1 of 2

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Y/TS-833/P2

ANNUAL REPORT OF 1991 GROUNDWATER
MONITORING DATA FOR THE KERR HOLLOW QUARRY
AND CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN
AT THE Y-12 PLANT:

Reporting and Statistical
Evaluation of the Subsequent
Year (Sixth) Data

Compiled by:

L. W. McMahon
Health, Safety, Environment,
and Accountability Division

T. M. Mercier
H&R Technical Associates, Inc.

Prepared for the
Oak Ridge Y-12 Plant
Oak Ridge, Tennessee 37831
managed by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
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1. INTRODUCTION

This annual report has historically been prepared to meet the annual reporting requirements of the Tennessee Department of Environment and Conservation (TDEC), Hazardous Waste Management Regulation 1200-1-11-.05 (6) (e), for detection monitoring data collected on Resource Conservation and Recovery Act (RCRA) wells in place around facilities which are accorded interim status. The regulatory authority for these units at the Y-12 Plant is currently in transition. A Federal Facility Agreement (FFA) with an effective date of January 1, 1992, has been negotiated with the Department of Energy (DOE) for the Oak Ridge Reservation. This agreement provides a framework for remediation of the Oak Ridge Reservation so that both RCRA and CERCLA requirements are integrated into the remediation process and provides for State, EPA, and DOE to proceed with CERCLA as the lead regulatory requirement and RCRA as an applicable or relevant and appropriate requirement.

This report is presented for the RCRA certified wells for two interim status units at the Y-12 Plant. These units are Kerr Hollow Quarry and Chestnut Ridge Sediment Disposal Basin. Kerr Hollow is currently undergoing clean closure under RCRA. The Chestnut Ridge Sediment Disposal Basin (CRSDB) was closed in 1989 under a TDEC approved RCRA closure plan. The relevance of a RCRA Post-Closure Permit to either of these units is a matter of contention between DOE and TDEC since the FFA does not contemplate post-closure permits.

2. Summary of Past and Planned Relevant Groundwater Monitoring Reports

The first year data were collected quarterly during CY 1986 and presented in Report No. Y/TS-242/P2.

In November 1986 each of the wells presented in this report was certified for groundwater monitoring purposes. At that time, the designation of upgradient and downgradient was based on the topographic relationship of the wells at each unit since no water elevation data had been collected prior to certification. Following a year of data collection, the wells were reevaluated for up- and downgradient designation using the hydrostatic head measurements obtained throughout the year. As a result of this investigation, the designation of well gradient was changed at both of the units.

During CY 1987 the wells were monitored semi-annually for parameters used as indicators of groundwater contamination [TN 1200-1-11-.05 (6) (c) 2 (iii)] and annually for parameters establishing groundwater quality [TN 1200-1-11-.05 (6) (c) 2 (ii)] and the results presented in Report No. Y/TS-388.

During CY 1988, the wells were again monitored semi-annually for parameters used as indicators of groundwater contamination. In addition, wells at the Chestnut Ridge Sediment Disposal Basin were monitored semi-annually for parameters establishing groundwater quality. The results were presented in Report No. Y/TS-511.

During CY 1989, the wells were again monitored semi-annually for parameters used as indicators of groundwater contamination. In addition, wells at the Chestnut Ridge Sediment Disposal Basin were monitored semi-annually for parameters establishing groundwater quality. The results were presented in Report No. Y/TS-625.

During CY 1990, the wells were again monitored semi-annually for parameters used as indicators of groundwater contamination. In addition, the wells were incorporated into the Y-12 Plant Comprehensive Groundwater Monitoring Program. The results were presented in Report No. Y/TS-724.

During CY 1991, the monitoring program remained the same as for CY 1990. In addition, annual Groundwater Quality Assessment Reports (GWQARs) have been prepared and submitted to TDEC for those units at the Y-12 Plant in the assessment monitoring phase of RCRA. Since 1987, this reporting mechanism has also been used by the Y-12 Plant as a forum to present additional information such as data interpretations, monitoring modifications, and detailed figures and maps to illustrate geology. Beginning in 1989 the Y-12 Plant has issued annual comprehensive GWQARs for the two hydrogeologic regimes (Bear Creek Hydrogeologic Regime and Upper East Fork Poplar Creek Hydrogeologic Regime) where contaminant plumes from multiple waste units have intermingled. Previous GWQARs for the Chestnut Ridge have addressed groundwater contamination at the Chestnut Ridge Security Pits, the only confirmed source of contaminant release to the environment in the Chestnut Ridge Hydrogeologic Regime (CRHR). For the purposes of consistency and to keep the regulatory community informed of groundwater monitoring actions at Y-12, the 1991 annual GWQAR for the Chestnut Ridge Hydrogeologic Regime will be expanded to include monitoring data collected through out the regime. This report, Groundwater Quality Assessment for the Chestnut Ridge Hydrogeologic Regime, Y/SUB/92-YP507C/3, will be issued in two parts. Part 1 will provide results of monitoring data collected in calendar year 1991. Part 2 will provide additional details of data interpretations and contaminant plume assessment for CRSP. Additional data, above and beyond RCRA interim status detection monitoring requirements, will be presented in the GWQAR for both Kerr Hollow Quarry and Chestnut Ridge Sediment Disposal Basin. Additional units in the CRHR, will be incorporated into this report. Groundwater quality monitoring, in support of RCRA Facility Investigations (RFIs), at the United Nuclear Corporation site, the Ash Disposal Basin, and Rogers Quarry units was initiated in 1988. Also located in the CRHR are two TDEC permitted non-hazardous solid waste disposal units, Industrial Landfill II and Industrial Landfill IV. In addition the Industrial Landfill III unit (also known as the Chestnut Ridge Borrow Area Waste Pile) containing soils removed from the Oak Ridge Civic Center and Oak Ridge Sewer Line Beltway is located within the CRHR. Additional data for each of these units will be included in the annual GWQAR for 1991, for the CRHR.

3. Summary of Statistical Methodology, False Positive Determinations and 1991 Well Replacements

This document addresses the annual reporting requirements for KHQ and CRSDB in detection monitoring [TDEC 1200-1-11-.05 (e) (1) (ii) (II)]. In the cases where a measurement has been reported as less than the minimum detection limit, the minimum detection limit has been used in calculating the mean. Therefore, the means are biased conservatively. The requirements for detection monitoring are noted below.

1. Tabulation of the results of CY 1991 sampling and analyses for
 - a. groundwater quality parameters (chloride, iron, manganese, phenols, sodium, and sulfate).
 - b. indicator parameters (pH, specific conductance, total organic carbon, and total organic halide).
2. Identification of any statistically significant increase (or decrease for pH) in indicator parameters from initial background values for

- a. downgradient wells (1991) vs corresponding upgradient well (1986)
- b. well by well comparisons, 1991 vs 1986. Significant increases (or decreases) were identified using the t-test methodology outlined in TDHE 1200-1-11-.05 Appendix .05/C.

In the initial 180-day report period of 1991, a semiannual sampling and analysis for contamination indicator parameters was conducted and results have been previously reported (Bostock, 1991a; Bostock, 1991b). In addition, a false positive demonstration (see Appendix C) for the units has previously been submitted to and approved by TDEC (Lagan, 1992). The false positive demonstration confirmed that statistically significant changes in RCRA detection monitoring parameters total organic carbon, total organic halide, pH, and specific conductance do not represent a release of contaminants to the groundwater at the respective units.

4. Exceptions to the Methodology

If there are instances of missing values in the groundwater monitoring data set tabulated in this report and the background data set compiled during CY 1986, they are reflected in the sample size (N). The background sample size should be N=16 (4 quarterly samples consisting of 4 replicate measurements each). The CY 1991 sample sizes should be N=4 (1 semi-annual or annual sample consisting of 4 replicate measurements).

The exceptions for this the 1991 report are noted below.

1. Total organic carbon samples were not purged prior to analysis through 04/04/87, thus 1986 background values for total organic carbon are not available. For the purposes of this report, 1987 total organic carbon results are used as the background values.
2. There are 12, not 16, 1987 background TOC results for the Chestnut Ridge Sediment Disposal Basin unit because the first quarter 1987 sampling event occurred prior to 04/04/87 (See #1).
3. There are 8, not 16, 1987 background TOC results for the Kerr Hollow Quarry unit because the 1987 sampling program for this unit specified a semi-annual sampling frequency.
4. After two years of statistical evaluation, it became apparent that the 1986 TOX values are abnormally high. Therefore, the comparison to 1987 data was determined to be more appropriate for this parameter.
5. There are 4, not 16, 1987 background TOX results for the Chestnut Ridge Sediment Disposal unit because the 1987 sampling program for this unit specified only an annual sample for TOX.
6. There are 8, not 16, 1987 background TOX results for the Kerr Hollow Quarry unit because the 1987 sampling program for this unit specified a semi-annual sampling frequency.
7. T-statistics could not be calculated for the following comparisons because variances used in the calculation were both equal to zero.
 - 1st Quarter 1991 vs Upgradient, 1987 Total Organic Carbon at the Chestnut Ridge Sediment Disposal Basin.

- 1987 vs 1st Quarter 1991 Total Organic Carbon for the Upgradient well (GW-159) at the Chestnut Ridge Sediment Disposal Basin.
- 1987 vs 3rd Quarter 1991 Total Organic Halide for a Downgradient well (GW-142) at the Kerr Hollow Quarry.
- 1987 vs 3rd Quarter 1991 Total Organic Carbon for the Upgradient well (GW-159) at the Chestnut Ridge Sediment Disposal Basin.

These exceptions were reviewed in detail with the TDEC during the 1991 Comprehensive Monitoring Evaluation - Compliance Evaluation Inspection and were the subject of a conference call on June 13, 1991, between representatives of the Y-12 Plant Groundwater Protection Program, DOE, and TDEC. Following is a list of the parties involved and a summary of the discussion.

L.W. McMahon	-	Y-12 Plant Environmental Surveillance
C.W. Kimbrough	-	Y-12 Plant Laboratory
T.M. Mercier	-	H&R Technical Associates, Inc.
G.W. Bodenstein	-	Department of Energy
L.J. Munkeboe	-	TDEC

Anomalous TOC and TOX data collected in 1986 were discussed in Y/YS-282 (Haase, et al, 1987).

Anomalous TOC data collected in 1986 are also addressed in the original post-closure permit application for CRSDB, Y/TS-520, issued March 18, 1988, and reissued March 10, 1989. The use of 1987 TOC and TOX data as base year data for statistical evaluations, rather than the anomalous 1986 data, is stated in the annual report for 1989, Y/TS-625/P2. Relevant portions of each of these documents were sent by facsimile to TDEC on June 14, 1991.

Based on a second telephone conversation of August 9, 1991, between L.J. Munkeboe and G.W. Bodenstein, verbal approval was granted for use of the 1987 TOC and TOX values as background for the purposes of the CY 1991 annual report. Written concurrence from TDEC for this exception was requested on August 15, 1991 (Bostock, 1991c).

5. Proposed Alternative Statistical Analysis for Chestnut Ridge Sediment Disposal Basin

For the CRSDB unit, an alternative statistical method has been proposed. In March of 1991, during a routine well inspection at CRSDB, it was discovered that downgradient detection monitoring wells GW-155 and GW-157 were partially filled with mud and sediment. When well maintenance activities were initiated, it was concluded that the wells had deteriorated beyond rehabilitation and they were plugged and abandoned subsequent to TDEC approval (Munkeboe, 1991). As a result, we are unable to provide a complete statistical analysis for this report period for the unit based on the traditional statistical methodology as described in Appendix .05/C of the TDEC regulation 1200-1-11-.05. Since no background data are available from the base years (1986,1987) for wells installed in 1991, no with-in well comparisons were possible for replacement downgradient wells. A partial report is enclosed (Table 27-35). TDEC approved the request to install replacement wells provided the replacement wells would be available to sample in the second 180-day monitoring period for calendar year 1991 (Munkeboe, 1991). Installation and development of replacement wells GW-731 and GW-732 was completed on September 25, 1991, and the wells were first sampled on September 27, 1991.

On August 21, 1991 representatives of the Y-12 Plant Groundwater Protection Program and DOE met with TDEC officials (see Appendix D for a list of attendees) to obtain guidance from, and understanding and agreement with, the regulatory community as to our actions necessary to ensure compliance for reporting 1991 data and to identify options for performing the statistical analyses based on recent amendments to the TDEC regulations and the fact that two detection monitoring wells were being replaced. As a result of this meeting it was agreed that traditional statistical methodology as described in Appendix .05/C of the TDEC regulation 1200-1-11-.05 was no longer applicable because two detection monitoring wells had been plugged and abandoned. It was further agreed that the February 1989 document PB89-151047 (U.S. EPA, 1989), "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Interim Final Guidance," would be used as the basis for establishing an alternative statistical method. Appendix E provides the details of the proposed alternative statistical method and applicable tolerance limits for suggested alternative indicator parameters (barium, cadmium, chromium, mercury, nickel, silver, and uranium) identified as constituents of the waste deposited at the unit (Kimbrough and Stone, 1989). None of the selected indicator parameters exceeded the established tolerance limits for samples collected from the second 180-day report period of 1991. The results of this comparison are included in Tables 45-52.

REFERENCES

Annual Groundwater Monitoring Data for Treatment, Storage and Disposal Facilities at the Y-12 Plant: Statistical Evaluation of First Year Data, Y/TS-242/P2.

Annual Report of 1987 Groundwater Monitoring Data for Treatment, Storage, or Disposal Facilities at the Y-12 Plant: Reporting and Statistical Evaluation of the Subsequent Year (Second) Year Data, Y/TS-388.

Annual Report of 1988 Groundwater Monitoring Data for Treatment, Storage, or Disposal Facilities at the Y-12 Plant: Reporting and Statistical Evaluation of the Third Year Data, Y/TS-511.

Annual Report of 1989 Groundwater Monitoring Data for Treatment, Storage, or Disposal Facilities at the Y-12 Plant: Reporting and Statistical Evaluation of the Fourth Year Data, Y/TS-625.

Annual Report of 1990 Groundwater Monitoring Data for Treatment, Storage, or Disposal Facilities at the Y-12 Plant: Reporting and Statistical Evaluation of the Fifth Year Data, Y/TS-724.

Munkeboe, L.J. 1991. Letter to Robert Spence. "Plugging and Abandonment of Monitoring wells at the Chestnut Ridge Sediment Disposal Basin," June 21, 1991.

Kimbrough, C.W. and J.E. Stone. 1989. Post Closure Permit Application for the Chestnut Ridge Sediment Disposal Basin at the Y-12 Plant. Prepared by Lee Wan and Associates, Inc. for Martin Marietta Energy Systems, Inc. (Y/TS-520).

