamma scan |
| Well 516 (3 samples) | $MnO_2$-coated Fiber | Gross alpha, gross beta, gamma scan |
| WOC 120 | Sediment | Gamma scan |

[a] See Fig. for locations of samples. WOC = White Oak Creek

[b] If gross alpha exceeded 1.0 Bq/L, then transuranic alpha emitters were determined.

[c] ICP = Inductively Coupled Plasma spectrometry (i.e., metals).

**Table B.9. Gross alpha and specific alpha emitters, gross beta and specific beta emitters in SWSA 5 North area samples[a]**

| Location | Gross alpha | $^{244}Cm$ | $^{241}Am$ | $^{23X}Pu$ | Gross beta | $^{90}Sr$ | $^{3}H$ |
|---|---|---|---|---|---|---|---|
| **White Oak Creek Samples[b]** | | | | | | | |
| WOC 0 | 0.16 ± 0.08 | | | | 4.6 ± 0.4 | 1.6 ± 0.2 | |
| WOC 15 | 0.15 ± 0.08 | | | | 3.9 ± 0.3 | | |
| WOC 60 | 0.08 ± 0.06 | | | | 4.7 ± 0.4 | | |
| WOC 120 | 0.14 ± 0.08 | | | | 3.4 ± 0.6 | | |
| WOC 150 | 0.08 ± 0.06 | | | | 4.2 ± 0.4 | | |
| WOC 180 | 0.23 ± 0.09 | | | | 4.5 ± 0.4 | | |
| WOC 210 | 0.15 ± 0.08 | | | | 4.6 ± 0.4 | | |
| WOC 240 | 0.18 ± 0.09 | | | | 4.8 ± 0.4 | | |
| WOC 270 | 0.04 ± 0.05 | | | | 5.6 ± 0.4 | 1.7 ± 0.2 | |
| WOC 300 | -0.04 ± 0.06 | | | | 4.4 ± 0.4 | | |
| WOC 330 | 0.04 ± 0.05 | | | | 3.5 ± 0.3 | | |
| WOC 360 | 0.05 ± 0.05 | | | | 5.1 ± 0.4 | 2.4 ± 0.2 | |
| **WOC Fiber Samples[c]** | | | | | | | |
| WOC 120 | | 0.044 ± 0.006 | 0.053 ± 0.007 | | | | |
| WOC 300 | | 0.052 ± 0.007 | 0.080 ± 0.009 | | | | |
| **South Tributary Samples[b]** | | | | | | | |
| 5NST 2 | 2.6 ± 0.3 | -0.03 ±0.008 | 0.04 ± 0.02 | 0.01 ± 0.008 | 2.1 ± 0.2 | | 760 ± 25 |
| Mouth | 2.8 ± 0.4 | 0.06 ± 0.03 | -0.01 ± 0.02 | 0.005 ± 0.004 | 6.1 ± 0.4 | | |

**Table B.9 (continued).**

| Location | Gross alpha | $^{244}Cm$ | $^{241}Am$ | $^{23X}Pu$ | Gross beta | $^{90}Sr$ | $^{3}H$ |
|---|---|---|---|---|---|---|---|
| | | | | **North Tributary Samples**[b] | | | |
| 5NNT 1 | 0.05 ± 0.06 | | | | 0.07 ± 0.06 | | 0.31 ± 0.14 |
| Mouth | 0.05 ± 0.05 | | | | 0.15 ± 0.12 | | |
| | | | | **Well Samples**[b] | | | |
| 513 | 0.02 ± 0.02 | | | | 0.01 ± 0.06 | | 25 ± 18 |
| 514 | 0.035 ± 0.036 | | | | 0.04 ± 0.1 | | 33 ± 17 |
| 516 | 38 ± 1 | 41 ± 2 | 1.7 ± 0.5 | 0.11 ± 0.04 | 2.2 ± 0.2 | 0.054 ± 0.034 | 51 ± 12 |
| 517 | 0.023 ± 0.041 | | | | 0.28 ± 0.11 | | 37 ± 17 |
| 518 | 0.14 ± 0.05 | | | | 0.32 ± 0.08 | | 22 ± 18 |
| 519 | 0.01 ± 0.04 | | | | 0.3 ± 0.11 | | 27 ± 17 |
| 520 | 0.05 ± 0.06 | | | | 0.08 ± 0.1 | | 36 ± 12 |
| 521 | 0.0 ± 0.05 | | | | 0.12 ± 0.08 | | -45 ± 16 |
| 523 | 0.15 ± 0.08 | | | | 0.22 ± 0.18 | | 55 ± 18 |
| 524 | -0.01 ± 0.03 | | | | 0.35 ± 0.12 | | 370 ± 22 |
| 525 | 0.05 ± 0.06 | | | | 0.17 ± 0.13 | | 2 ± 10 |
| 708 | 0.01 ± 0.02 | | | | 0.10 ± 0.06 | | 220 ± 20 |
| 715 | 0.03 ± 0.03 | | | | 0.6 ± 0.12 | | 10 ± 16 |
| 716 | 0.04 ± 0.03 | | | | 0.27 ± 0.08 | | -30 ± 17 |
| 982 | 1.1 | | | | *d* | *d* | *d* |
| 983 | *d* | | | | *d* | *d* | *d* |
| 984 | *d* | | | | *d* | *d* | 86 |

**Table B.9 (continued).**

| Location | Gross alpha | $^{244}Cm$ | $^{241}Am$ | $^{23X}Pu$ | Gross beta | $^{90}Sr$ | $^{3}H$ |
|---|---|---|---|---|---|---|---|
| | | | **Well Fiber Sample**[c] | | | | |
| Well 516 | | 32.8 ± 2.02[e] | | | | | |
| Blank[f] | | <0.002 | <0.002 | | | | |
| | | | **December 1990 Seep Samples**[b] | | | | |
| 5NW 1 | 0.17 ± 0.09 | | | | 0.27 ± 0.12 | | |
| 5NW 2 | 0.12 ± 0.08 | | | | 0.40 ± 0.14 | | |
| WOC 160 | 0.12 ± 0.08 | | | | 0.47 ± 0.14 | | |
| WOC 175 | 0.09 ± 0.07 | | | | 0.80 ± 0.18 | | |
| WOC 213 | 0.26 ± 0.16 | | | | 0.50 ± 0.23 | | |
| WOC 255 | 0.27 ± 0.11 | | | | 0.31 ± 0.13 | | |
| | | | **January 1991 Seep Samples**[b] | | | | |
| 5NW 1 | 0.07 ± 0.09 | | | | 0.31 ± 0.23 | | 39 ± 35 |
| 5NW 2 | -0.02 ± 0.01 | | | | 0.02 ± 0.16 | | 220 ± 40 |
| WOC 160 | 0.03 ± 0.07 | | | | 0.12 ± 0.20 | | 170± 40 |
| WOC 175 | -0.01 ± 0.05 | | | | 0.25 ± 0.19 | | 200 ± 40 |
| WOC 213 | 13 ± 1 | 13 ± 1 | 0.72 ± 0.22 | | 1.6 ± 0.4 | | |
| WOC 255 | 0.99 ± 0.31 | 0.79 ± .18 | 0.04 ± 0.06 | | 0.06 ± 0.17 | | 33 ± 35 |

**Table B.9 (continued).**

| Location | Gross alpha | $^{244}Cm$ | $^{241}Am$ | $^{23X}Pu$ | Gross beta | $^{90}Sr$ | $^{3}H$ |
|---|---|---|---|---|---|---|---|
| | | | **March 1991 Seep Sample**[b] | | | | |
| WOC 213 | 79 ± 3 | 67 ± 4 | 1.1 ± 0.6 | | 6.8 ± 0.7 | | |

[a] Results are presented as mean ± SE (counting error only). Blanks indicate analysis not performed.
[b] Results are in Bq/L.
[c] Results are in Bq/sample.
[d] Value not reported by Analytical Chemistry Division (ACD).
[e] Results are mean of three replicate samples ± SE.
[f] A 50-g sample of fiber was soaked for ~16 h in deionized water and submitted to ACD as a blind blank.