Lagan, C. 1992. Letter to D.J. Bostock. Approval for "False-Positive Demonstration for Chestnut Ridge Sediment Disposal Basin and Kerr Hollow Quarry," January 9, 1992.

Bostock, D.J. 1991a. Letter to Tom Tiesler. "Semi-annual Statistical Determinations of Groundwater Quality Data for the Kerr Hollow Quarry - Y-12 Plant," August 30, 1991.

Bostock, D.J. 1991b. Letter to Tom Tiesler. "Semi-annual Statistical Determinations of Groundwater Quality Data from the Chestnut Ridge Sediment Disposal Basin - Y-12 Plant," August 30, 1991.

Bostock, D.J. 1991c. Letter to Tom Tiesler. "Notice of Violations for Annual Report of 1990 Groundwater Monitoring Data for Treatment, Storage, or Disposal Facilities at the Y-12 Plant: Request for Approval of Exception to Reporting Requirements for the Semi-annual Statistical Evaluation at the Kerr Hollow Quarry (KHQ) and Chestnut Ridge Sediment Disposal Basin (CRSDB) for Calendar Year 1991."

U.S. Environmental Protection Agency. 1989. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Interim Final Guidance, U.S. EPA, Office of Solid Waste, Waste Management Division, PB89-151047, February 1989.

Haase, C.S., et al. 1987. Preliminary Analysis of Groundwater Data for the Chestnut Ridge Sludge Disposal Basin at the Y-12 Plant, Oak Ridge Tennessee, 1987, Y/YS-282.

FIGURE 1

KERR HOLLOW QUARRY WELL LOCATION MAP

Fig. 1 Well location map for the Kerr Hollow Quarry Site.
Elevation Values are Given in Feet.

APPENDIX A

KERR HOLLOW QUARRY

TABLE 1

ANNUAL Y-12 RCRA REPORT
KERR HOLLOW QUARRY - UPGRADIENT WELL
GROUNDWATER QUALITY PARAMETERS
UNIT IS MILLIGRAMS PER LITER

WELL IDENTITY	GW-145	GW-145
DATE SAMPLED	03/16/91	09/04/91
SULFATE (MG/L)	29.9	33
CHLORIDE (MG/L)	9.7	9
IRON, BY ICAP (MG/L)	0.15	0.15
MANGANESE, BY ICAP (MG/L)	0.03	0.024
SODIUM, BY ICAP (MG/L)	4.8	6.4
PHENOLS (MG/L)	<0.03	<0.05

TABLE 2
ANNUAL Y-12 RCRA REPORT
KERR HOLLOW QUARRY - DOWNGRADIENT WELLS
GROUNDWATER QUALITY PARAMETERS
UNIT IS MILLIGRAMS PER LITER

WELL IDENTITY DATE SAMPLED	GW-142 03/16/91	GW-142 08/03/91	GW-144 03/16/91	GW-144 09/05/91	GW-231 03/14/91	GW-231 09/04/91
SULFATE (MG/L)	29.7	6	9.3	9	4	3
CHLORIDE (MG/L)	37.4	1	3.3	2	1	1
IRON, BY ICAP (MG/L)	2.5	4	0.024	0.0098	0.025	0.0067
MANGANESE, BY ICAP (MG/L)	0.038	0.07	<0.001	<0.001	0.087	0.015
SODIUM, BY ICAP (MG/L)	1.1	0.89	1.8	1.5	1.1	0.84
PHENOLS (MG/L)	<0.03	<0.05	<0.03	<0.05	<0.03	<0.05

TABLE 3
ANNUAL Y-12 RCRA REPORT
KERR HOLLOW QUARRY - UPGRADIENT WELL
INDICATOR PARAMETERS
UNIT AS STATED

WELL IDENTITY DATE SAMPLED	GW-145 03/16/91	GW-145 09/04/91
CONDUCTIVITY (UMHOS/CM)	501	539
REP. 2	505	538
REP. 3	505	538
REP. 4	508	538
PH (PH UNITS)	7	8
REP. 2	7.1	8
REP. 3	7	7.9
REP. 4	7.1	8
TOC (MG/L)	<1	2
REP. 2	<1	2
REP. 3	<1	2
REP. 4	2	2
TOX (UG/L)	<10	22
REP. 2	<10	<10
REP. 3	11	<10
REP. 4	<10	<10

TABLE 4
ANNUAL Y-12 RCRA REPORT
KERR HOLLOW QUARRY - DOWNGRAIDENT WELLS
INDICATOR PARAMETERS
UNIT AS STATED

WELL IDENTITY DATE SAMPLED	GW-142 03/16/91	GW-142 08/03/91	GW-144 03/16/91	GW-144 09/05/91	GW-231 03/14/91	GW-231 09/04/91
CONDUCTIVITY (UMHOS/CM)	438	462	278	330	211	378
REP. 2	438	462	297	325	215	375
REP. 3	441	462	304	331	219	375
REP. 4	441	462	304	331	215	376
PH (PH UNITS)	7.1	7.9	6.9	7.7	6.8	7.5
REP. 2	7.1	7.8	6.9	7.8	6.9	7.4
REP. 3	7.1	7.8	6.9	7.8	6.9	7.4
REP. 4	7.1	7.8	6.9	7.8	6.9	7.4
TOC (MG/L)	2	3	2	1	<1	2
REP. 2	2	4	2	1	<1	2
REP. 3	2	4	2	1	<1	2
REP. 4	2	4	2	1	<1	2
TOX (UG/L)	<10	<10	<10	<10	<10	<10
REP. 2	<10	<10	<10	<10	<10	<10
REP. 3	12	<10	<10	<10	<10	<10
REP. 4	<10	<10	<10	<10	<10	13

TABLE 5

SUMMARY OF STATISTICALLY SIGNIFICANT T-TEST RESULTS AT THE
KERR HOLLOW QUARRY
(Annual)

CONDUCTIVITY (umhos/cm)

GW-142 Significantly greater than 1986 (462/351)

TOTAL ORGANIC CARBON (mg/l)

GW-142 Significantly greater than 1987 upgradient (3.75/1.43)

TOTAL ORGANIC HALIDE (ug/l)

No significant change

pH (pH units)

GW-144 Significantly less than 1986 (7.8/8.0)

GW-231 Significantly less than 1986 (7.4/7.9)
Significantly less than 1986 upgradient (7.4/8.3)

TABLE 6
ANNUAL Y-12 RCRA REPORT
ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
CONDUCTIVITY (UMHOS/CM)
BY WELL - 1986 VS 3RD QUARTER 1991

----- SITE=KERR HOLLOW QUARRY --DOWNGRADIENT -----

WELL IDENTITY	N, 1986	N, 1991	MEAN, 1986	MEAN, 1991	VARIANCE, 1986	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-142	16	4	351.375	462.000	4430.783	0.000	3.257	2.552	**SIGNIF. INC.**
GW-144	16	4	367.937	329.250	1578.729	8.250	-1.907	2.552	NO SIGNIF. INC.
GW-231	16	4	332.937	376.000	3460.729	2.000	1.434	2.552	NO SIGNIF. INC.

----- SITE=KERR HOLLOW QUARRY --UPGRADIENT -----

WELL IDENTITY	N, 1986	N, 1991	MEAN, 1986	MEAN, 1991	VARIANCE, 1986	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-145	16	4	601.500	538.250	1547.600	0.250	-3.151	2.552	NO SIGNIF. INC.

TABLE 7
ANNUAL Y-12 RCRA REPORT
ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
TOTAL ORGANIC CARBON (MG/L)
BY WELL - 1987 VS 3RD QUARTER 1991

----- SITE=KERR HOLLOW QUARRY --DOWNGRADIENT -----

WELL IDENTITY	N, 1987	N, 1991	MEAN, 1987	MEAN, 1991	VARIANCE, 1987	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-142	8	4	3.625	3.750	7.982	0.250	0.086	2.764	NO SIGNIF. INC.
GW-144	8	4	2.513	1.000	2.430	0.000	-1.894	2.764	NO SIGNIF. INC.
GW-231	8	4	3.300	2.000	5.677	0.000	-1.065	2.764	NO SIGNIF. INC.

----- SITE=KERR HOLLOW QUARRY --UPGRADIENT -----

WELL IDENTITY	N, 1987	N, 1991	MEAN, 1987	MEAN, 1991	VARIANCE, 1987	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-145	8	4	1.425	2.000	1.094	0.000	1.073	2.764	NO SIGNIF. INC.

TABLE 8
ANNUAL Y-12 RCRA REPORT
ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
TOTAL ORGANIC HALIDE (UG/L)
BY WELL - 1987 VS 3RD QUARTER 1991

----- SITE=KERR HOLLOW QUARRY --=DOWNGRADIENT -----									
WELL IDENTITY	N, 1987	N, 1991	MEAN, 1987	MEAN, 1991	VARIANCE, 1987	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-142	8	4	10.000	10.000	0.000	0.000	.	2.764	
GW-144	8	4	13.125	10.000	40.411	0.000	-0.959	2.764	NO SIGNIF. INC.
GW-231	8	4	17.375	10.750	257.982	2.250	-0.804	2.764	NO SIGNIF. INC.

----- SITE=KERR HOLLOW QUARRY --=UPGRADIENT -----									
WELL IDENTITY	N, 1987	N, 1991	MEAN, 1987	MEAN, 1991	VARIANCE, 1987	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-145	8	4	11.125	13.000	10.125	36.000	0.724	2.764	NO SIGNIF. INC.

TABLE 9
ANNUAL Y-12 RCRA REPORT
TWO-TAILED T-TEST TO TEST FOR SIGNIFICANT DIFFERENCE IN
MEAN PH
BY WELL - 1986 VS 3RD QUARTER 1991

----- SITE=KERR HOLLOW QUARRY --DOWNGRADIENT -----									
WELL IDENTITY	N, 1986	N, 1991	MEAN, 1986	MEAN, 1991	VARIANCE, 1986	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-142	16	4	8.175	7.825	0.231	0.003	-1.424	2.878	NO SIGNIF. DIFF.
GW-144	16	4	7.956	7.775	0.007	0.002	-4.208	2.878	**SIGNIF. DEC.**
GW-231	16	4	7.856	7.425	0.032	0.002	-4.691	2.878	**SIGNIF. DEC.**

----- SITE=KERR HOLLOW QUARRY --UPGRADIENT -----									
WELL IDENTITY	N, 1986	N, 1991	MEAN, 1986	MEAN, 1991	VARIANCE, 1986	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-145	16	4	8.263	7.975	0.132	0.003	-1.549	2.878	NO SIGNIF. DIFF.

TABLE 10
ANNUAL Y-12 RCRA REPORT
ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
CONDUCTIVITY (UMHOS/CM)
DOWNGRAIENT, 3RD QUARTER 1991 VS UPGRADIENT, 1986

----- SITE=KERR HOLLOW QUARRY -----

WELL	N, 'UP' 1986	N, 'DOWN' 1991	MEAN, 'UP' 1986	MEAN, 'DOWN' 1991	VARIANCE, 'UP' 1986	VARIANCE, 'DOWN' 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-142	16	4	601.500	462.000	1547.600	0.000	-6.949	2.552	NO SIGNIF. INC.
GW-144	16	4	601.500	329.250	1547.600	8.250	-13.554	2.552	NO SIGNIF. INC.
GW-231	16	4	601.500	376.000	1547.600	2.000	-11.231	2.552	NO SIGNIF. INC.

TABLE 11

ANNUAL Y-12 RCRA REPORT
 ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
 TOTAL ORGANIC CARBON (MG/L)
 DOWNGRADIENT, 3RD QUARTER 1991 VS UPGRADIENT, 1987

----- SITE=KERR HOLLOW QUARRY -----

WELL	N, 'UP' 1987	N, 'DOWN' 1991	MEAN, 'UP' 1987	MEAN, 'DOWN' 1991	VARIANCE, 'UP' 1987	VARIANCE, 'DOWN' 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-142	8	4	1.425	3.750	1.094	0.250	4.141	2.764	**SIGNIF. INC.**
GW-144	8	4	1.425	1.000	1.094	0.000	-0.793	2.764	NO SIGNIF. INC.
GW-231	8	4	1.425	2.000	1.094	0.000	1.073	2.764	NO SIGNIF. INC.

TABLE 12
ANNUAL Y-12 RCRA REPORT
ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
TOTAL ORGANIC HALIDE (UG/L)
DOWNGRADIENT, 3RD QUARTER 1991 VS UPGRADIENT, 1987

----- SITE=KERR HOLLOW QUARRY -----

WELL	N, 'UP' 1987	N, 'DOWN' 1991	MEAN, 'UP' 1987	MEAN, 'DOWN' 1991	VARIANCE, 'UP' 1987	VARIANCE, 'DOWN' 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-142	8	4	11.125	10.000	10.125	0.000	-0.690	2.764	NO SIGNIF. INC.
GW-144	8	4	11.125	10.000	10.125	0.000	-0.690	2.764	NO SIGNIF. INC.
GW-231	8	4	11.125	10.750	10.125	2.250	-0.220	2.764	NO SIGNIF. INC.

TABLE 13
ANNUAL Y-12 RCRA REPORT
TWO-TAILED T-TEST TO TEST FOR SIGNIFICANT DIFFERENCE IN
MEAN PH
DOWNGRADIENT, 3RD QUARTER 1991 VS UPGRADIENT, 1986

SITE=KERR HOLLOW QUARRY									
WELL	N, 'UP' 1986	N, 'DOWN' 1991	MEAN, 'UP' 1986	MEAN, 'DOWN' 1991	VARIANCE, 'UP' 1986	VARIANCE, 'DOWN' 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-142	16	4	8.263	7.825	0.132	0.003	-2.357	2.878	NO SIGNIF. DIFF.
GW-144	16	4	8.263	7.775	0.132	0.002	-2.626	2.878	NO SIGNIF. DIFF.
GW-231	16	4	8.263	7.425	0.132	0.002	-4.511	2.878	**SIGNIF. DEC.**

TABLE 14

SUMMARY OF STATISTICALLY SIGNIFICANT T-TEST RESULTS AT THE
KERR HOLLOW QUARRY
(Semi-Annual)

CONDUCTIVITY (umhos/cm)

GW-142 Significantly greater than 1986 (440/351)

TOTAL ORGANIC CARBON (mg/l)

TOTAL ORGANIC HALIDE (ug/l)

pH (pH units)

GW-142	Significantly less than 1986	(7.1/8.2)
	Significantly less than 1986 upgradient	(7.1/8.3)
GW-144	Significantly less than 1986	(6.9/8.0)
	Significantly less than 1986 upgradient	(6.9/8.3)
GW-231	Significantly less than 1986	(6.9/7.9)
	Significantly less than 1986 upgradient	(6.9/8.3)
GW-145	Significantly less than 1986	(7.1/8.3)

TABLE 15
ANNUAL Y-12 RCRA REPORT
ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
CONDUCTIVITY (UMHOS/CM)
BY WELL - 1986 VS 1ST QUARTER 1991

----- SITE=KERR HOLLOW QUARRY --DOWNGRADIENT -----

WELL IDENTITY	N, 1986	N, 1991	MEAN, 1986	MEAN, 1991	VARIANCE, 1986	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-142	16	4	351.375	439.500	4430.783	3.000	2.594	2.552	**SIGNIF. INC.**
GW-144	16	4	367.937	295.750	1578.729	150.917	-3.527	2.552	NO SIGNIF. INC.
GW-231	16	4	332.937	215.000	3460.729	10.667	-3.927	2.552	NO SIGNIF. INC.