**Table B.10. Gamma-scan results in water, fiber, and sediment samples from the SWSA 5 North area[a,b]**

| Location | $^{40}K$ | $^{60}Co$ | $^{137}Cs$ | $^{152}Eu$ | $^{154}Eu$ |
|---|---|---|---|---|---|
| **White Oak Creek Samples[b]** | | | | | |
| WOC 0 | 1.94 ± 0.4 | <0.1 | 1.73 ± 0.07 | <0.5 | <0.5 |
| WOC 15 | <4 | <0.2 | 1.67 ± 0.11 | <0.5 | <0.5 |
| WOC 60 | <4 | <0.2 | 1.67 ± 0.11 | <0.5 | <0.5 |
| WOC 120 | <1 | 0.06 ± 0.07 | 15.37 ± 0.12 | <0.5 | <0.5 |
| WOC 120-2[c] | <1 | 0.03 ± 0.02 | 0.78 ± 0.04 | <0.5 | <0.5 |
| WOC 150 | <2 | <0.1 | 1.86 ± 0.07 | <0.5 | <0.5 |
| WOC 180 | <4 | <0.2 | 1.59 ± 0.10 | <0.5 | <0.5 |
| WOC 210 | <4 | <0.2 | 1.70 ± 0.10 | <0.5 | <0.5 |
| WOC 240 | <4 | 0.1 ± 0.06 | 1.53 ± 0.07 | <0.5 | <0.5 |
| WOC 270 | <2 | <0.1 | 2.02 ± 0.06 | <0.5 | <0.5 |
| WOC 300 | <1 | <0.1 | 1.47 ± 0.04 | <0.5 | 0.5 |
| WOC 330 | 0.04 ± 0.96 | <0.2 | 1.58 ± 0.13 | <0.5 | <0.5 |
| WOC 360 | <2 | <0.1 | 1.48 ± 0.06 | <0.5 | <0.5 |
| **North Tributary Samples[b]** | | | | | |
| 5NNT 1 | 7.4 ± 1.0 | -0.01 ± 0.21 | 0.01 ± 0.21 | | |
| Mouth | 1.54 ± 0.71 | <0.1 | <0.1 | <0.5 | <0.5 |
| **South Tributary Samples[b]** | | | | | |
| 5NST 2 | 4.5 ± 1.6 | -0.02 ± 0.27 | 0.08 ± 0.22 | | |
| Mouth | <1 | <0.1 | <0.1 | <0.5 | <0.5 |
| **WOC Fiber Samples[d]** | | | | | |
| WOC 120 | 12.2 ± 0.44 | 1.15 ± 0.04 | 106 ± 0.22 | 0.63 ± 0.07 | 1.48 ± 0.37 |
| WOC 300 | 11.3 ± 0.56 | 2.44 ± 0.07 | 333 ± 0.37 | 12.2 ± 0.37 | 4.82 ± 0.74 |
| **December 1990 Seep Samples[b]** | | | | | |
| 5NW 1 | 11.3 ± 1.78 | <0.5 | <0.5 | <0.5 | <0.5 |
| 5NW 2 | <1 | <0.5 | 0.13 ± 0.12 | <0.5 | <0.5 |
| WOC 160 | <1 | <0.5 | <0.5 | <0.5 | <0.5 |
| WOC 175 | <1 | <0.5 | <0.5 | <0.5 | <0.5 |
| WOC 213 | <1 | <0.5 | <0.5 | <0.5 | <0.5 |
| WOC 255 | 0.94 ± 1.13 | <0.5 | <0.5 | <0.5 | <0.5 |

**Table B.10 (continued).**

| Location | $^{40}K$ | $^{60}Co$ | $^{137}Cs$ | $^{152}Eu$ | $^{154}Eu$ |
|---|---|---|---|---|---|
| | | **January 1991 Seep Samples**[b] | | | |
| 5NW 1 | | -0.03 ± 0.31 | -0.01 ± 0.30 | | |
| 5NW 2 | | 0.23 ± 0.27 | 0.11 ± 0.45 | | |
| WOC 160 | | 0.40 ± 0.27 | -0.8 ± 2.5 | | |
| WOC 175 | | 0.19 ± 0.59 | 0.12 ± 0.62 | | |
| WOC 213 | | -0.10 ± 1.30 | 0.3 ± 1.1 | | |
| WOC 255 | | 0.01 ± 0.15 | 0.03 ± 0.13 | | |
| | | **Well Samples**[b] | | | |
| 513 | <1 | -0.08 ± 0.23 | -0.08 ± 0.19 | | |
| 514 | | 0.06 ± 0.31 | 0.12 ± 0.25 | | |
| 516 | 1.30 ± 0.55 | 0.32 ± 0.91 | <0.1 | <0.2 | <0.2 |
| 517 | | -0.11 ± 0.33 | 0.05 ± 0.30 | | |
| 518 | 1.1 ± 1.4 | 0.08 ± 0.28 | 0.05 ± 0.31 | | |
| 519 | | 0.05 ± 0.28 | 0.18 ± 0.27 | | |
| 520 | 7.2 ± 1.0 | 0.12 ± 0.18 | 0.02 ± 0.18 | | |
| 521 | 1.0 ± 1.2 | 0.04 ± 0.24 | -0.04 ± 0.24 | | |
| 523 | | 0.10 ± 0.19 | -0.04 ± 0.18 | | |
| 524 | | -0.02 ± 0.24 | 0.04 ± 0.24 | | |
| 525 | 12 ± 1 | -0.06 ± 0.24 | 0.11 ± 0.21 | | |
| 708 | <3 | 0.07 ± 0.21 | 0.15 ± 0.12 | | |
| 715 | | -0.09 ± 0.34 | -0.03 ± 0.28 | | |
| 716 | 0.11 ± 0.01 | 0.11 ± 0.19 | 0.09 ± 0.20 | | |
| 983 | | | 0.31 | | |
| | | **Well Fiber Sample**[d,e] | | | |
| Well 516 | 5.4 ± 0.90 | <0.01 | 0.037± 0.01 | <0.2 | <0.2 |
| | | **WOC Sediment Sample**[f] | | | |
| WOC 120 | 0.50 ± 0.01 | 0.20 ± 0.001 | 16.1 ± 0.01 | 0.08 ± 0.001 | |

[a] Results are presented as mean plus 1 standard error (counting error only). Blanks denote value not reported.

[b] Results are in Bq/L.

[c] A second sample was collected from WOC 120 and filtered prior to acidification.

[d] Results are in Bq/sample.

[e] Results are mean of three replicate samples ± standard error of mean.

[f] Results are in Bq/g.

**Table B.11. Metal concentrations in SWSA 5 North well 516**

| Metal | Concentration (mg/L) |
|---|---|
| Ag | <0.005 |
| As | <0.05 |
| Ba | 0.40 |
| Ca | 130 |
| Cd | <0.005 |
| Co | <0.004 |
| Cr | 0.008 |
| Cu | <0.007 |
| Fe | <0.05 |
| Mg | 16 |
| Mn | <0.001 |
| Mo | <0.04 |
| Na | 12 |
| Ni | 0.004 |
| Pb | <0.05 |
| Se | <0.05 |
| Si | 8.6 |
| Sn | <0.05 |
| Sr | 0.20 |
| Zn | <0.005 |

# APPENDIX C: BIOLOGICAL CHARACTERIZATION OF TUMULUS DISCHARGE

nternal Correspondence

MARTIN MARIETTA ENERGY SYSTEMS, INC.

May 2, 1991

Tom Ashwood

**Results of *Ceriodaphnia* Toxicity Test of Tumulus Runoff Water**

Here's a "short report" on the results of the toxicity test of the water you sent to us. The test was conducted during April 4-11, but the sample was delivered earlier (March 18). The sample was stored in our refrigerator (4°C) until dilutions were prepared for the test. When the test was started, the pH of the full-strength sample was 9.67. Extended storage of water with a high pH generally allows Ph to decline through uptake of atmospheric $CO_2$, so I would guess that the test we conducted would underestimate toxicity somewhat. Even so, the water clearly hammered the little rascals even after it was diluted to 75% of full-strength. The concentration causing a 50% reduction in survival (7-d) ($LC_{50}$) was estimated graphically to be about 68%.

If you have questions about the test, feel free to give me a call, and we'll provide whatever help possible.

A. J. Stewart, Bldg. 1504, MS-6351 (4-7835)

enc

*CERIODAPHNIA DUBIA*

TOXICITY TEST REPORT

TOXICOLOGY LABORATORY

ENVIRONMENTAL SCIENCES DIVISION
OAK RIDGE NATIONAL LABORATORY
P.O. BOX 2008, MS 6351
OAK RIDGE, TN 37831-6351

EXPERIMENT NUMBER C-685

Tumulus

April 4-11, 1991

## CERIODAPHNIA 7-DAY SURVIVAL AND REPRODUCTION TEST

Experiment number C-685

Starting date: April 4, 1991.
Ending date: April 11, 1991.

1. *CERIODAPHNIA* SURVIVAL AND FECUNDITY TEST RESULTS

1.1 Daily results from the *Ceriodaphnia* toxicity test:

| Concentration | Day | Replicate[a] 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Number of live adults | Total live young |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Control | 1 | - | - | - | - | - | - | - | - | - | - | 10 | 0 |
| | 2 | - | - | - | - | - | - | - | - | - | - | 10 | 0 |
| | 3 | - | - | 3 | - | - | - | 2 | - | - | - | 10 | 5 |
| | 4 | 4 | 5 | 0 | 4 | 6 | 5 | 6 | 4 | 4 | 3 | 10 | 41 |
| | 5 | 11 | 8 | 8 | 7 | 10 | 8 | 7 | 10 | 10 | 8 | 10 | 87 |
| | 6 | 10 | 0 | 11 | 10 | 11 | 0 | 0 | 13 | 0 | 0 | 10 | 55 |
| | 7 | 0 | 8 | 0 | 0 | 0 | 10 | 15 | 0 | 11 | 11 | 10 | 55 |
| | total | 25 | 21 | 22 | 21 | 27 | 23 | 30 | 27 | 25 | 22 | | 243 |
| 50% | 1 | - | - | - | - | - | - | - | - | - | - | 10 | 0 |
| | 2 | - | - | - | - | - | - | - | - | - | - | 10 | 0 |
| | 3 | 4 | 2 | - | - | - | - | - | - | - | - | 10 | 6 |
| | 4 | 0 | 0 | 4 | 4 | 4 | 4 | 4 | 2 | 4 | 3 | 10 | 29 |
| | 5 | 10 | 10 | 9 | 9 | 7 | 8 | 13 | 8 | 8 | 10 | 10 | 92 |
| | 6 | 4 | 13 | 0 | 10 | 12 | 14 | 14 | 10 | 15 | 18 | 10 | 110 |
| | 7 | 4 | 17 | 9 | 0 | 0 | 0 | 0 | 15 | 0 | 0 | 10 | 45 |
| | total | 22 | 42 | 22 | 23 | 23 | 26 | 31 | 35 | 27 | 31 | | 282 |
| 75% | 1 | - | - | - | - | - | - | - | - | - | - | 10 | 0 |
| | 2 | x | x | x | x | - | x | x | - | x | - | 3 | 0 |
| | 3 | x | x | x | x | x | x | x | x | x | - | 1 | 0 |
| | 4 | x | x | x | x | x | x | x | x | x | 3 | 1 | 3 |
| | 5 | x | x | x | x | x | x | x | x | x | 1 | 1 | 1 |
| | 6 | x | x | x | x | x | x | x | x | x | 9 | 1 | 9 |
| | 7 | x | x | x | x | x | x | x | x | x | 10 | 1 | 10 |
| | total | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 23 | | 23 |
| 100% | 1 | x | x | x | x | x | x | x | x | x | x | 0 | 0 |
| | 2 | x | x | x | x | x | x | x | x | x | x | 0 | 0 |
| | 3 | x | x | x | x | x | x | x | x | x | x | 0 | 0 |
| | 4 | x | x | x | x | x | x | x | x | x | x | 0 | 0 |
| | 5 | x | x | x | x | x | x | x | x | x | x | 0 | 0 |
| | 6 | x | x | x | x | x | x | x | x | x | x | 0 | 0 |
| | 7 | x | x | x | x | x | x | x | x | x | x | 0 | 0 |
| | total | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |

[a] - = live female too young to produce offspring; x = dead adult, no young produced before death; Nx = Dead adult, with N young produced before death.

1.2 Summary of results from the *Ceriodaphnia* toxicity test:

| Effluent concentration | Number of replicates | Number of animals surviving for 7 d | Mean number of offspring per female ($\pm$ *S*) |
|---|---|---|---|
| Control | 10 | 10 | 24.3 $\pm$ 4.0 |
| 50% | 10 | 10 | 28.2 $\pm$ 6.6 |
| 75% | 10 | 1 | 23.0 $\pm$ --- |
| 100% | 10 | 0 | ---- $\pm$ --- |

1.3 Statistical Analyses:

No analyses were conducted, for reproduction of the concentrations with 100% survival tested was greater than the reproduction of the controls.