----- SITE=KERR HOLLOW QUARRY --UPGRADIENT -----

WELL IDENTITY	N, 1986	N, 1991	MEAN, 1986	MEAN, 1991	VARIANCE, 1986	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-145	16	4	601.500	504.750	1547.600	8.250	-4.817	2.552	NO SIGNIF. INC.

TABLE 16

ANNUAL Y-12 RCRA REPORT
 ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
 TOTAL ORGANIC CARBON (MG/L)
 BY WELL - 1987 VS 1ST QUARTER 1991

----- SITE=KERR HOLLOW QUARRY --=DOWNGRADIENT -----

WELL IDENTITY	N, 1987	N, 1991	MEAN, 1987	MEAN, 1991	VARIANCE, 1987	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-142	8	4	3.625	2.000	7.982	0.000	-1.123	2.764	NO SIGNIF. INC.
GW-144	8	4	2.513	2.000	2.430	0.000	-0.642	2.764	NO SIGNIF. INC.
GW-231	8	4	3.300	1.000	5.677	0.000	-1.884	2.764	NO SIGNIF. INC.

----- SITE=KERR HOLLOW QUARRY --=UPGRADIENT -----

WELL IDENTITY	N, 1987	N, 1991	MEAN, 1987	MEAN, 1991	VARIANCE, 1987	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-145	8	4	1.425	1.250	1.094	0.250	-0.312	2.764	NO SIGNIF. INC.

TABLE 17

ANNUAL Y-12 RCRA REPORT
 ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
 TOTAL ORGANIC HALIDE (UG/L)
 BY WELL - 1987 VS 1ST QUARTER 1991

SITE=KERR HOLLOW QUARRY --DOWNGRADIENT

WELL IDENTITY	N, 1987	N, 1991	MEAN, 1987	MEAN, 1991	VARIANCE, 1987	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-142	8	4	10.000	10.500	0.000	1.000	1.491	2.764	NO SIGNIF. INC.
GW-144	8	4	13.125	10.000	40.411	0.000	-0.959	2.764	NO SIGNIF. INC.
GW-231	8	4	17.375	10.000	257.982	0.000	-0.896	2.764	NO SIGNIF. INC.

SITE=KERR HOLLOW QUARRY --UPGRADIENT

WELL IDENTITY	N, 1987	N, 1991	MEAN, 1987	MEAN, 1991	VARIANCE, 1987	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-145	8	4	11.125	10.250	10.125	0.250	-0.534	2.764	NO SIGNIF. INC.

TABLE 18
ANNUAL T-12 RCRA REPORT
TWO-TAILED T-TEST TO TEST FOR SIGNIFICANT DIFFERENCE IN
MEAN PH
BY WELL - 1986 VS 1ST QUARTER 1991

----- SITE=KERR HOLLOW QUARRY --DOWNGRADIENT -----

WELL IDENTITY	N, 1986	N, 1991	MEAN, 1986	MEAN, 1991	VARIANCE, 1986	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
QM-142	16	4	8.175	7.100	0.231	0.000	-4.300	2.878	**SIGNIF. DEC.**
QM-144	16	4	7.956	6.900	0.007	0.000	-25.430	2.878	**SIGNIF. DEC.**
QM-231	16	4	7.856	6.875	0.032	0.003	-10.673	2.878	**SIGNIF. DEC.**

----- SITE=KERR HOLLOW QUARRY --UPGRADIENT -----

WELL IDENTITY	N, 1986	N, 1991	MEAN, 1986	MEAN, 1991	VARIANCE, 1986	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
QM-145	16	4	8.263	7.050	0.132	0.003	-6.527	2.878	**SIGNIF. DEC.**

TABLE 19
ANNUAL T-12 RCRA REPORT
ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
CONDUCTIVITY (UMHOS/CM)
DOWNGRADIENT, 1ST QUARTER 1991 VS UPGRADIENT, 1991

SITE=KERR HOLLOW QUARRY

WELL	N, "UP" 1986	N, "DOWN" 1991	MEAN, "UP" 1986	MEAN, "DOWN" 1991	VARIANCE, "UP" 1986	VARIANCE, "DOWN" 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-142	16	4	601.500	439.500	1547.600	3.000	-8.068	2.552	NO SIGNIF. INC.
GW-144	16	4	601.500	295.750	1547.600	150.917	-15.004	2.552	NO SIGNIF. INC.
GW-231	16	4	601.500	215.000	1547.600	10.667	-19.239	2.552	NO SIGNIF. INC.

TABLE 20
ANNUAL Y-12 RCRA REPORT
ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
TOTAL ORGANIC CARBON (MGL)
DOWNGRADIENT, 1ST QUARTER 1991 VS UPGRAIDENT, 1987

----- SITE-KERR HOLLOW QUARRY -----

WELL	N, "UP" 1987	N, "DOWN" 1991	MEAN, "UP" 1987	MEAN, "DOWN" 1991	VARIANCE, "UP" 1987	VARIANCE, "DOWN" 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-142	8	4	1.425	2.000	1.00%	0.000	1.073	2.764	NO SIGNIF. INC.
GW-144	8	4	1.425	2.000	1.00%	0.000	1.073	2.764	NO SIGNIF. INC.
GW-231	8	4	1.425	1.000	1.00%	0.000	-0.793	2.764	NO SIGNIF. INC.

TABLE 21

ANNUAL T-12 RCRA REPORT
 ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
 TOTAL ORGANIC HALIDE (UG/L)
 DOWNGRADIENT, 1ST QUARTER 1991 VS UPGRADEMENT, 1987

----- SITE=KEHR HOLLOW QUARRY -----

WELL	N, "UP" 1987	N, "DOWN" 1991	MEAN, "UP" 1987	MEAN, "DOWN" 1991	VARIANCE, "UP" 1987	VARIANCE, "DOWN" 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
CU-142	8	4	11.125	10.500	10.125	1.000	-0.376	2.764	NO SIGNIF. INC.
CU-144	8	4	11.125	10.000	10.125	0.000	-0.690	2.764	NO SIGNIF. INC.
CU-231	8	4	11.125	10.000	10.125	0.000	-0.690	2.764	NO SIGNIF. INC.

TABLE 22
ANNUAL T-12 RCRA REPORT
TWO-TAILED T-TEST TO TEST FOR SIGNIFICANT DIFFERENCE IN
MEAN PH
DOWNGRADIENT, 1ST QUARTER 1991 VS UPGRAIENT, 1986

WELL	N, "UP" 1986	N, "DOWN" 1991	MEAN, "UP" 1986	MEAN, "DOWN" 1991	VARIANCE, "UP" 1986	VARIANCE, "DOWN" 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-142	16	4	8.263	7.100	0.132	0.000	-6.274	2.878	**SIGNIF. DEC.**
GW-144	16	4	8.263	6.900	0.132	0.000	-7.353	2.878	**SIGNIF. DEC.**
GW-231	16	4	8.263	6.875	0.132	0.003	-7.474	2.878	**SIGNIF. DEC.**

FIGURE 2

CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN WELL LOCATION MAP

Fig. 2

Well Location Map for the Chestnut Ridge Sediment Disposal Basin Site. Elevations Values are Given in Feet Above Mean Sea Level. The triangles mark the locations of the destroyed, and plugged and abandoned wells. GW-155 is replaced by GW-732, and GW-157 is replaced by GW-731.

APPENDIX B

CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN

TABLE 23
ANNUAL Y-12 RCRA REPORT
CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN - UPGRADIENT WELL
GROUNDWATER QUALITY PARAMETERS
UNIT IS MILLIGRAMS PER LITER

WELL IDENTITY	GW-159	GW-159
DATE SAMPLED	02/28/91	08/23/91
SULFATE (MG/L)	10	8
CHLORIDE (MG/L)	<1	<1
IRON, BY ICAP (MG/L)	0.48	1
MANGANESE, BY ICAP (MG/L)	0.066	0.044
SODIUM, BY ICAP (MG/L)	0.94	0.63
PHENOLS (MG/L)	.	<0.05 *

Sample date: 10/29/91

TABLE 24

ANNUAL Y-12 RCRA REPORT
 CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN - DOWNGRADIENT WELLS
 GROUNDWATER QUALITY PARAMETERS
 UNIT IS MILLIGRAMS PER LITER

WELL IDENTITY DATE SAMPLED	GW-155 02/28/91	GW-156 02/28/91	GW-156 08/23/91	GW-157 02/28/91	GW-731 09/27/91	GW-732 09/27/91
SULFATE (MG/L)	1	9	9	17	17.6	2
CHLORIDE (MG/L)	<1	2	2	2	2.5	<1
IRON, BY ICAP (MG/L)	1.1	3	0.047	1.5	1.1	0.077
MANGANESE, BY ICAP (MG/L)	0.02	0.24	0.0021	0.042	0.028	0.0019
SODIUM, BY ICAP (MG/L)	0.43	17	3.5	2	8.6	1.4
PHENOLS (MG/L)	.	.	<0.05 *	.	<0.05	<0.05

Sample date: 10/30/91

TABLE 25
ANNUAL Y-12 RCRA REPORT
CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN - UPGRADIENT WELL
INDICATOR PARAMETERS
UNIT AS STATED

WELL IDENTITY	GW-159	GW-159
DATE SAMPLED	02/28/91	08/23/91
CONDUCTIVITY (UMHOS/CM)	349	340
REP. 2	349	330
REP. 3	356	333
REP. 4	352	335
PH (PH UNITS)	7.6	7.9
REP. 2	7.5	7.9
REP. 3	7.6	7.9
REP. 4	7.6	7.9
TOC (MG/L)	<1	2
REP. 2	<1	2
REP. 3	1	2
REP. 4	1	2
TOX (UG/L)	<10	<10
REP. 2	<10	<10
REP. 3	<10	<10
REP. 4	<10	<10

TABLE 26
ANNUAL Y-12 RCRA REPORT
CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN - DOWNGRADIENT WELLS
INDICATOR PARAMETERS
UNIT AS STATED

WELL IDENTITY DATE SAMPLED	GW-155 02/28/91	GW-156 02/28/91	GW-156 06/23/91	GW-157 02/28/91	GW-731 09/27/91	GW-732 09/27/91
CONDUCTIVITY (UMHOS/CM)	256	783	604	345	202	272
REP. 2	260	764	595	356	201	278
REP. 3	263	805	598	352	205	278
REP. 4	267	824	614	356	203	275
PH (PH UNITS)	6.9	7.2	7.4	7.4	9.7	8.1
REP. 2	6.8	7.3	7.3	7.4	9.6	8
REP. 3	6.9	7.3	7.3	7.5	9.7	8
REP. 4	6.9	7.3	7.4	7.4	9.6	8
TOC (MG/L)	<1	2	2	2	9	<1
REP. 2	<1	2	3	2	3	2
REP. 3	<1	2	3	2	2	<1
REP. 4	<1	2	3	2	6	2
TOX (UG/L)	<10	<10	<10	<10	<10	<10
REP. 2	<10	<10	<10	<10	10	<10
REP. 3	11	<10	<10	<10	17	<10
REP. 4	<10	<10	<10	<10	12	<10

TABLE 27

**SUMMARY OF STATISTICALLY SIGNIFICANT T-TEST RESULTS AT THE
CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN
(Annual)**

CONDUCTIVITY (umhos/cm)

TOTAL ORGANIC CARBON (mg/l)

GW-156 Significantly greater than 1987 upgradient (2.75/1.00)

GW-731 Significantly greater than 1987 upgradient (5.00/1.00)

GW-732 Significantly greater than 1987 upgradient (1.50/1.00)

TOTAL ORGANIC HALIDE (ug/l)

pH (pH units)

GW-156 Significantly less than 1986 upgradient (7.4/9.2)

TABLE 2B
ANNUAL T-12 RCRA REPORT
ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
CONDUCTIVITY (UMHOS/CM)
BY WELL - 1986 VS 3RD QUARTER 1991

----- SITE=C.R. SEDIMENT DISP. --DOWNGRADIENT -----

WELL IDENTITY	N, 1986	N, 1991	MEAN, 1986	MEAN, 1991	VARIANCE, 1986	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
CU-155	16	-	251.812	-	142.429	-	-	-	-
CU-156	16	4	809.187	682.750	54048.563	70.250	-1.606	2.552	NO SIGNIF. INC.
CU-157	16	-	448.250	-	2688.600	-	-	-	-
CU-731	-	4	-	202.750	-	2.917	-	-	-
CU-732	-	4	-	275.750	-	8.250	-	-	-

----- SITE=C.R. SEDIMENT DISP. --UPGRADIENT -----

WELL IDENTITY	N, 1986	N, 1991	MEAN, 1986	MEAN, 1991	VARIANCE, 1986	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
CU-159	16	4	929.937	334.500	1821879.66	17.667	-1.155	2.552	NO SIGNIF. INC.