1.4 Summary of *Ceriodaphnia* toxicity test results:

No-observed-effect concentration (NOEC): 50%

Lowest-observed-effect concentration (LOEC): 75%

2. CHEMICAL ANALYSES

2.1 Results of the daily chemical analyses:

| Day | Concentration | pH | Cond.[a] | Alk.[b] | Hardness[c] | New Oxygen[d] |
|---|---|---|---|---|---|---|
| 1 | Control | 7.72 | 200 | 61.0 | 76 | 8.4 |
| | 50% | 9.40 | 650 | 260.0 | 38 | 8.4 |
| | 100% | 9.67 | 1117 | 458.0 | 2 | 8.3 |

[a]Cond. = conductivity expressed as $\mu$S/cm, corrected to 25°C. [b]Alk. = alkalinity expressed as mg/L $CaCO_3$. [c]mg/L $CaCO_3$. [d]mg/L dissolved oxygen.

April 29, 1991

Tom Ashwood

**Survey of Benthic Macroinvertebrates in SWSA 6 - Effects of Tumulus I Discharges**

It recently came to my attention that water having a relatively high pH (pH ≥ 10.5) was periodically being discharged (up to ≈2000 gal during a single release) into the lower reaches of the West Tributary in SWSA 6 (Fig. 1). There was concern that this periodic release of water may be impacting the biota of this small stream. In order to try to determine if any impact was occurring, qualitative/semi-quantitative samples of benthic macroinvertebrates were collected from the West Tributary on March 21, 1991. Following the same procedures described in a memorandum to Jim Loar (April 9, 1991, Results of Benthic Macroinvertebrate Surveys of Streams in SWSA 6 - May 1990), one qualitative/semi-quantitative sample was collected above and one below the point of discharge of the water. Additionally, a single sample was collected from a reference site on a small unnamed tributary of upper Melton Branch (MEK) located east-southeast of the High Flux Isotope Reactor at the Oak Ridge National Laboratory (Fig. 2). This reference site was the same Melton Branch tributary reference site used in the May 1990 survey. Procedures for processing the samples were the same as those described in the April 9 memorandum to Jim Loar.

A checklist of the invertebrates collected from the West Tributary in SWSA 6 and the reference site is presented in Table 1. Also included in Table 1 is an estimate of the relative abundance of each taxon at each site. The relative abundance of each taxon and the taxonomic composition of each site in the West Tributary were very similar. The relative abundance of the major taxa (% abundance, Fig. 3a) and total and EPT (Ephemeroptera, Plecoptera, and Trichoptera) richness of the West Tributary sites showed even stronger similarities (Fig. 3b), with only minor between-site differences. As was found in the 1990 survey, the West Tributary and the MEK tributary differed considerably in taxonomic composition, relative abundance of major taxonomic groups, total richness, and EPT richness (Table 1; Figs. 3a and 3b). The most abundant taxon at all three sites was the isopod, *Lirceus*. However, the contribution of the Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa to the relative abundance at the two West Tributary sites was very low relative to the MEK tributary. Furthermore, total taxonomic richness was almost 2X higher at the MEK tributary than at either West Tributary site, and EPT richness was at least 3X higher. Finally, no Ephemeroptera were collected from either site in the West Tributary, while six taxa were collected from the MEK tributary. Most Ephemeroptera are relatively intolerant of poor water quality (Lenat 1988; Wiederholm 1984), thus their absence continues to indicate impacted conditions in the West Tributary.

In conclusion, there appear to be no notable adverse impacts to the invertebrate community of lower West Tributary associated with the periodic release of water from Tumulus I. If any impacts occur, they are probably temporary and result from the sudden increase in flow when the water is released. Because the upper reaches of the stream are not affected by releases of water, any displaced organisms in the lower reaches are probably replaced within a matter of days by drifting organisms from upstream. In terms of protecting aquatic life in the West Tributary, the best corrective action to take would probably be to cover the Tumulus to avoid any releases altogether. A second alternative would be to allow the water to runoff continuously. A third alternative would be to release the accumulated water slowly, which would reduce the effects associated with the sudden release of a large volume of water. However, this latter alternative may increase the exposure period of the biota to water having a higher pH, which in turn, may increase the chances for chronic effects.

If you have any questions please don't hesitate to call.

J. G. Smith, Building 1505, MS-6038 (6-4163)

Attachments

cc: J. M. Loar
C. M. Morrissey

## Literature Cited

Lenat, D. R. 1988. Water quality assessment of streams using a qualitative collection method for benthic macroinvertebrates. Journal of the North American Benthological Society 7:222-233.

Wiederholm, T. 1984. Responses of aquatic insects to environmental pollution. pp. 508-557. IN: V. H. Resh and D. M. Rosenberg (eds.), The Ecology of Aquatic Insects. Praeger Publishers, New York. 626 pp.

Table 1. Checklist and relative abundance of benthic macroinvertebrates from the West Tributary in SWSA 6 (WT2L and WT2U) and a nearby reference site on a tributary of Melton Branch (MEK), March 21, 1991. Values are the relative abundance of each taxon expressed as a % of the total number of individuals in the semi-quantitative portion of the sample; an "X" denotes a taxon's occurrence in the qualitative portion of the sample only; a "-" indicates the taxon was not collected.

| | Site | | |
|---|---|---|---|
| Taxon | WT2L | WT2U | MEK |
| Turbellaria | | | |
| Planariidae | X | - | - |
| Nematoda | - | 0.1 | 0.3 |
| Oligochaeta | 0.1 | 0.9 | 1.3 |
| Crustacea | | | |
| Copepoda | 0.3 | 0.2 | - |
| Ostracoda | - | 0.1 | - |
| Isopoda | | | |
| Asellidae | | | |
| *Lirceus* | 86.8 | 84.7 | 65.8 |
| Amphipoda | | | |
| Gammaridae | | | |
| *Crangonyx* | 1.6 | 4.1 | 3.4 |
| Decapoda | | | |
| Cambaridae | 0.1 | - | 0.1 |
| Insecta | | | |
| Collembola | | | |
| Entomobryomorpha | 0.6 | 0.3 | - |
| Ephemeroptera | | | |
| Baetidae | | | |
| *Baetis* | - | - | 0.3 |
| Ephemerellidae | | | |
| *Eurylophella bicolor* | - | - | 0.2 |
| *Eurylophella funeralis* | - | - | 0.5 |
| Heptageniidae | | | |
| *Leucrocuta*? | - | - | 0.1 |

Table 1 (cont.).

| Taxon | Site | | |
|---|---|---|---|
| | WT2L | WT2U | MEK |
| Ephemeroptera (cont.) | | | |
| Leptophlebiidae | | | |
| *Paraleptophlebia* | - | - | 0.7 |
| Siphlonuridae | | | |
| *Ameletus* | - | - | 0.1 |
| Odonata | | | |
| Anisoptera | | | |
| Cordulegastridae | | | |
| *Cordulegaster* | 0.1 | - | - |
| *Cordulegaster obliquua* | - | - | 0.7 |
| Zygoptera | | | |
| Calopterygidae | | | |
| *Calopteryx* | - | X | - |
| Coenagrionidae | - | 0.1 | - |
| Plecoptera | | | |
| Leuctridae | | | |
| *Leuctra* | - | - | 1.0 |
| Nemouridae | | | |
| *Amphinemura* | 5.4 | 2.9 | 14.4 |
| *Paranemoura*? | - | X | - |
| Perlidae | - | - | X |
| *Eccoptura xanthenes* | - | - | X |
| Perlodidae | | | |
| *Clioperla clio* | - | - | X |
| *Isoperla* | 0.2 | - | - |
| *Isoperla holochlora*? | - | 0.3 | 2.4 |
| Megaloptera | | | |
| Sialidae | | | |
| *Sialis* | - | X | - |

Table 1 (cont.)

| Taxon | Site | | |
|---|---|---|---|
| | WT2L | WT2U | MEK |
| Trichoptera | | | |
| Glossosomatidae | | | |
| *Agapetus* | - | - | X |
| Hydroptilidae | | | |
| *Ochrotrichia* | - | X | 1.0 |
| Limnephilidae | | | |
| *Ironoquia* | 0.1 | 0.1 | 0.3 |
| *Neophylax* | - | - | 0.1 |
| *Pycnopsyche* | X | - | - |
| *Pycnopsyche scabripennis* | - | X | 0.1 |
| Phryganeidae | | | |
| *Ptilostomis* | - | - | X |
| Rhyacophilidae | | | |
| *Rhyacophila fenestra-ledra* | 0.3 | 0.2 | X |
| Coleoptera | | | |
| Dytiscidae | - | 0.1 | - |
| *Hydroporus* | 0.1 | 0.1 | 0.1 |
| *Hydroporus*? | 0.1 | - | - |
| Elmidae | | | |
| *Optioservus* | - | - | X |
| *Stenelmis* | - | - | X |
| Diptera | | | |
| Ceratopogonidae | 0.1 | 0.9 | 0.4 |
| Chironomidae | 0.1 | - | X |
| Chironominae | | | |
| Chironomini | 0.3 | 0.5 | 0.2 |
| Tanytarsini | 0.1 | 0.2 | 0.4 |
| Orthocladiinae | 2.8 | 2.7 | 3.5 |
| Tanypodinae | 0.6 | 1.2 | 1.2 |
| Culicidae | 0.1 | - | - |

Table 1 (cont.)

| Taxon | Site | | |
|---|---|---|---|
| | WT2L | WT2U | MEK |
| Diptera (cont.) | | | |
| Dixidae | | | |
| *Dixa* | - | - | 0.4 |
| *Dixella* | - | 0.1 | - |
| Ptychopteridae | | | |
| *Ptychoptera* | - | - | X |
| Simuliidae | | | |
| *Stegopterna mutata* | 0.2 | 0.2 | 0.1 |
| Stratiomyidae | | | |
| *Odontomyia* | - | - | X |
| Tabanidae | | | |
| *Chrysops*? | 0.1 | - | - |
| Tipulidae | | | |
| *Hexatoma* | - | - | 0.1 |
| *Hexatoma*? | - | - | 0.1 |
| *Pseudolimnophila*? | - | - | 0.1 |
| *Tipula* | - | X | - |
| *Tipula abdominalis* | - | - | X |
| Mollusca | | | |
| Gastropoda | | | |
| Lymnaeidae | | | |
| *Pseudosuccinea columella* | - | - | X |
| Lymnaeidae? | - | X | - |
| Physidae | | | |
| *Physella* | X | - | - |
| Bivalvia | | | |
| Sphaeriidae | 0.1 | - | - |
| *Pisidium* | - | X | X |
| *Sphaerium* | - | - | 0.1 |

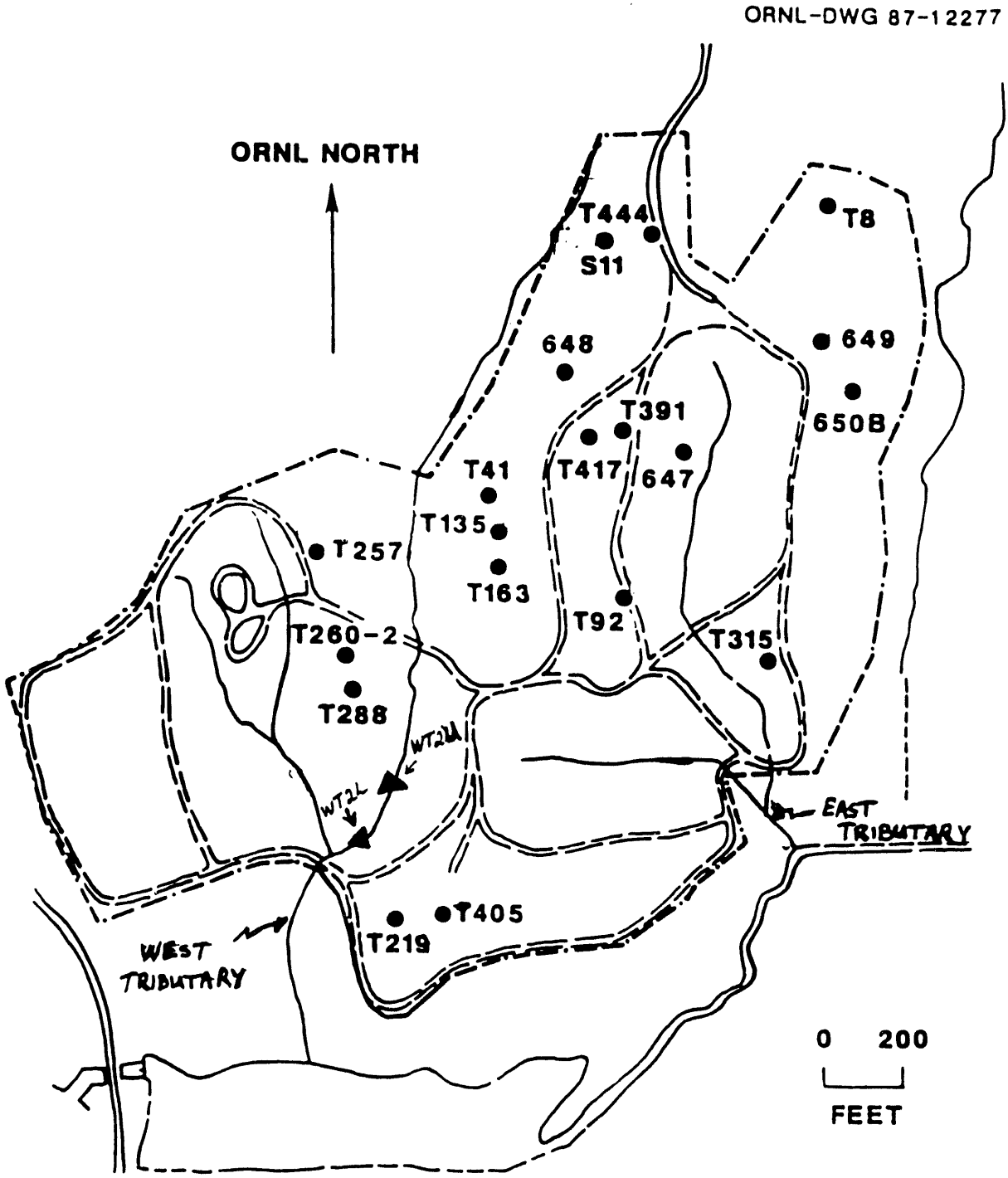



Fig. 1. Locations of benthic macroinvertebrate sampling sites (▲) on West Tributary (WT2L and WT2U only) in SWSA 6, March 21, 1991. Also shown are locations of trench and groundwater monitoring wells (•).