TABLE 29
ANNUAL Y-12 RCRA REPORT
ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
TOTAL ORGANIC CARBON (TOC/L)
BY WELL - 1987 VS 3RD QUARTER 1991

----- SITE-C.R. SEDIMENT DISP. -DOWNGRADIENT -----

WELL IDENTITY	N, 1987	N, 1991	MEAN, 1987	MEAN, 1991	VARIANCE, 1987	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GM-155	12	-	1.217	-	0.362	-	-	-	-
GM-156	12	4	2.005	2.750	1.507	0.250	1.013	2.624	NO SIGNIF. INC.
GM-157	12	-	3.425	-	2.646	-	-	-	-
GM-731	-	4	-	5.000	-	10.000	-	-	-
GM-732	-	4	-	1.500	-	0.333	-	-	-

----- SITE-C.R. SEDIMENT DISP. -UPGRADIENT -----

WELL IDENTITY	N, 1987	N, 1991	MEAN, 1987	MEAN, 1991	VARIANCE, 1987	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GM-159	12	4	1.000	2.000	0.000	0.006	-	2.624	-

TABLE 30

ANNUAL T-12 DATA REPORT
ONE-TAILED T TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
TOTAL ORGANIC CARBON (TOC/L)
BY WELL - 1987 VS 3RD QUARTER 1991

SITE-C.R. SEDIMENT DISP. - CONCENTRATIONS

WELL IDENTITY	N, 1987	N, 1991	MEAN, 1987	MEAN, 1991	VARIANCE, 1987	VARIANCE, 1991	T STATISTIC	T CRITICAL	T TEST RESULT
CM-155	4	-	17.500	-	91.667	-	-	-	-
CM-156	4	4	25.000	10.000	900.000	0.000	1.000	3.143	NO SIGNIF. INC.
CM-157	4	-	10.250	-	92.250	-	-	-	-
CM-731	-	4	-	12.250	-	10.917	-	-	-
CM-732	-	4	-	10.000	-	0.000	-	-	-

SITE-C.R. SEDIMENT DISP. - OPERANDS

WELL IDENTITY	N, 1987	N, 1991	MEAN, 1987	MEAN, 1991	VARIANCE, 1987	VARIANCE, 1991	T STATISTIC	T CRITICAL	T TEST RESULT
CM-159	4	4	22.750	10.000	504.917	0.000	1.054	3.143	NO SIGNIF. INC.

NO. OF TESTS	NO. OF TESTS	NO. OF TESTS	NO. OF TESTS	NO. OF TESTS	NO. OF TESTS	NO. OF TESTS	NO. OF TESTS	NO. OF TESTS	NO. OF TESTS
1	2	3	4	5	6	7	8	9	10

TABLE 1. SUMMARY OF TEST RESULTS

NO. OF TESTS	NO. OF TESTS	NO. OF TESTS	NO. OF TESTS	NO. OF TESTS	NO. OF TESTS	NO. OF TESTS	NO. OF TESTS	NO. OF TESTS	NO. OF TESTS
1	2	3	4	5	6	7	8	9	10

TABLE 2. SUMMARY OF TEST RESULTS

TABLE 3. SUMMARY OF TEST RESULTS

TABLE 4

TABLE 32
 ANNUAL Y-12 OCHA REPORT
 ONE-TAILED T TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
 CONDUCTIVITY (MICRO/CM)
 DOWNHOLE, 3RD QUARTER 1991 VS UPHOLE, 1990

SITE-C.B. SEDIMENT DISP.

WELL	N, "UP" 1990	N, "DOWN" 1991	MEAN, "UP" 1990	MEAN, "DOWN" 1991	VARIANCE, "UP" 1990	VARIANCE, "DOWN" 1991	T STATISTIC	T CRITICAL	T TEST RESULT
CH-750	16	4	929.957	682.750	1027079.66	79.250	-0.634	2.552	NO SIGNIF. INC.
CH-751	16	4	929.957	202.750	1027079.66	2.917	-1.670	2.552	NO SIGNIF. INC.
CH-752	16	4	929.957	275.750	1027079.66	8.250	-1.200	2.552	NO SIGNIF. INC.

TABLE 33

ANNUAL T-12 NORM REPORT
 ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
 TOTAL ORGANIC CARBON (TOC/L)
 DEPENDENT, 2ND QUARTER 1991 VS INDEPENDENT, 1987

 SITE-C.R. SEDIMENT DISP.

WELL	N, "UP" 1987	N, "DOWN" 1991	MEAN, "UP" 1987	MEAN, "DOWN" 1991	VARIANCE, "UP" 1987	VARIANCE, "DOWN" 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-156	12	4	1.000	2.750	0.000	0.250	13.096	2.626	**SIGNIF. INC.**
GW-751	12	4	1.000	5.000	0.000	10.000	4.733	2.626	**SIGNIF. INC.**
GW-752	12	4	1.000	1.500	0.000	0.333	3.240	2.626	**SIGNIF. INC.**

TABLE 34

ANNUAL Y-12 NORA REPORT
 ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
 TOTAL ORGANIC HALIDE (UG/L)
 DOWNGRADIENT, 3RD QUARTER 1991 VS UPGRAIDENT, 1987

----- SITE=C.R. SEDIMENT DISP. -----

WELL	N, "UP" 1987	N, "DOWN" 1991	MEAN, "UP" 1987	MEAN, "DOWN" 1991	VARIANCE, "UP" 1987	VARIANCE, "DOWN" 1991	T-STATISTIC	T CRITICAL	T-TEST RESULT
GM-156	4	4	22.750	10.000	506.917	0.000	-1.054	3.143	NO SIGNIF. INC.
GM-731	4	4	22.750	12.250	506.917	10.917	-0.860	3.143	NO SIGNIF. INC.
GM-732	4	4	22.750	10.000	506.917	0.000	-1.054	3.143	NO SIGNIF. INC.

TABLE 35
ANNUAL Y-12 RCRA REPORT
TWO-TAILED T-TEST TO TEST FOR SIGNIFICANT DIFFERENCE IN
MEAN PH
DOWNGRAIENT, 3RD QUARTER 1991 VS UPGRADIENT, 1986

SITE=C.R. SEDIMENT DISP.									
WELL	N, 'UP' 1986	N, 'DOWN' 1991	MEAN, 'UP' 1986	MEAN, 'DOWN' 1991	VARIANCE, 'UP' 1986	VARIANCE, 'DOWN' 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-156	16	4	9.206	7.350	1.171	0.003	-3.360	2.878	**SIGNIF. DEC.**
GW-731	16	4	9.206	9.650	1.171	0.003	0.803	2.878	NO SIGNIF. DIFF.
GW-732	16	4	9.206	8.025	1.171	0.003	-2.138	2.878	NO SIGNIF. DIFF.

TABLE 36

SUMMARY OF STATISTICALLY SIGNIFICANT T-TEST RESULTS AT THE
CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN
(Semi-Annual)

CONDUCTIVITY (umhos/cm)

TOTAL ORGANIC CARBON (mg/l)

TOTAL ORGANIC HALIDE (ug/l)

pH (pH units)

GW-155	Significantly less than 1986	(6.9/7.8)
	Significantly less than 1986 upgradient	(6.9/9.2)
GW-156	Significantly less than 1986 upgradient	(7.3/9.2)
GW-157	Significantly less than 1986 upgradient	(7.4/9.2)
GW-159	Significantly less than 1986	(7.6/9.2)

TABLE 37
ANNUAL Y-12 RCRA REPORT
ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
CONDUCTIVITY (UMHOS/CM)
BY WELL - 1986 VS 1ST QUARTER 1991

----- SITE=C.R. SEDIMENT DISP. --DOWNGRADIENT -----									
WELL IDENTITY	N, 1986	N, 1991	MEAN, 1986	MEAN, 1991	VARIANCE, 1986	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-155	16	4	251.812	261.500	142.429	21.667	1.567	2.552	NO SIGNIF. INC.
GW-156	16	4	809.187	794.000	56848.563	680.667	-0.125	2.552	NO SIGNIF. INC.
GW-157	16	4	448.250	352.250	2680.600	26.917	-3.630	2.552	NO SIGNIF. INC.

----- SITE=C.R. SEDIMENT DISP. --UPGRADIENT -----									
WELL IDENTITY	N, 1986	N, 1991	MEAN, 1986	MEAN, 1991	VARIANCE, 1986	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-159	16	4	929.937	351.500	1021079.66	11.000	-1.122	2.552	NO SIGNIF. INC.

TABLE 38

ANNUAL Y-12 RCRA REPORT
 ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
 TOTAL ORGANIC CARBON (MG/L)
 BY WELL - 1987 VS 1ST QUARTER 1991

----- SITE=C.R. SEDIMENT DISP. --DOWNGRADIENT -----

WELL IDENTITY	N, 1987	N, 1991	MEAN, 1987	MEAN, 1991	VARIANCE, 1987	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-155	12	4	1.217	1.000	0.362	0.000	-0.704	2.624	NO SIGNIF. INC.
GW-156	12	4	2.083	2.000	1.587	0.000	-0.129	2.624	NO SIGNIF. INC.
GW-157	12	4	3.425	2.000	2.646	0.000	-1.712	2.624	NO SIGNIF. INC.

----- SITE=C.R. SEDIMENT DISP. --UPGRADIENT -----

WELL IDENTITY	N, 1987	N, 1991	MEAN, 1987	MEAN, 1991	VARIANCE, 1987	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-159	12	4	1.000	1.000	0.000	0.000	.	2.624	

TABLE 39
ANNUAL Y-12 RCRA REPORT
ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
TOTAL ORGANIC HALIDE (UG/L)
BY WELL - 1987 VS 1ST QUARTER 1991

----- SITE=C.R. SEDIMENT DISP. --DOWNGRADIENT -----									
WELL IDENTITY	N, 1987	N, 1991	MEAN, 1987	MEAN, 1991	VARIANCE, 1987	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-155	4	4	17.500	10.250	91.667	0.250	-1.512	3.143	NO SIGNIF. INC.
GW-156	4	4	25.000	10.000	900.000	0.000	-1.000	3.143	NO SIGNIF. INC.
GW-157	4	4	18.250	10.000	92.250	0.000	-1.718	3.143	NO SIGNIF. INC.

----- SITE=C.R. SEDIMENT DISP. --UPGRADIENT -----									
WELL IDENTITY	N, 1987	N, 1991	MEAN, 1987	MEAN, 1991	VARIANCE, 1987	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-159	4	4	22.750	10.000	584.917	0.000	-1.054	3.143	NO SIGNIF. INC.

TABLE 40
ANNUAL Y-12 RCRA REPORT
TWO-TAILED T-TEST TO TEST FOR SIGNIFICANT DIFFERENCE IN
MEAN PH
BY WELL - 1986 VS 1ST QUARTER 1991

----- SITE=C.R. SEDIMENT DISP. --DOWNGRADIENT -----									
WELL IDENTITY	N, 1986	N, 1991	MEAN, 1986	MEAN, 1991	VARIANCE, 1986	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-155	16	4	7.825	6.875	0.059	0.002	-7.611	2.878	**SIGNIF. DEC.**
GW-156	16	4	8.125	7.275	0.377	0.002	-2.712	2.878	NO SIGNIF. DIFF.
GW-157	16	4	7.725	7.425	0.046	0.003	-2.726	2.878	NO SIGNIF. DIFF.

----- SITE=C.R. SEDIMENT DISP. --UPGRADIENT -----									
WELL IDENTITY	N, 1986	N, 1991	MEAN, 1986	MEAN, 1991	VARIANCE, 1986	VARIANCE, 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-159	16	4	9.206	7.575	1.171	0.002	-2.953	2.878	**SIGNIF. DEC.**

TABLE 41
ANNUAL Y-12 RCRA REPORT
ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
CONDUCTIVITY (UMHOS/CM)
DOWNGRAIENT, 1ST QUARTER 1991 VS UPGRADIENT, 1991

----- SITE=C.R. SEDIMENT DISP. -----

WELL	N, 'UP' 1986	N, 'DOWN' 1991	MEAN, 'UP' 1986	MEAN, 'DOWN' 1991	VARIANCE, 'UP' 1986	VARIANCE, 'DOWN' 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-155	16	4	929.937	261.500	1021079.66	21.667	-1.296	2.552	NO SIGNIF. INC.
GW-156	16	4	929.937	794.000	1021079.66	680.667	-0.264	2.552	NO SIGNIF. INC.
GW-157	16	4	929.937	352.250	1021079.66	26.917	-1.120	2.552	NO SIGNIF. INC.

TABLE 42

ANNUAL Y-12 RCRA REPORT
 ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
 TOTAL ORGANIC CARBON (MG/L)
 DOWNGRADIENT, 1ST QUARTER 1991 VS UPGRADEMENT, 1987

----- SITE=C.R. SEDIMENT DISP. -----

WELL	N, 'UP' 1987	N, 'DOWN' 1991	MEAN, 'UP' 1987	MEAN, 'DOWN' 1991	VARIANCE, 'UP' 1987	VARIANCE, 'DOWN' 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GU-155	12	4	1.000	1.000	0.000	0.000	.	2.624	
GU-156	12	4	1.000	2.000	0.000	0.000	.	2.624	
GU-157	12	4	1.000	2.000	0.000	0.000	.	2.624	

TABLE 43

ANNUAL Y-12 RCRA REPORT
 ONE-TAILED T-TEST TO TEST FOR SIGNIFICANT INCREASE IN MEAN
 TOTAL ORGANIC HALIDE (UO/L)
 DOWNGRADIENT, 1ST QUARTER 1991 VS UPGRADEMENT, 1987

----- SITE=C.R. SEDIMENT DISP. -----

WELL	N, "UP" 1987	N, "DOWN" 1991	MEAN, "UP" 1987	MEAN, "DOWN" 1991	VARIANCE, "UP" 1987	VARIANCE, "DOWN" 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
GW-155	4	4	22.750	10.250	504.917	0.250	-1.033	3.143	NO SIGNIF. INC.
GW-156	4	4	22.750	10.000	504.917	0.000	-1.054	3.143	NO SIGNIF. INC.
GW-157	4	4	22.750	10.000	504.917	0.000	-1.054	3.143	NO SIGNIF. INC.