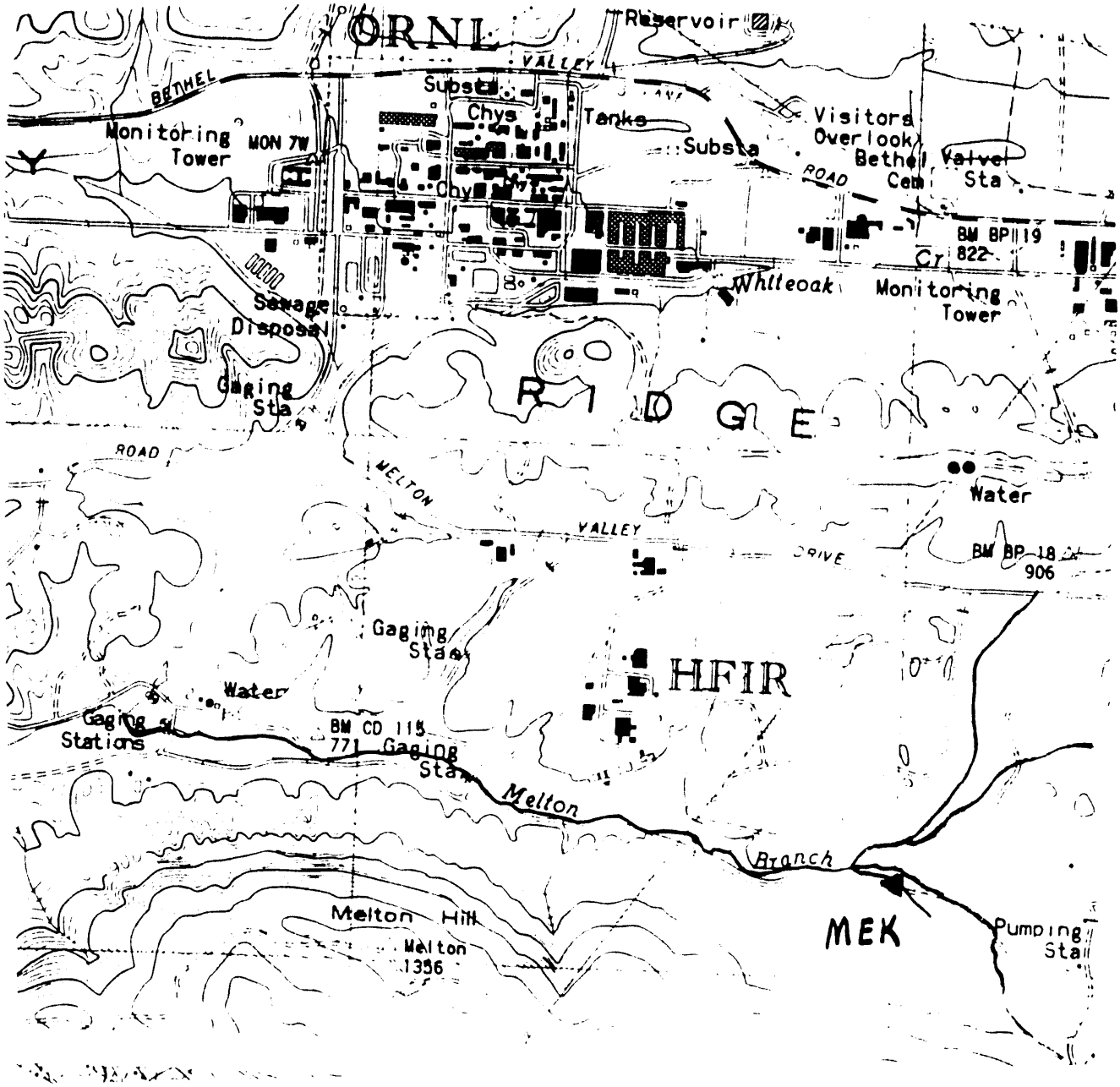



Fig. 2. Location of the benthic macroinvertebrate sampling site (▲) on a Melton Branch tributary, March 21, 1991.

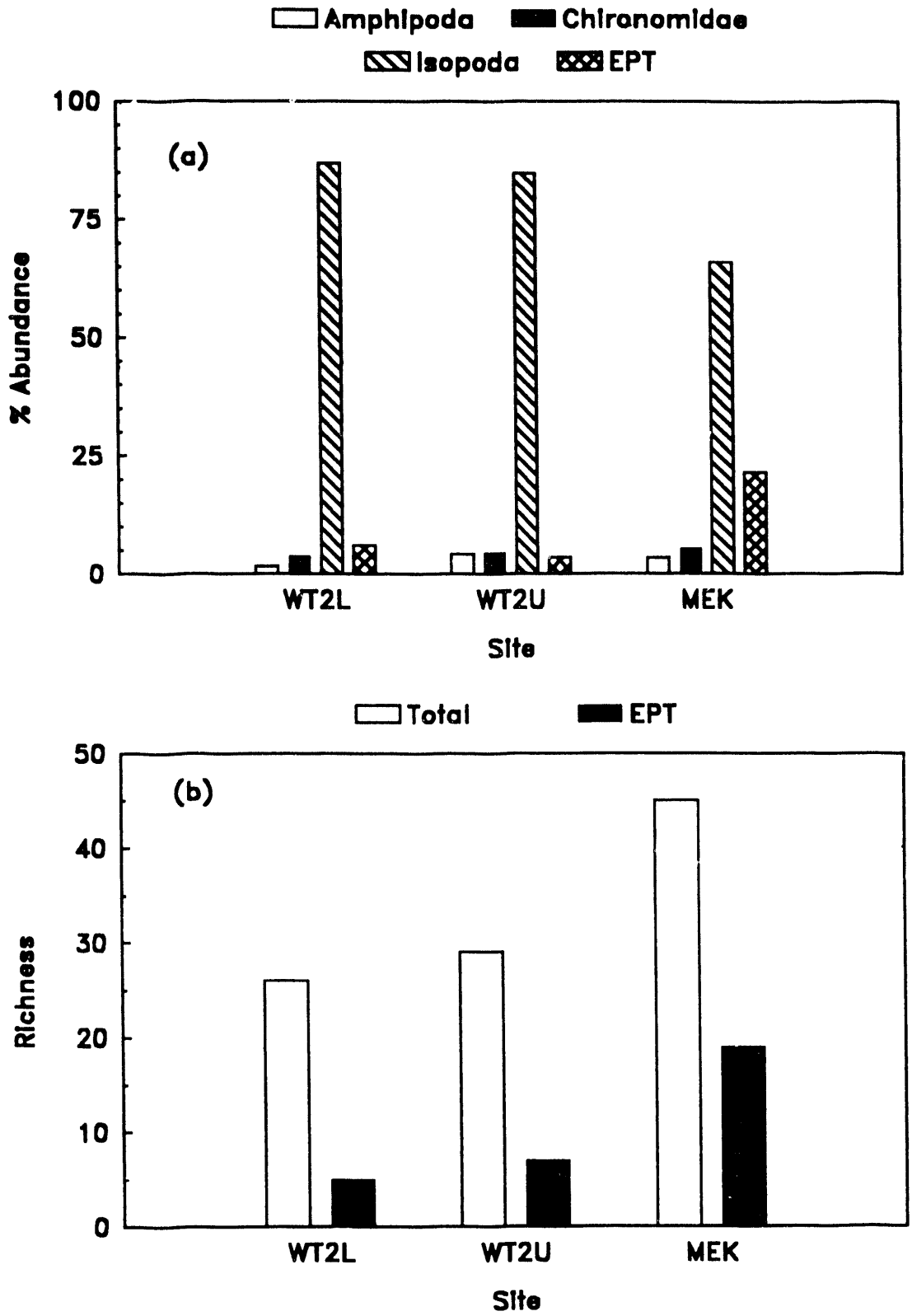



Fig. 3. (a) Relative abundance (% of total number of individuals) and (b) total and EPT (Ephemeroptera, Plecoptera, and Trichoptera) richness of benthic macroinvertebrates in the West Tributary of SWSA 6 (WT2L and WT2U) and a reference site on a tributary of Melton Branch (MEK), March 21, 1991.

# APPENDIX D: ACTION PLAN FOR FURTHER INVESTIGATION OF TRU CONTAMINATION IN SWSA 5 NORTH

## INTRODUCTION

As part of the Active Sites Environmental Monitoring Program (ASEMP) streams and groundwater wells around the TRU waste storage area in Solid Waste Storage Area (SWSA) 5 North are sampled quarterly (Ashwood et al., 1990a). Well 516, immediately down-gradient from a group of TRU waste trenches (Fig. A.2), contains gross alpha activity on the order of 150 Bq/L (Ashwood et al., 1990b; Wickliff et al., 1991). Curium-244 is the dominant radionuclide, with traces of $^{243}Am$ (6 Bq/L) and $^{241}Am$ (0.7 Bq/L) having been reported from separate samples. The TRU waste trenches also contain some RCRA-regulated wastes—primarily lead (Stewart et al., 1989). However, samples from Well 516 have not contained detectable concentrations of lead or other heavy metals. The trenches are upgradient from White Oak Creek (WOC) which drains most of ORNL and eventually enters the Clinch River. Because WOC represents a direct pathway offsite, certain regulatory reporting and corrective action requirements may be invoked if radionuclides or heavy metals have been released to the stream.

Elevated gross alpha activity, ~3 Bq/L (80 pCi/L), was also found in a sample collected from a small stream south of SWSA 5 North (Wickliff et al., 1991). This stream is a tributary of WOC and drains both a portion of SWSA 5 North and a portion of SWSA 5 (Fig. A.2). If the gross alpha activity is due to the presence of transuranic elements that originate in SWSA 5 North, the same regulatory issues as for WOC may apply.

Elevated tritium activity was recently found in Well 524 just north of SWSA 5 North (Fig. 1) and in samples from two seeps just west of SWSA 5 North (Fig. A.2). If the $^{3}H$ originates in SWSA 5 North, it may represent the front of a contaminant plume because $^{3}H$ is geochemically conservative and moves more rapidly in ground water than do other radioisotopes.

The primary objectives of this investigation are to characterize the extent of radionuclide migration from the trenches in SWSA 5 North and to determine the source of gross alpha contamination in South Tributary. Additional objectives are to determine whether SWSA 5 North is the source of tritium in Well 524 and the seeps, to demonstrate the effectiveness of MnO fibers as a monitoring and/or characterization tool, and to provide information to assist Solid Waste Operations in identifying the appropriate corrective action(s) if needed.

## APPROACH

The investigation will be carried out in phases. At the end of each phase, results will be presented in a letter report. Before deciding to proceed, activities in future phases will be evaluated in light of the results from the previous phase. An action plan for the next phase will be included in the letter report for review and concurrence by Solid Waste Operations (SWO).

### PHASE 1

In Phase 1, existing data and sampling sites will be utilized to better define and bound the problem. Activities in this phase will not require NEPA documentation or additional permits; thus, they can be implemented without delay once the wetter season begins. Phase 1 will also provide information that can be used to optimize succeeding phases.

## Data Review

There are two piezometer and three Regulatory Compliance Monitoring wells in the area of Well 516 (Fig. A.2). Well construction data for these wells and some water levels in the piezometer wells have been obtained and will be reviewed. The Compliance wells were sampled in August 1990. We will obtain results from this sampling. To our knowledge, the piezometer wells have not been sampled; however, a database search will be made for reports that may contain water quality data for groundwater wells in or around SWSA 5 North.

## Well Sampling

Piezometer wells, 708 and 716, will be added to the ASEMP quarterly sampling. Samples will be analyzed for gross alpha, gross beta, and gamma activity, as specified in the ASEMP Program Plan (Ashwood, et al., 1990). In addition, the samples will be submitted for $^{3}H$ analysis. The elevated $^{3}H$ levels found in Well 524 and the seeps are below the National Primary Drinking Water Standard of 740 Bq/L (20,000 pCi/L). However, $^{3}H$ concentrations may be useful in defining potential contaminant sources or flow paths. Tritium is conservative (non-reactive) in its geochemical behavior; therefore, it may be more easily leached and transported in the groundwater system than other radionuclides which are particle reactive (e.g., $^{244}Cm$ and $^{241,243}Am$).

## Stream Survey

White Oak Creek

Contaminant transport studies around ORNL suggest that radionuclides are transported along discrete pathways (e.g. fractures) that may be missed using wells alone. It is possible that the transuranic elements seen in Well 516 may reach WOC without ever being detected in the other nearby wells. Because WOC is a direct pathway offsite it is essential to determine to the best of our ability whether detectable quantities of transuranic elements are being released to WOC.

A 1-L water sample will be collected every 15 m (50 ft) along the reach of WOC potentially impacted by contamination from the trenches. Samples will be analyzed for gross alpha, gross beta, and $^{3}H$ concentrations, and scanned for high-energy gamma emitters ($^{137}Cs$, $^{60}Co$, etc.). If gross alpha or gross beta activities exceed action levels in any sample, that sample will be further analyzed to determine the specific isotope(s) generating the activity.

The volume of water flowing through this reach of WOC is likely to provide enough dilution to mask any contamination transported from SWSA 5 North. In order to provide sufficient concentration of any such contamination, a series of MnO fiber samplers will be installed at the same locations where water samples are collected. These samplers consist of water-permeable packets containing a small quantity (~15 g) of MnO fibers.

Previous studies have demonstrated that particle-reactive elements (including most radionuclides except $^{3}H$ and $^{90}Sr$) are preferentially adsorbed out of the water onto the fibers and concentrated by factors of $10^{3}$-$10^{5}$. This concentration factor should offset the dilution of the stream and permit detection of relatively low levels of contaminant influx. Although the particle-sorption theory behind these samplers is well established at both local and international levels, the samplers themselves have only been demonstrated in salt

water. It will be necessary to demonstrate the degree of sensitivity of these samplers to the specific isotopes of concern (primarily $^{244}Cm$ and $^{241}Am$) in a freshwater stream like WOC. A small laboratory experiment will be conducted in conjunction with the field work. The purpose of this study will be to determine the minimum water concentration of that can be detected with this method and the effects of small variations in pH and dissolved oxygen (DO) on the sensitivity of the method. In addition to the lab experiment, pH and DO will be measured at each sampler location on WOC. Replicates will be used in lab and field work.