TABLE 44
 ANNUAL Y-12 RCRA REPORT
 TWO-TAILED T-TEST TO TEST FOR SIGNIFICANT DIFFERENCE IN
 MEAN PH
 DOWNGRADIENT, 1ST QUARTER 1991 VS UPGRADE, 1986

----- SITE=C.R. SEDIMENT DISP. -----

WELL	N, "UP" 1986	N, "DOWN" 1991	MEAN, "UP" 1986	MEAN, "DOWN" 1991	VARIANCE, "UP" 1986	VARIANCE, "DOWN" 1991	T-STATISTIC	T-CRITICAL	T-TEST RESULT
CU-155	16	4	9.206	6.875	1.171	0.002	-4.220	2.870	**SIGNIF. DEC.**
CU-156	16	4	9.206	7.275	1.171	0.002	-3.406	2.870	**SIGNIF. DEC.**
CU-157	16	4	9.206	7.425	1.171	0.003	-3.225	2.870	**SIGNIF. DEC.**

**RESULTS OF PROPOSED STATISTICAL ANALYSIS ALTERNATIVE TO CHESTNUT
RIDGE SEDIMENT DISPOSAL BASIN**

TABLES

45 - 52

APPENDIX C

FALSE POSITIVE DEMONSTRATION REPORTS FOR KERR HOLLOW QUARRY AND CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN

TABLE 45
CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN

<u>WELL IDENTITY</u>		<u>BARIUM ICAP</u> <u>(MG/L)</u>	<u>COMMENT</u>
GW-156	Downgradient	0.022	Doesn't exceed tolerance limit (0.2207 mg/L)
GW-159	Upgradient	0.016	Doesn't exceed tolerance limit (0.2207 mg/L)
GW-731	Downgradient	0.011	Doesn't exceed tolerance limit (0.2207 mg/L)
GW-732	Downgradient	0.0073	Doesn't exceed tolerance limit (0.2207 mg/L)

TABLE 46
CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN

<u>WELL IDENTITY</u>		<u>URANIUM FLUORIMETRIC (MG/L)</u>	<u>COMMENT</u>
GW-156	Downgradient	0.003	Doesn't exceed tolerance limit (0.009 mg/L)
GW-159	Upgradient	0.002	Doesn't exceed tolerance limit (0.009 mg/L)
GW-731	Downgradient	<0.001	Doesn't exceed tolerance limit (0.009 mg/L)
GW-732	Downgradient	0.001	Doesn't exceed tolerance limit (0.009 mg/L)

TABLE 47
CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN

<u>WELL IDENTITY</u>		<u>CHROMIUM AAS (MG/L)</u>	<u>COMMENT</u>
GW-156	Downgradient	<0.01	Doesn't exceed tolerance limit (0.038 mg/L)
GW-159	Upgradient	<0.01	Doesn't exceed tolerance limit (0.038 mg/L)
GW-731	Downgradient	<0.01	Doesn't exceed tolerance limit (0.038 mg/L)
GW-732	Downgradient	<0.01	Doesn't exceed tolerance limit (0.038 mg/L)

TABLE 48
CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN

<u>WELL IDENTITY</u>	<u>MERCURY CVAA (MG/L)</u>	<u>COMMENT</u>
GW-156 Downgradient	<0.0002	Doesn't exceed tolerance limit (0.0004 mg/L)
GW-159 Upgradient	0.00037	Doesn't exceed tolerance limit (0.0004 mg/L)
GW-731 Downgradient	<0.0002	Doesn't exceed tolerance limit (0.0004 mg/L)
GW-732 Downgradient	<0.0002	Doesn't exceed tolerance limit (0.0004 mg/L)

TABLE 49
CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN

<u>WELL IDENTITY</u>		<u>NICKEL ICAP (MG/L)</u>	<u>COMMENT</u>
GW-156	Downgradient	0.016	Doesn't exceed tolerance limit (0.076 mg/L)
GW-159	Upgradient	<0.01	Doesn't exceed tolerance limit (0.076 mg/L)
GW-731	Downgradient	<0.01	Doesn't exceed tolerance limit (0.076 mg/L)
GW-732	Downgradient	<0.01	Doesn't exceed tolerance limit (0.076 mg/L)

TABLE 50
CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN

<u>WELL IDENTITY</u>		<u>SILVER ICAP (MG/L)</u>	<u>COMMENT</u>
GW-156	Downgradient	<0.006	Doesn't exceed tolerance limit (0.045 mg/L)
GW-159	Upgradient	<0.006	Doesn't exceed tolerance limit (0.045 mg/L)
GW-731	Downgradient	<0.006	Doesn't exceed tolerance limit (0.045 mg/L)
GW-732	Downgradient	<0.006	Doesn't exceed tolerance limit (0.045 mg/L)

TABLE 51
CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN

<u>WELL IDENTITY</u>		<u>CADMIUM AAS (MG/L)</u>	<u>COMMENT</u>
GW-156	Downgradient	<0.002	Doesn't exceed tolerance limit (0.0061 mg/L)
GW-159	Upgradient	<0.002	Doesn't exceed tolerance limit (0.0061 mg/L)
GW-731	Downgradient	<0.002	Doesn't exceed tolerance limit (0.0061 mg/L)
GW-732	Downgradient	<0.002	Doesn't exceed tolerance limit (0.0061 mg/L)

TABLE 52
CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN

<u>WELL IDENTITY</u>		<u>LEAD AAS (MG/L)</u>	<u>COMMENT</u>
GW-156	Downgradient	<0.004	Doesn't exceed tolerance limit (0.19 mg/L)
GW-159	Upgradient	<0.004	Doesn't exceed tolerance limit (0.19 mg/L)
GW-731	Downgradient	<0.004	Doesn't exceed tolerance limit (0.19 mg/L)
GW-732	Downgradient	<0.004	Doesn't exceed tolerance limit (0.19 mg/L)

**FALSE-POSITIVE DEMONSTRATION FOR
CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN
AND KERR HOLLOW QUARRY**

OAK RIDGE Y-12 PLANT

C. Stephen Haase¹
Helen L. King²
Terre M. Mercier³

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- ¹ Environmental Sciences Division, Oak Ridge National Laboratory,
P. O. Box 2008, Oak Ridge, Tennessee 37831-6352
- ² Environmental Management Department, Oak Ridge Y-12 Plant, P. O. Box 2009,
Oak Ridge, Tennessee 37831-8219
- ³ H & R Technical Associates, Oak Ridge, Tennessee 37830

Introduction

Groundwater quality data were collected for two sites in RCRA Interim Status - Detection Monitoring at the Oak Ridge Y-12 Plant during the first quarter of calendar year (CY) 1991. As required by Rule 1200-1-1-.05(6) of the Tennessee Department of Environment and Conservation, monitoring results for indicator parameters (pH, conductivity, total organic carbon (TOC), and total organic halides (TOX)) were reviewed to determine if a statistically significant change had occurred in the values of one or more indicator parameters. Analysis of the data obtained for the first quarter of 1991 indicated that statistically significant changes had occurred in pH for upgradient and downgradient wells at the Chestnut Ridge Sediment Disposal Basin and in pH and conductivity for upgradient and downgradient wells at Kerr Hollow Quarry.

The purpose of this document is to review pH and conductivity data in question to determine if the statistically significant changes in the indicator parameters noted for first-quarter 1991 data represent a release of contaminants into the groundwater from the facilities, or if the changes observed are due to other, naturally occurring factors.

Chestnut Ridge Sediment Disposal Basin

Data Summary

Data obtained during the first-quarter of 1991 indicate that statistically significant changes in pH occurred for both upgradient and downgradient monitoring wells at the Chestnut Ridge Sediment Disposal Basin. To evaluate these findings, all pH data from groundwater monitoring wells surrounding the facility (Fig. 1) have been reviewed to determine if the pH changes observed are truly indicative of contaminant releases from the Chestnut Ridge Sediment Disposal Basin.

Evaluation of pH Data

The mean, median, and variance of pH measurements obtained for all groundwater monitoring wells at the Chestnut Ridge Sediment Disposal Basin During are illustrated in Fig. 2. The data indicate that (1) the median pH values for all wells except well 1096 fall between 7.0 and 8.0 and (2) the degree of variance, as calculated by the distance between the 25th and 75th percentiles, is variable from well to well and ranges from approximately 0.5 pH units for wells GW-156 and GW-159 to approximately 2.0 pH units in well GW-158.

Skewness and kurtosis values for the data sets for each well were evaluated to determine if the pH values followed a normal distribution. Such an analysis suggests that pH values in four out of ten wells at the site may not be normally distributed. Of importance to detection monitoring requirements, the skewness and kurtosis values suggest that pH values for upgradient well GW-159, and downgradient wells GW-155 and GW-156 may not be normally distributed.

Trend plots for pH measurements from the upgradient and downgradient wells at the Chestnut Ridge Sediment Disposal Basin are illustrated in Figs. 3 through 6. Data for each of the wells will be summarized and interpreted in the following sections.

GW-159. Upgradient well GW-159 had pH values >8.0 for the base year of CY 1986 (Fig. 3). Subsequent to the base year, all pH values from well GW-159 were less than those observed during the base year, with values ranging from slightly above 8.0 to slightly less than 6.0. After the base year, pH values for well GW-159 exhibit a sawtooth cyclic variation. Values for pH gradually decline from approximately 8.0 to 6.0 during the period 1987 through mid-1989. During late CY 1989, pH values increase back to approximately 8.0 and mark the beginning of a second sawtooth cycle. Subsequent to this abrupt increase, pH values exhibit a gradual decline from approximately 8.0 to 7.0 during CY 1990. The pH value for first quarter 1991 is 7.6, which is below the median of 7.8, but within the interquartile range of 7.4 to 8.1 for the well (see Figs. 2 and 3), and within the maximum range of pH values observed in the well (see Fig. 3).

GW-155. Downgradient well GW-155 had pH values between slightly greater than 8.0 and approximately 7.5 during the base year of CY 1986 (Fig. 4). After the base year, pH values for well GW-155 exhibit a sawtooth cyclic variation similar to that observed in the upgradient well GW-159. Values for pH gradually decline from approximately 7.5 to slightly less than 6.0 during the period 1987 through mid-1989. During late CY 1989, pH values increase back to approximately 8.0, and mark the beginning of a second sawtooth cycle. Subsequent to this abrupt increase, pH values exhibit a gradual decline from approximately 8.0 to 7.0 during CY 1990. In general pattern of pH fluctuations in well GW-155 is similar to that observed in the upgradient well. The pH value for first quarter 1991 is 6.9, which is below the median of 7.5, but within the interquartile range of 6.9 to 7.7 for the well (see Figs. 2 and 4), and within the maximum range of pH values observed in the well (see Fig. 4).

GW-156. Downgradient well GW-156 had pH values between slightly less than 9.0 and approximately 8.0 during the base year of CY 1986 (Fig. 5). Subsequent to the base year, pH values for well GW-156 were typically less than those obtained during the base year, with values ranging between approximately 8.0 and slightly less than 7.0. Values for pH gradually decline from approximately 7.8 to slightly less than 7.0 during the period 1987 through mid-1989. During CY 1990, pH values have increased somewhat, and range between approximately 7.8 and 7.3. The general

pattern of pH fluctuations in well GW-156 is similar to that observed in the upgradient well (GW-159), although the sawtooth pattern is subdued due to the smaller range of pH fluctuation exhibited by well GW-156. The pH value for first quarter 1991 is 7.3, which is below the median of 7.5, but within the interquartile range of 7.3 to 7.7 for the well (see Figs. 2 and 5), and within the maximum range of pH values observed in the well (see Fig. 5).

GW-157. Downgradient well GW-157 had pH values between approximately 7.5 and approximately 8.5 during the base year of CY 1986 (Fig. 6). Subsequent to the base year, pH values for well GW-157 were typically less than those obtained during the base year, with values ranging between approximately 7.5 and slightly less than 7.0. Values for pH gradually declined from approximately 7.5 to slightly less than 7.0 during the period 1987 through mid-1989. During the last part of CY 1989, pH values have increased from approximately 7.0 to greater than approximately 7.5, and range between approximately 7.5 and 7.8. The general pattern of pH fluctuations in well GW-157 is similar to that observed in the upgradient well (GW-159), although the sawtooth pattern is subdued due to the smaller range of pH fluctuation exhibited by well GW-157. The pH value for first quarter 1991 is 7.4, which is at the median of 7.4, within the interquartile range of 7.2 to 7.5 for the well (see Figs. 2 and 6), and within the maximum range of pH values observed in the well (see Fig. 6).

Discussion and Summary

Temporal variations in downgradient wells at the Chestnut Ridge Sediment Disposal Basin are generally similar to those exhibited by the upgradient well. The temporal pH trend of the upgradient well is interpreted to represent naturally-occurring, secular pH fluctuations of the groundwater system surrounding the Chestnut Ridge Sediment Disposal Basin. All of the downgradient wells exhibit similar trends to that observed in the upgradient well. The temporal pH trend for well GW-155 is essentially identical to that observed in the upgradient well. The pH trends exhibited in downgradient wells GW-156 and GW-157 have similar form but differ in the magnitude of the the range of pH values observed. The similarity of trends suggests that variations in pH for groundwaters from all wells at the Chestnut Ridge Sediment Disposal Basin are due to secular variations in groundwater chemistry and not to contaminant releases from the site.

The pH values obtained during the base year of 1986 for the upgradient well and two of the three downgradient wells are always above 8.0, and typically above 9.0. Such values are significantly higher than those typical of uncontaminated groundwater from the Knox Group studied elsewhere on the Oak Ridge Reservation (HSW 1991a through e). Such values are interpreted to represent partial contamination of the groundwater samples by fluids remaining in the formation from well construction activities. All of the groundwater monitoring wells at the Chestnut Ridge Sediment Disposal Basin were developed after construction, and purged prior to sampling. However, the fractured and karstified nature of the Knox aquifer makes

development of wells potentially problematical. Because of such complications, and the fact that pH values for all wells during subsequent years were within ranges typical of Know Group groundwaters elsewhere in the Oak Ridge area, data obtained during the base period are suspect.

Based on the factors discussed above, the statistically significant changes in pH noted for wells at the Chestnut Ridge Sediment Disposal Basin are interpreted to be false positives, and to not represent a release of contaminants into groundwater from the site.

Kerr Hollow Quarry

Data Summary

Data obtained during the first-quarter of 1991 indicate that statistically significant changes in pH were noted for the upgradient well (GW-145) and all three downgradient monitoring wells (GW-142, GW-144, and GW-231) at Kerr Hollow Quarry (Fig. 7). Additionally, statistically significant increases in conductivity for one downgradient well (GW-142) were noted. To evaluate these findings, all pH and conductivity data from groundwater monitoring wells surrounding the facility have been reviewed to determine if the changes observed are truly indicative of contaminant releases from Kerr Hollow Quarry.

Evaluation of pH Data

The mean, median, and variance of pH measurements obtained for all groundwater monitoring wells at Kerr Hollow Quarry are illustrated in Fig. 8. The data indicate that (1) the median pH values for all wells fall between 7.5 and 8.0 and (2) the variability or spread of the middle 50 percent of the data for each well, as illustrated by the interquartile distance (distance between the 25th and 75th percentiles), is variable from well to well and ranges from approximately 0.5 pH units for well GW-231 to approximately 2.0 pH units in well GW-146.

Skewness and kurtosis values for the data sets for each well were evaluated to determine if the pH values followed a normal distribution. Such an analysis suggests that pH values in four out of seven wells at the site may not be normally distributed. Of importance to detection monitoring requirements, the skewness and kurtosis values suggest that pH values in downgradient wells GW-144 and GW-231 may not be normally distributed.

Trend plots for pH measurements from the upgradient and downgradient wells at Kerr Hollow Quarry are illustrated in Figs. 9 through 12. Data for each of the wells will be summarized and interpreted in the following sections

GW-145. Upgradient well GW-145 had pH values ranging between approximately 7.9 and 8.7 for the base year of CY 1986 (Fig. 9). Subsequent to the base year, all pH values from well GW-145 were typically less than 8.5, with values ranging from slightly above 8.3 to approximately 6.6. After the base year, pH values for well GW-145 exhibit a generalized decline through during the period 1987 through 1989, although the trend of this decline in values is complex and exhibits several reversals. This period of decreasing pH values concludes in late CY 1989, when pH values of approximately 6.6 are measured. Such values are the lowest values obtained during the period of observation. The pH value from the sample obtained in late in CY 1989 exhibits an abrupt increase back to approximately 8.0. Subsequent to this abrupt increase, pH values during CY 1990 exhibit a gradual decline that is again characterized by much variability and at least one reversal of trend. The pH value for first quarter 1991 is 7.1, which is below the median of 7.9, but within the interquartile range of 7.3 to 8.2 for the well (see Figs. 8 and 9), and within the maximum range of pH values observed in the well (see Fig. 9).

GW-142. Downgradient well GW-142 had pH values ranging between approximately 8.8 and 7.5 for the base year of CY 1986 (Fig. 10). Subsequent to the base year, all pH values from well GW-145 were typically less than 8.0, with values ranging from approximately 7.9 to 6.6. Values for pH from well GW-142 exhibit a generalized decline through 1989, although the trend of this decline in values is complex and exhibits several reversals. This period of decreasing pH values ends in late CY 1989, when pH values of approximately 6.6 are obtained. Such values are the lowest values obtained during the period of observation. The pH value from the sample obtained in late in CY 1989 exhibits an abrupt increase back to approximately 8.0. Subsequent to this abrupt increase, pH values during CY 1990 exhibit a gradual decline that is again characterized by much variability and at least one reversal of trend. The pH value for first quarter 1991 is 7.1, which is below the median of 7.5, but within the interquartile range of 7.1 to 7.8 for the well (see Figs. 8 and 10), and within the maximum range of pH values observed in the well (see Fig. 10). In general, the trend of pH values for well GW-142 resembles that observed in upgradient well GW-145.

GW-144. Downgradient well GW-144 had pH values between approximately 8.0 to 7.8 during the base year of CY 1986 (Fig. 11). Subsequent to the base year, all pH values from well GW-144 were typically less than 8.0, with values ranging from approximately 7.9 to 6.5. Values for pH from well GW-144 exhibit a generalized decline through 1989, although the trend of this decline in values is complex and exhibits several reversals. This period of decreasing pH values ends in late CY 1989, when pH values of approximately 6.5 are obtained. Such values are the lowest values obtained during the period of observation. The pH value from the sample obtained in late in CY 1989 exhibits an abrupt increase back to approximately 7.7. Subsequent to this abrupt increase, pH values during CY 1990 exhibit a gradual decline that is again characterized by much variability and at least one reversal of trend. The pH value for first quarter 1991 is 6.9, which is below the median of 7.6,

but within the interquartile range of 7.6 to 7.9 for the well (see Figs. 8 and 11), and within the maximum range of pH values observed in the well (see Fig. 11). In general, the trend of pH values for well GW-144 resembles that observed in upgradient well GW-145.

GW-231. Downgradient well GW-231 had pH values between approximately 8.1 and 7.6 during the base year of CY 1986 (Fig. 12). Subsequent to the base year, all pH values from well GW-231 were typically less than 7.5, with values ranging from approximately 7.5 to 6.3. Values for pH from well GW-231 exhibit a generalized decline through 1989, although the trend of this decline in values is complex and exhibits several reversals. This period of decreasing pH values ends in late CY 1989, when pH values of approximately 6.3 are obtained. Such values are the lowest values obtained during the period of observation. The pH value from the sample obtained in late in CY 1989 exhibits an abrupt increase back to approximately 7.7. Subsequent to this abrupt increase, pH values during CY 1990 exhibit a gradual decline that is again characterized by much variability and at least one reversal of trend. The pH value for first quarter 1991 is 6.9, which is below the median of 7.5, below the interquartile range of 7.0 to 7.6 for the well (see Figs. 8 and 12), but within the maximum range of pH values observed in the well (see Fig. 12). In general, the trend of pH values for well GW-231 resembles that observed in upgradient well GW-145.

Evaluation of Conductivity Data

The mean, median, and variance of conductivity measurements obtained for all groundwater monitoring wells at Kerr Hollow Quarry are illustrated in Fig. 13. The data indicate that (1) the median conductivity values for all wells fall between approximately 250 and 500 $\mu\text{mhos/cm}$ and (2) the variability or range of the middle 50 percent of the data for each well, as illustrated by the interquartile distance, is variable from well to well and ranges from approximately 75 $\mu\text{mhos/cm}$ in well GW-231 to approximately 200 $\mu\text{mhos/cm}$ in well GW-146.

Skewness and kurtosis values for the data sets for each well were evaluated to determine if the conductivity values followed a normal distribution. Such an analysis suggests that conductivity values in five out of seven wells at the site may not be normally distributed. Of importance to detection monitoring requirements, the skewness and kurtosis values suggest that conductivity values in upgradient well GW-145 and in downgradient wells GW-144 and GW-231 may not be normally distributed.

Trend plots for conductivity measurements from the upgradient well (GW-145) and the downgradient well (GW-142) of interest at Kerr Hollow Quarry are illustrated in Figs. 14 through 15. Data for each of the wells will be summarized and interpreted in the following sections

GW-145. Upgradient well GW-145 had conductivity values ranging between approximately 650 and 550 $\mu\text{mhos/cm}$ for the base year of CY 1986 (Fig. 14). Subsequent to the base year, all conductivity values from well GW-145 were less than 600 $\mu\text{mhos/cm}$, and ranged from approximately 560 to 375 $\mu\text{mhos/cm}$. Conductivity values gradually decline during the period 1987 through 1990, although the trend of this decline in values is complex and exhibits several reversals. The conductivity value for first quarter 1991 is 505 $\mu\text{mhos/cm}$, which is below the median of 567 $\mu\text{mhos/cm}$, below the interquartile range of 508 to 587 $\mu\text{mhos/cm}$ for the well (see Figs. 13 and 14), and among the lowest values obtained for groundwater from well GW-145 (Fig. 14).

GW-142. Downgradient well GW-142 had conductivity values between approximately 300 and 450 $\mu\text{mhos/cm}$ during the base year of CY 1986 (Fig. 15). After the base year, conductivity values for well GW-142 exhibit a generally constant trend with an average of approximately 400 $\mu\text{mhos/cm}$ during the period 1987 through 1989. The conductivity value for first quarter 1991 is 440 $\mu\text{mhos/cm}$, which is above the median of 406 $\mu\text{mhos/cm}$, above the interquartile range of 377 to 435 $\mu\text{mhos/cm}$ for the well (see Figs. 13 and 15), but within the maximum range of conductivity values observed in the well (see Fig. 15). Throughout the period of observation, the median conductivity values for downgradient well GW-142 has been less than that for upgradient well GW-145 (406 $\mu\text{mhos/cm}$ compared to 567 $\mu\text{mhos/cm}$, respectively; see Fig. 13).

Discussion and Summary

Temporal variations in downgradient wells at the Kerr Hollow Quarry are generally similar to those exhibited by the upgradient well. The temporal pH trend of the upgradient well is interpreted to represent naturally-occurring, secular pH fluctuations of the groundwater system surrounding the Kerr Hollow Quarry. All of the downgradient wells exhibit similar trends to that observed in the upgradient well. The temporal pH trend for downgradient wells are essentially identical to that observed in the upgradient well, although the magnitude of the the range of pH values observed differs from well to well. The similarity of trends suggests that variations in pH for groundwaters from all wells at the Kerr Hollow Quarry strongly suggests that observed pH variations are due to secular variations in groundwater chemistry and not to contaminant releases from the site.

The pH values obtained during the base year of 1986 for the upgradient well and one of the three downgradient wells (GW-142) are always above 7.5, and typically above 8.0. Such values are greater than those typical of uncontaminated groundwater from the Knox Group studied elsewhere on the Oak Ridge Reservation (HSW 1991a through e). Such values are interpreted to represent partial contamination of the groundwater samples by fluids remaining in the formation from well construction activities. All of the groundwater monitoring wells at the Kerr Hollow Quarry were developed after construction, and purged prior to sampling. However, the fractured

and karstified nature of the Knox aquifer makes development of wells potentially problematical. Because of such complications, and the fact that pH values for all wells during subsequent years were within ranges typical of Knox Group groundwaters elsewhere in the Oak Ridge area, data obtained during the base period are suspect.

The conductivity values for well GW-142 are less than those of the upgradient well (GW-145) at the site. Additionally, the temporal trends of conductivity values from both well GW-142 and the upgradient well (GW-145) exhibit much variability, with sample to sample changes of 50 $\mu\text{mhos/cm}$ not uncommon. Because the temporal conductivity trend in well GW-142 has a similar character to that of the upgradient well, and because conductivity values are less in well GW-142 than those from the upgradient well, the observed conductivity changes are interpreted to be due to secular groundwater variations and not due to a release of contaminants from the site.

Based on the factors discussed above, the statistically significant changes in pH and conductivity noted for wells at the Kerr Hollow Quarry are interpreted to be false positives, and to not represent a release of contaminants into groundwater from the site.

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Figure 1. Location map for the Chestnut Ridge Sediment Disposal Basin. Upgradient monitoring well is GW-159. Downgradient monitoring wells are GW-155, GW-156, and GW-157.

Figure 2. Statistical summary of pH data for groundwater monitoring wells at the Chestnut Ridge Sediment Disposal Basin. Box outlines represent the 25th percentile (bottom of box), median (middle line terminated with asterisks), and 75th percentile (top of box) of the data set for an individual well. Mean is indicated by central plus sign (+) within the box. Central lines or tails extending above and below the box indicate the range of outliers within 1.5 interquartile ranges below the 25th percentile and above the 75th percentile. Outliers beyond this range are illustrated by zero (0) if they are within 3 interquartile ranges. More extreme outliers are illustrated by an asterisk (*). Because of scale, some boxes appear incomplete.

Figure 3. Plot of mean pH values for the upgradient well (GW-159) at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

Figure 4. Plot of mean pH values for downgradient well GW-155 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

Figure 5. Plot of mean pH values for downgradient well GW-156 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

Figure 6. Plot of mean pH values for downgradient well GW-157 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

Figure 7. Location map for the Kerr Hollow Quarry. Upgradient monitoring well is GW-145. Downgradient monitoring wells are GW-142, GW-144, and GW-231.

Figure 8.

Statistical summary of pH data for groundwater monitoring wells at the Kerr Hollow Quarry. Box outlines represent the 25th percentile (bottom of box), median (middle line terminated with asterisks), and 75th percentile (top of box) of the data set for a individual well. Mean is indicated by central plus sign (+) within the box. Central lines or tails extending above and below the box indicate the range of outliers within 1.5 interquartile ranges below the 25th percentile and above the 75th percentile. Outliers beyond this range are illustrated by zero (0) if they are within 3 interquartile ranges. More extreme outliers are illustrated by an asterisk (*). Because of scale, some boxes appear incomplete.

Figure 9. Plot of mean pH values for upgradient well GW-145 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 10. Plot of mean pH values for downgradient well GW-144 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 11. Plot of mean pH values for upgradient well GW-144 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 12. Plot of mean pH values for upgradient well GW-231 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 13. Statistical summary of conductivity data for groundwater monitoring wells at the Kerr Hollow Quarry. Box outlines represent the 25th percentile (bottom of box), median (middle line terminated with asterisks), and 75th percentile (top of box) of the data set for an individual well. Mean is indicated by central plus sign (+) within the box. Central lines or tails extending above and below the box indicate the range of outliers within 1.5 interquartile ranges below the 25th percentile and above the 75th percentile. Outliers beyond this range are illustrated by zero (0) if they are within 3 interquartile ranges. More extreme outliers are illustrated by an asterisk (*). Because of scale, some boxes appear incomplete.

Figure 14. Plot of mean conductivity values for the upgradient well (GW-145) at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 15. Plot of mean conductivity values for downgradient well GW-142 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

2 of 2

EVALUATION OF TOTAL ORGANIC CARBON AND TOTAL ORGANIC HALIDE
MEASUREMENTS FOR GROUNDWATER FROM THE CHESTNUT RIDGE
SEDIMENT DISPOSAL BASIN AND KERR HOLLOW QUARRY

OAK RIDGE Y-12 PLANT

C. Stephen Haase¹

Helen L. King²

Terre M. Mercier³

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- ¹ Environmental Sciences Division, Oak Ridge National Laboratory,
P. O. Box 2008, Oak Ridge, Tennessee 37831-6352
- ² Environmental Management Department, Oak Ridge Y-12 Plant, P. O. Box 2009,
Oak Ridge, Tennessee 37831-8219
- ³ H & R Technical Associates, Oak Ridge, Tennessee 37830

Introduction

Groundwater quality data were collected for two sites in RCRA Interim Status - Detection Monitoring at the Oak Ridge Y-12 Plant during the first quarter of calendar year (CY) 1991. As required by Rule 1200-1-1-.05(6) of the Tennessee Department of Environment and Conservation, monitoring results for indicator parameters (pH, conductivity, total organic carbon (TOC), and total organic halides (TOX)) were reviewed to determine if a statistically significant change had occurred in the values of one or more indicator parameters. Analysis of the data obtained during the period 1987 through 1990 indicated that statistically significant changes had sporadically occurred in both TOC and TOX for groundwater samples obtained from upgradient and downgradient wells at both the Chestnut Ridge Sediment Disposal Basin and Kerr Hollow Quarry.

The purpose of this document is to review TOC and TOX data for groundwater monitoring wells at both facilities to determine if the statistically significant changes in the indicator parameters noted represent a release of contaminants into the groundwater from the facilities, or if the changes observed are due to other, naturally occurring factors.

Chestnut Ridge Sediment Disposal Basin

Evaluation of TOC Data

Total organic carbon measurements were obtained from groundwater monitoring wells at the Chestnut Ridge Sediment Disposal Basin (Fig. 1) beginning in CY 1987. The mean, median, and variance of TOC measurements are illustrated in Fig. 2. The data indicate that (1) in wells GW-155, GW-158, GW-241, GW-159, and No. 1096 the majority of TOC values obtained were below the detection limit of 1 mg/L, (2) for wells GW-156, GW-157, GW-303, GW-304, and No. 1095 the majority of TOC values are above the detection limit, and for these wells the median TOC values are less than 5 mg/L, (3) for wells GW-156, GW-157, GW-303, GW-304, and No. 1095 the degree of variance, as calculated by the distance between the 25th and 75th percentiles, is typically less than 1 mg/L, and (4) the greatest TOC values measured in any well during the period of observation was 7.1 mg/L from well GW-157.