South Tributary

The elevated gross alpha activity measured in one sample from this stream may originate in SWSA 5 or in SWSA 5 North. The stream is intermittent during dry periods, and samples can only be taken at a few locations during these conditions. In order to pinpoint the location at which the contamination enters the stream and the radionuclide causing the elevated gross alpha activity, it will be necessary to sample several sites along the stream during or immediately after a rain event.

A 1-L water sample will be collected every 15 m (50 ft). Samples will be analyzed for gross alpha and gross beta concentrations, and scanned for high-energy gamma emitters ($^{137}Cs$, $^{60}Co$, etc.). If gross alpha or gross beta concentrations exceed action levels in any sample, that sample will be further analyzed to determine the specific isotope(s) generating the activity.

### Seep Survey

Transport of groundwater along discrete pathways to the soil surface occurs during higher saturation conditions forming seeps. Seeps provide good sampling locations to monitor discrete contaminant transport that may be missed by wells. Therefore, an intensive investigation and sampling of seeps in the area of Well 516 will be conducted once ground saturation conditions increase (with the wetter seasons). In addition to the two seep locations 5NW 01 and 5NW 02, other seeps found during a field survey and a survey along the bank of WOC will be sampled. It has also become apparent from recent studies that near subsurface stormflow is an important transport mechanism of contaminants from burial trenches to nearby streams. Therefore, the seeps will be sampled shortly following a rainstorm when shallow subsurface groundwater transport is greatest. The seeps will also be sampled during relatively dry conditions (yet still during a wet season) when dilution by infiltrating rainwater is at a minimum. Samples will be analyzed for gross alpha, gross beta, and $^{3}H$ concentrations, and scanned for high-energy gamma emitters ($^{137}Cs$, $^{60}Co$, etc.).

### NEPA Documentation

During Phase 1 NEPA documentation will be prepared for potential activities to be done during subsequent phases. Approval for the NEPA documentation will likely take a long time, so it is essential to begin the process early in Phase 1.

## FUTURE PHASES

Transuranic elements, which can be detected at very low levels, serve as a tracer for other wastes (e.g., lead) buried in SWSA 5 North. If radioactive or hazardous contamination from the TRU trenches in SWSA 5 North has already reached White Oak Creek (WOC) further characterization of the extent of contamination becomes academic, except as

needed to design a remedial action. Future phases can provide additional information on extent of contaminants, on transport pathways and semi-quantitative data on transport times. Dye-tracer tests, modeling, instillation and sampling of drive-point wells, instillation and testing of groundwater wells, and soil-core collection and analyzes are potential activities to be conducted during future phases.

## HEALTH AND SAFETY

A project safety summary will be prepared for this work.

## QUALITY ASSURANCE

All work on this project will be conducted in accordance with the Quality Assurance Plan prepared for the Active Sites Environmental Monitoring Program. This plan is fully consistent with the ESD Quality Assurance Manual and ANSI NQA-1.

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# APPENDIX E: FABRICATION, INSTALLATION, AND ANALYSIS OF MANGANESE-OXIDE-COATED FIBER SAMPLERS

## INTRODUCTION

The use of $MnO_2$-coated fibers to remove Ra from sea and fresh water has been repeatedly demonstrated (Moore and Reid 1973, Moore and Cook 1975, Moore et al. 1985). The potential for removal of other radionuclides on these fibers is high (W. S. Moore, Univ. South Carolina, personal communication, 1990). Cerling and Spalding (1982) demonstrated that $^{60}Co$ was bound up in the MnO coatings on stream gravels in White Oak Creek (WOC) and that $^{90}Sr$ was found in these same coatings or on exchange sites on the gravels.

## FABRICATION AND INSTALLATION

Acrylic fibers were prepared in a potassium-permanganate solution as described by Moore et al. (1985). For this study, $MnO_2$-coated fibers were supplied by W. S. Moore (University of South Carolina).

Fibers were encased in a nylon mesh sheath. Two different sizes were used: ~50 g of fiber were used for each sample in well 516 and for a blank sample, and ~100 g of fiber were used in the WOC samplers. The sheathed fibers were placed in plastic bottles which had been drilled with several 0.6-cm holes.

Three 50-g sheaths were placed in three 250-mL bottles. The bottles were suspended on a nylon cord at approximately 0.3-m intervals and lowered into well 516 so that the uppermost bottle was below the water surface in the well. The bottles were installed in well 516 on 14 Dec 1990 and were removed three weeks later on 4 Jan 1991.

Ten 100-g sheaths were placed in 1-L bottles and installed at locations along WOC (Table E.1). Nine of the bottles were anchored by nylon cord between two bricks on the bottom of the creek. At WOC 300 the water was too deep for this approach, so the bottle was suspended on nylon cord from a tree limb and weighted with a single brick. At each WOC location, water parameters were measured just after installation of the bottles (Table E.1). Samplers were installed on 19 Dec 1990. On 8 Jan 1991, an attempt was made to recover the samplers. However, the 20-year storm that occurred on 23 Dec 1990 apparently washed all but two of the samplers (WOC 120 and WOC 300) away.

**Table E.1. Sample locations and water parameters for installation of $MnO_2$-coated-fiber samplers**

| Location | Sampler no. | Temperature (° C) | pH | Specific conductance (mmhos) |
|---|---|---|---|---|
| WOC 0 | 9 | 14.44 | 7.22 | 0.372 |
| WOC 120 | 10 | 14.50 | 7.15 | 0.365 |
| WOC 180 | 7 | 14.33 | 7.25 | 0.370 |
| WOC 195 | 11 | 14.30 | 7.24 | 0.370 |
| WOC 210 | 13 | 14.28 | 7.26 | 0.374 |
| WOC 225 | 4 | 14.26 | 7.26 | 0.374 |
| WOC 240 | 6 | 14.25 | 7.26 | 0.375 |
| WOC 270 | 12 | 14.22 | 7.26 | 0.374 |
| WOC 300 | 8 | 14.20 | 7.26 | 0.375 |
| South Tributary | 5 | 10.72 | 6.92 | 0.367 |

## ANALYSIS

After collection, all samples were washed twice with distilled water to remove as much suspended sediment as possible. Nevertheless, is is possible that a small amount of sediment remained embedded in the fibers.

Fibers were subjected to two analyses: gamma counting and alpha spectrometry. Gamma counting was accomplished in the Environmental Sciences Division counting rooms. Samples were squeezed to remove excess moisture prior to counting. The 50-g samples were placed in 125-cc plastic jars for counting. The 100-g samples were placed into 500-mL Maranelli beakers for counting.

After gamma-counting, samples were transferred to the Analytical Chemistry Division (ACD) for alpha analysis. A 50-g blank sample of fiber was prepared by allowing the fiber to stand in deionized water overnight. This sample was placed in a 125-cc plastic jar and labelled 516-4 so that it would serve as a blind blank to ACD.

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Cerling, T. E., and B. P. Spalding. 1982. Distribution and relationship of radionuclides to streambed gravels in a small watershed. Environ. Geol. 4:99-116.

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