Total organic carbon measurements reflect dissolved and suspended organic carbon within a groundwater sample. Naturally occurring humic and fulvic acids are major contributors to the dissolved component, and suspended organic material and soil debris are major contributors to the suspended component. In contaminated groundwaters, dissolved organic chemicals, such as petroleum products, chlorinated solvents, and chemically complex organic leachates are typically major contributors to TOC values.

Trend plots for TOC measurements from the upgradient and downgradient wells at the Chestnut Ridge Sediment Disposal Basin are illustrated in Figs. 3a through 6a. To evaluate whether the fluctuations observed in TOC values are naturally-occurring or are due to influxes of contaminant-related organic carbon, trend plots for summed chlorinated and aromatic volatile organic compounds (VOCs) are illustrated in Figs. 3b through 6b. Volatile organic compounds, such as carbon tetrachloride and trichloroethene, are the major potential organic contaminants at the Chestnut Ridge Sediment Disposal Basin and, therefore, are the only contaminant-related source of organic carbon that could impact TOC values in groundwater. Data for TOC and summed chlorinated and aromatic VOC measurements for the upgradient and downgradient monitoring wells is summarized and discussed in the following sections.

GW-159. The majority of TOC values for upgradient well GW-159 were below the detection limit of 1 mg/L (Fig. 3a). Three samples obtained during the period 1989 through 1990 were above detection limits and ranged between 2 and 3 mg/L. Summed chlorinated and aromatic VOCs for well GW-159 range between 0 and 10 µg/L (see Fig. 3b: note these concentrations are a factor of 1000 less than those of TOC values). None of the three TOC values above detection limits corresponds to elevated summed chlorinated and aromatic VOCs values, suggesting that the variations in TOC values noted are due to natural, secular fluctuations in the upgradient well.

GW-155. The majority of TOC values for downgradient well GW-155 were below the detection limit of 1 mg/L (Fig. 4a). Four samples obtained during the period 1989 through 1990 were above detection limits and ranged between 2 and 3 mg/L, which is within the range of TOC values noted for the upgradient well. Summed chlorinated and aromatic VOCs for well GW-155 range between 0 and 5 µg/L (see Fig. 4b: note these concentrations are a factor of 1000 less than those of TOC values). Only one of the four TOC values above detection limits corresponds to a nonzero summed chlorinated and aromatic VOCs value, but the smallness of the summed chlorinated and aromatic VOCs value (5 µg/L) compared to the TOC value (~1.5 mg/L) suggests that the TOC value represents natural-occurring fluctuations.

GW-156. The majority of TOC values for downgradient well GW-156 were above the detection limit of 1 mg/L (Fig. 5a). Samples obtained during the period 1987 through 1990 that were above the detection limit had a median of 2 mg/L and ranged from the detection limit of 1 to ~4.5 mg/L. This range of TOC values is greater than that noted for those samples from the upgradient well, but the median value of 2 mg/L is within the range noted for the upgradient well. Summed chlorinated and aromatic VOCs for well GW-156 range between 0 and ~12 µg/L (see Fig. 5b: note these concentrations are a factor of 1000 less than those of TOC values). During the period 1988 through 1990, however all summed chlorinated and aromatic VOCs values were 0. The fluctuations observed in TOC during that period, therefore, cannot be due to the introduction of contaminant-related organic carbon and must represent natural-occurring fluctuations.

GW-157. All TOC values for downgradient well GW-157 were above the detection limit of 1 mg/L (Fig. 6a). Samples obtained during the period 1987 through 1990 had a median of 3 mg/L and ranged from the detection limit of 1 to ~5.5 mg/L. This range of TOC values is greater than that noted for those samples from the upgradient well, but the median value of 2 mg/L is within the range noted for the upgradient well. Summed chlorinated and aromatic VOCs for well GW-157 range between 0 and ~45 µg/L (see Fig. 6b; note these concentrations are a factor of 1000 less than those of TOC values). Only three summed chlorinated and aromatic VOC values were above 10 µg/L, however, and the majority of values is within the range 0 to 5 µg/L. Examination of Figs. 6a and 6b indicates that there is no correlation between increases in TOC values and increases in summed chlorinated and aromatic VOCs values, suggesting that the TOC fluctuations represent natural-occurring variations.

Discussion and Summary. Temporal variations in TOC values for both the upgradient and downgradient wells at the Chestnut Ridge Sediment Disposal Basin exhibit no identifiable trend or relationship to each other. Many TOC values for all wells are below the 1 mg/L detection limit, and values above the detection limit typically range between 2 and 3 mg/L. Such a range is within what is expected for uncontaminated groundwaters (Hem 1986; Drever 1988). It is also typical of the range noted for uncontaminated groundwaters that occur elsewhere on the Oak Ridge Reservation (HSW 1991 a-e). Variations in TOC for a well are not correlated with variations in the summed chlorinated and aromatic VOC values in that well. In all case variations in summed chlorinated and aromatic VOC values are small, with the values at or near 0 µg/L.

Based on the factors discussed above, the statistically significant changes in TOC noted for wells at the Chestnut Ridge Sediment Disposal Basin are interpreted to be false positives, and to not represent a release of contaminants into groundwater from the site.

Evaluation of TOX Data

Total organic halide measurements were obtained from groundwater monitoring wells at the Chestnut Ridge Sediment Disposal Basin (Fig. 1) beginning in CY 1986. The mean, median, and variance of TOX measurements are illustrated in Fig. 7. The data indicate that (1) much of the data for all wells is less than the 10 µg/L detection limit, and because of this the median values for all wells are at the detection limit, (2) six of the ten wells at the site have extreme outliers, (3) the extreme outliers for the upgradient well (GW-159) range up to ~900 µg/L, and (4) extreme outliers for the downgradient wells range up to ~400 µg/L (GW-156).

Trend plots for TOX measurements from the upgradient and downgradient wells at the Chestnut Ridge Sediment Disposal Basin are illustrated in Figs. 8a through 11a.

For comparison, trend plots of summed chlorinated VOCs are presented in Figs. 8b through 11b. Data for TOX and summed chlorinated VOC measurements for the upgradient and downgradient monitoring wells is summarized and discussed in the following sections.

GW-159. The majority of TOX values for upgradient well GW-159 were less than 25 $\mu\text{g/L}$ (Fig. 8a). Samples obtained during CY 1986 range from the detection limit of 10 $\mu\text{g/L}$ to ~900 $\mu\text{g/L}$. Subsequent to 1986 no TOX values greater than 25 $\mu\text{g/L}$ were obtained, which suggests that the results for CY 1986 represent spurious analytical data. Summed chlorinated VOCs for well GW-159 during the period 1986 through 1990 range between 0 and 8 $\mu\text{g/L}$ (Fig. 8b), with the results for the period 1987 through 1990 all being less than 5 $\mu\text{g/L}$. No consistent correlation or temporal pattern in TOX and summed chlorinated VOC values is noted, suggesting that the variability observed likely represents analytical uncertainties.

GW-155. With one exception, all TOX values for downgradient well GW-155 were less than 50 $\mu\text{g/L}$ (Fig. 9a), and the majority of values are below the detection limit of 10 $\mu\text{g/L}$. Samples obtained during CY 1986 range from the detection limit of 10 $\mu\text{g/L}$ to ~90 $\mu\text{g/L}$. Subsequent to 1986 no TOX values greater than 30 $\mu\text{g/L}$ were obtained, which suggests that the results for CY 1986 represent spurious analytical data. Summed chlorinated VOCs for well GW-155 during the period 1986 through 1990 range between 0 and 5 $\mu\text{g/L}$ (Fig. 9b). No consistent correlation or temporal pattern in TOX and summed chlorinated VOC values is noted, suggesting that the variability observed likely represents analytical uncertainties.

GW-156. With two exceptions, all TOX values for downgradient well GW-156 were less than ~30 $\mu\text{g/L}$ (Fig. 10a), and the majority of values are below the detection limit of 10 $\mu\text{g/L}$. Samples obtained during CY 1986 range from the detection limit of 10 $\mu\text{g/L}$ to ~350 $\mu\text{g/L}$. Subsequent to 1986 no TOX values greater than 30 $\mu\text{g/L}$ were obtained, which suggests that the results for CY 1986 represent spurious analytical data. Summed chlorinated VOCs for well GW-156 during the period 1987 through 1990 range from 0 to ~8 $\mu\text{g/L}$ (Fig. 10b), with the results for the period 1988 through 1990 all being 0 $\mu\text{g/L}$. No consistent correlation or temporal pattern in TOX and summed chlorinated VOC values is noted, suggesting that the variability observed likely represents analytical uncertainties.

GW-157. With one exception, all TOX values for downgradient well GW-157 were less than ~50 $\mu\text{g/L}$ (Fig. 11a), and the majority of values are below the detection limit of 10 $\mu\text{g/L}$. Samples obtained during CY 1986 range from the detection limit of 10 $\mu\text{g/L}$ to ~250 $\mu\text{g/L}$. Subsequent to 1986 no TOX values greater than 50 $\mu\text{g/L}$ were obtained, which suggests that the results for CY 1986 represent spurious analytical data. During the period 1989 through 1990, TOX values were less than ~20 $\mu\text{g/L}$. Summed chlorinated VOCs for well GW-157 during the period 1987 through 1990 range from 0 to ~45 $\mu\text{g/L}$ (Fig. 11b). With one exception, the results for the period 1988 through 1990 were all between 0 and 5 $\mu\text{g/L}$. No consistent correlation or

temporal pattern in TOX and summed chlorinated VOC values is noted, suggesting that the variability observed likely represents analytical uncertainties.

Discussion and Summary. Temporal variations in TOX values for both the upgradient and downgradient wells at the Chestnut Ridge Sediment Disposal Basin exhibit no identifiable trend or relationship to each other. Many TOX values for all wells are below the 10 µg/L detection limit, and values above the detection limit typically range between 10 and 50 µg/L. Variations in TOX for a well are not correlated with variations in the summed chlorinated and aromatic VOC values in that well. In all cases variations in summed chlorinated and aromatic VOC values are small, with the values at or near 0 µg/L.

Based on the factors discussed above, the statistically significant changes in TOX noted for wells at the Chestnut Ridge Sediment Disposal Basin are interpreted to be false positives, and to not represent a release of contaminants into groundwater from the site.

Kerr Hollow Quarry

Evaluation of TOC Data

Total organic carbon measurements were obtained from groundwater monitoring wells at Kerr Hollow Quarry (Fig. 12) beginning in CY 1987. The mean, median, and variance of TOC measurements are illustrated in Fig. 13. The data indicate that (1) in all wells the majority of TOC values obtained were below the detection limit of 1 mg/L, (2) although the median value for TOC in all wells is at or close to the detection limit of 1 mg/L, most wells have several outliers whose values can be as large as ~60 mg/L, and (3) because many of the data are less than the detection limit, the TOC data set is truncated, making statistical analysis difficult.

Total organic carbon measurements reflect dissolved and suspended organic carbon within a groundwater sample. Naturally occurring humic and fulvic acids are major contributors to the dissolved component, and suspended organic material and soil debris are major contributors to the suspended component. In contaminated groundwaters, dissolved organic chemicals, such as petroleum products, chlorinated solvents, and chemically complex organic leachates are typically major contributors to TOC values.

Trend plots for TOC measurements from the upgradient and downgradient wells at Kerr Hollow Quarry are illustrated in Figs. 14a through 17a. To evaluate whether the fluctuations observed in TOC values are naturally-occurring or are due to influxes of contaminant-related organic carbon, trend plots for summed chlorinated and aromatic volatile organic compounds (VOCs) are illustrated in Figs. 14b through 17b. Volatile organic compounds, such as carbon tetrachloride and trichloroethene, are the major potential organic contaminants at Kerr Hollow Quarry and, therefore,

are the only contaminant-related source of organic carbon that could impact TOC values in groundwater. Data for TOC and summed chlorinated and aromatic VOC measurements for the upgradient and downgradient monitoring wells is summarized and discussed in the following sections.

GW-145. The TOC values for upgradient well GW-145 range from the detection limit of 1 mg/L to ~3.3 mg/L (Fig. 14a), and, with the exception of one sample, all TOC values are less than 2 mg/L. Summed chlorinated and aromatic VOCs for well GW-145 are 0 µg/L throughout the period of interest (see Fig. 14b: note these concentrations are a factor of 1000 less than those of TOC values). These data suggest that the variations in TOC values noted are due to natural, secular fluctuations in the upgradient well, and not to contaminant-related organic carbon sources.

GW-142. The TOC values for downgradient well GW-142 range from the detection limit of 1 mg/L to ~6.3 mg/L (Fig. 15a). With the exception of two samples, all TOC values are less than 2 mg/L, which is within the range of values noted for the upgradient well. With one exception, summed chlorinated and aromatic VOCs for well GW-142 range from 0 to ~3 µg/L throughout the period of interest, with most values being 0 mg/L (see Fig. 15b: note these concentrations are a factor of 1000 less than those of TOC values). There is no correlation between TOC and summed chlorinated and aromatic VOCs variations, which suggests that the variations in TOC values noted are due to natural, secular fluctuations, and not to contaminant-related organic carbon sources.

GW-144. The TOC values for downgradient well GW-144 range from the detection limit of 1 mg/L to ~4 mg/L (Fig. 16a). With the exception of one sample, all TOC values are less than ~2 mg/L, which is within the range of values noted for the upgradient well. Summed chlorinated and aromatic VOCs for well GW-144 range from 0 to ~4 µg/L throughout the period of interest, with most values being 0 mg/L (see Fig. 16b: note these concentrations are a factor of 1000 less than those of TOC values). There is no correlation between TOC and summed chlorinated and aromatic VOCs variations, which suggests that the variations in TOC values noted are due to natural, secular fluctuations, and not to contaminant-related organic carbon sources.

GW-231. The TOC values for downgradient well GW-231 range from the detection limit of 1 mg/L to ~5.7 mg/L (Fig. 17a). With the exception of two samples, all TOC values are less than 2 mg/L, which is within the range of values noted for the upgradient well. Summed chlorinated and aromatic VOCs for well GW-231 range from 0 to ~3 µg/L throughout the period of interest, with most values being 0 mg/L (see Fig. 17b: note these concentrations are a factor of 1000 less than those of TOC values). There is no correlation between TOC and summed chlorinated and aromatic VOCs variations, which suggests that the variations in TOC values noted are due to natural, secular fluctuations, and not to contaminant-related organic carbon sources.

Discussion and Summary. Temporal variations in TOC values for both the upgradient and downgradient wells at the Kerr Hollow Quarry exhibit no identifiable trend or relationship to each other. Many TOC values for all wells are below the 1 mg/L detection limit, and values above the detection limit typically range between 2 and 3 mg/L. Such a range is within what is expected for uncontaminated groundwaters (Hem 1986; Drever 1988). It is also typical of the range noted for uncontaminated groundwaters that occur elsewhere on the Oak Ridge Reservation (HSW 1991 a-e). Variations in TOC for a well are not correlated with variations in the summed chlorinated and aromatic VOC values in that well. In all case variations in summed chlorinated and aromatic VOC values are small, with the values at or near 0 µg/L.

Based on the factors discussed above, the statistically significant changes in TOC noted for wells at the Kerr Hollow Quarry are interpreted to be false positives, and to not represent a release of contaminants into groundwater from the site.

Evaluation of TOX Data

Total organic halide measurements were obtained from groundwater monitoring wells at Kerr Hollow Quarry (Fig. 12) beginning in CY 1986. The mean, median, and variance of TOX measurements are illustrated in Fig. 18. The data indicate that (1) much of the data for all wells is less than the 10 µg/L detection limit, and because of this, the median values for all wells are at the detection limit, (2) three of the seven wells at the site have extreme outliers that range up to ~1900 µg/L, (3) two of the downgradient wells (GW-142 and GW-144) have extreme outliers that range up to ~400 µg/L, and (4) one of the downgradient wells (GW-231) has extreme outliers that range to ~1900 µg/L.

Trend plots for TOX measurements from the upgradient and downgradient wells at Kerr Hollow Quarry are illustrated in Figs. 19a through 22a. For comparison, trend plots of summed chlorinated VOCs are presented in Figs. 19b through 22b. Data for TOX and summed chlorinated VOC measurements for the upgradient and downgradient monitoring wells is summarized and discussed in the following sections.

GW-145. The majority of TOX values for upgradient well GW-159 were less than 25 µg/L (Fig. 19a). Samples obtained during CY 1986 range from ~25 µg/L to ~220 µg/L. Subsequent to 1986 TOX values greater than 25 µg/L were not obtained, which suggests that the results for CY 1986 represent spurious analytical data. Summed chlorinated VOCs for well GW-145 during the period 1987 through 1990 are 0 µg/L (Fig. 19b). No consistent correlation or temporal pattern in TOX and summed chlorinated VOC values is noted, suggesting that the variability observed likely represents analytical uncertainties.

GW-142. With one exception, all TOX values for downgradient well GW-142 were less than 50 µg/L (Fig. 20a), and the majority of values are below the detection limit of 10 µg/L. Samples obtained during CY 1986 range from the detection limit of 10 µg/L to ~380 µg/L. Subsequent to 1986 no TOX values greater than ~40 µg/L were obtained, which suggests that the results for CY 1986 represent spurious analytical data. Summed chlorinated VOCs for well GW-142 during the period 1987 through 1990 range between 0 and 1 µg/L (Fig. 20b). No consistent correlation or temporal pattern in TOX and summed chlorinated VOC values is noted, suggesting that the variability observed likely represents analytical uncertainties.

GW-144. With three exceptions, all TOX values for downgradient well GW-144 were less than ~20 µg/L (Fig. 21a). Samples obtained during CY 1986 range from the detection limit of 10 µg/L to ~80 µg/L. Subsequent to 1986 only one TOX value exceeded ~20 µg/L, suggesting that the results for CY 1986 represent spurious analytical data. Summed chlorinated VOCs for well GW-144 during the period 1987 through 1990 range from 0 to ~3 µg/L (Fig. 21b), with only two results being greater than 0 µg/L. No consistent correlation or temporal pattern in TOX and summed chlorinated VOC values is noted, suggesting that the variability observed likely represents analytical uncertainties.

GW-231. With one exception, all TOX values for downgradient well GW-231 were less than ~50 µg/L (Fig. 22a), and the majority of values are below the detection limit of 10 µg/L. Samples obtained during CY 1986 range from the detection limit of 10 µg/L to ~1750 µg/L. Subsequent to 1986 no TOX values greater than 50 µg/L were obtained, which suggests that the results for CY 1986 represent spurious analytical data. During the period 1989 through 1990, TOX values were less than ~20 µg/L. Summed chlorinated VOCs for well GW-231 during the period 1987 through 1990 range from 0 to 1 µg/L (Fig. 22b), with only one value above 0 µg/L. No consistent correlation or temporal pattern in TOX and summed chlorinated VOC values is noted, suggesting that the variability observed likely represents analytical uncertainties.

Discussion and Summary. Temporal variations in TOX values for both the upgradient and downgradient wells at the Kerr Hollow Quarry exhibit no identifiable trend or relationship to each other. Many TOX values for all wells are below the 10 µg/L detection limit, and values above the detection limit typically range between 10 and 50 µg/L. Variations in TOX for a well are not correlated with variations in the summed chlorinated and aromatic VOC values in that well. In all cases variations in summed chlorinated and aromatic VOC values are small, with the values at or near 0 µg/L.

Based on the factors discussed above, the statistically significant changes in TOX noted for wells at the Kerr Hollow Quarry are interpreted to be false positives, and to not represent a release of contaminants into groundwater from the site.

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Figure 1. Location map for the Chestnut Ridge Sediment Disposal Basin. Upgradient monitoring well is GW-159. Downgradient monitoring wells are GW-155, GW-156, and GW-157.

Figure 2. Statistical summary of TOC data for groundwater monitoring wells at the Chestnut Ridge Sediment Disposal Basin. Box outlines represent the 25th percentile (bottom of box), median (middle line terminated with asterisks), and 75th percentile (top of box) of the data set for a individual well. Mean is indicated by central plus sign (+) within the box. Central lines or tails extending above and below the box indicate the range of outliers within 1.5 interquartile ranges below the 25th percentile and above the 75th percentile. Outliers beyond this range are illustrated by zero (0) if they are within 3 interquartile ranges. More extreme outliers are illustrated by an asterisk (*). Because of scale, some boxes appear incomplete.

Figure 3a. Plot of TOC values for upgradient well GW-159 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

Figure 3b. Plot of summed chlorinated and aromatic VOCs for upgradient well GW-159 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

Figure 4a. Plot of TOC values for downgradient well GW-155 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

Figure 4b. Plot of summed chlorinated and aromatic VOCs for downgradient well GW-155 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

Figure 5a. Plot of TOC values for downgradient well GW-156 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

Figure 5b. Plot of summed chlorinated and aromatic VOCs for downgradient well GW-156 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

Figure 6a. Plot of TOC values for downgradient well GW-157 at the Chestnut Ridge Sediment Disposal Basin.
Each data point is the mean of four measurements.

Figure 6b. Plot of summed chlorinated and aromatic VOCs for downgradient well GW-157 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

Figure 7. Statistical summary of TOX data for groundwater monitoring wells at the Chestnut Ridge Sediment Disposal Basin. Box outlines represent the 25th percentile (bottom of box), median (middle line terminated with asterisks), and 75th percentile (top of box) of the data set for a individual well. Mean is indicated by central plus sign (+) within the box. Central lines or tails extending above and below the box indicate the range of outliers within 1.5 interquartile ranges below the 25th percentile and above the 75th percentile. Outliers beyond this range are illustrated by zero (0) if they are within 3 interquartile ranges. More extreme outliers are illustrated by an asterisk (*). Because of scale, some boxes appear incomplete.

Figure 8b. Plot of summed chlorinated VOCs for upgradient well GW-159 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

Figure 9a. Plot of TOX values for downgradient well GW-155 at the Chestnut Ridge Sediment Disposal Basin.
 Each data point is the mean of four measurements.

Figure 9b. Plot of summed chlorinated VOCs for downgradient well GW-155 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

Figure 10a. Plot of TOX values for downgradient well GW-156 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

Figure 10b. Plot of summed chlorinated VOCs for downgradient well GW-156 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

Figure 11a. Plot of TOX values for downgradient well GW-157 at the Chestnut Ridge Sediment Disposal Basin.
Each data point is the mean of four measurements.

Figure 11b. Plot of summed chlorinated VOCs for downgradient well GW-157 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

Figure 12. Location map for the Kerr Hollow Quarry. Upgradient monitoring well is GW-145. Downgradient monitoring wells are GW-142, GW-144, and GW-231.

Figure 13. Statistical summary of TOC data for groundwater monitoring wells at the Kerr Hollow Quarry. Box outlines represent the 25th percentile (bottom of box), median (middle line terminated with asterisks), and 75th percentile (top of box) of the data set for a individual well. Mean is indicated by central plus sign (+) within the box. Central lines or tails extending above and below the box indicate the range of outliers within 1.5 interquartile ranges below the 25th percentile and above the 75th percentile. Outliers beyond this range are illustrated by zero (0) if they are within 3 interquartile ranges. More extreme outliers are illustrated by an asterisk (*). Because of scale, some boxes appear incomplete.

Figure 14a. Plot of TOC values for upgradient well GW-145 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 14b. Plot of summed chlorinated and aromatic VOCs for upgradient well GW-145 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 15a. Plot of TOC values for downgradient well GW-142 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 16a. Plot of TOC values for downgradient well GW-144 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 16b. Plot of summed chlorinated and aromatic VOCs for downgradient well GW-144 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 17a. Plot of TOC values for downgradient well GW-231 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 17b. Plot of summed chlorinated and aromatic VOCs for downgradient well GW-231 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 18. Statistical summary of TOX data for groundwater monitoring wells at the Kerr Hollow Quarry. Box outlines represent the 25th percentile (bottom of box), median (middle line terminated with asterisks), and 75th percentile (top of box) of the data set for a individual well. Mean is indicated by central plus sign (+) within the box. Central lines or tails extending above and below the box indicate the range of outliers within 1.5 interquartile ranges below the 25th percentile and above the 75th percentile. Outliers beyond this range are illustrated by zero (0) if they are within 3 interquartile ranges. More extreme outliers are illustrated by an asterisk (*). Because of scale, some boxes appear incomplete.

Figure 19a. Plot of TOX values for upgradient well GW-145 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 19b. Plot of summed chlorinated VOCs for upgradient well GW-145 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 20a. Plot of TOX values for downgradient well GW-142 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 20b. Plot of summed chlorinated VOCs for downgradient well GW-142 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 21a. Plot of TOX values for downgradient well GW-144 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 21b. Plot of summed chlorinated VOCs for downgradient well GW-144 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 22a. Plot of TOX values for downgradient well GW-231 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 22b. Plot of summed chlorinated VOCs for downgradient well GW-231 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

TENNESSEE DEPARTMENT OF CONSERVATION

Customs House
701 Broadway
Nashville, TN 37243

January 9, 1992

Mr. Jeff Bostock
Y-12 Plant Manager
Martin Marietta Systems, Inc.
P. O. Box 2009
Oak Ridge, TN 37831-8010

RE: Approval for "False-Positive Demonstration for Chestnut Ridge Sediment Disposal Basin and Kerr Hollow Quarry"
Y-12 Plant
Oak Ridge, Tennessee
TND 89-009-0001

Dear Mr. Bostock:

Your addendum to the "False-Positive Demonstration for Kerr Hollow Quarry and Chestnut Ridge Sediment Disposal Basin" has been received by the Division of Solid Waste Management. Your False-Positive Demonstrations have been approved by the Division.

If you have any questions concerning this letter please do not hesitate to contact me at (615) 741-3424.

Sincerely,

A handwritten signature in dark ink, appearing to read "Chris Lagan", with a stylized flourish extending to the right.

Chris Lagan
Division of Solid Waste Management

CL/F5112008

cc: Mr. James Kutzman, EPA Region IV, Atlanta
Leo Romanowski, EPA Region IV, RCRA Federal Facilities
Dave Hopkins, EPA Region IV, Federal Facilities
Earl Loring, DSW, Knoxville Field Office
Gary Bodenstein, U.S. DOE
Wayne McMahon, NCES, Y-12
Tom Perry, NCES
Bob Sleeman, U.S. DOE
Leland Willis, NCES
William Kriepin, DSW, Nashville

APPENDIX D

Y-12 GROUNDWATER COMPLIANCE MEETING

Y-12 GROUNDWATER COMPLIANCE MEETING

<u>Name</u>	<u>Organization</u>	<u>Phone</u>
L. Wayne McMahon	Y-12 EMD	574-7535
Bill Krispin	SWM	741-3424
Brian Dementia	Y-12 site Office	576-9254
Lori Munkeboe	SWM	741-3424
Sherry Lankford	DOE-Y-12-OR	576-9559
Helen L. King	Y-12 EMD	574-7536
Earl Leming	TDEC	594-6035
Jacqueline Okoreeh-Baceh	TDEC	741-3424
Gary Bodenstein	DOE	579-9429 (8984)
Terre Mercier	H&R	481-5208

APPENDIX E

**ALTERNATIVE TEST FOR
CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN**

CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN GROUNDWATER DATA ANALYSIS

S. E. Stinnette
M. W. Sherrill

Historical data from one up-gradient well (GW-159) and three down-gradient wells (GW-155, GW-156, and GW-157) at the Chestnut Ridge Sediment Disposal Basin have been statistically analyzed. The analyses were performed to compare levels of constituents from up-gradient and down-gradient wells and to attempt to establish some sort of limit for each constituent in order to evaluate future data at the site. The data consisted of measurements taken approximately quarterly from the wells over the time period of February 1986 to February 1991. The eight constituents whose data were statistically analyzed were barium, cadmium, chromium, mercury, lead, nickel, silver, and uranium.

Statistical tests were performed for barium, lead, and uranium data in order to see if the data from the up-gradient well came from the same distribution as the data from the down-gradient wells. Results indicated that differences were detected between the up-gradient well's distribution and the down-gradient wells' distributions for barium and for uranium, while no such differences were detected for lead.

Similar tests on the distributions of up- and down-gradient wells were not possible for the data from the remaining five constituents (cadmium, chromium, mercury, nickel, or silver) because most of these results were "non-detects." No statistical differences in proportions of "non-detects" were detected between the up-gradient well and the down-gradient wells for any of these five elements. A copy of the data is presented in the attached Appendix.

GENERAL APPROACH

The first goal was to determine if there was a statistically significant difference between the levels of the constituents at the up-gradient well vs. the down-gradient wells. Depending on the results from this test, an attempt was made to statistically determine a single upper limit from the historical data, against which future data could be compared.

The approach to the statistical analyses followed the general guidelines as suggested in the February 1989 document, PB89-151047 (STATISTICAL ANALYSIS OF GROUND-WATER MONITORING DATA AT RCRA FACILITIES - INTERIM FINAL GUIDANCE), published by the Office of Solid Waste, Waste Management Division of the U.S. Environmental Protection Agency. This document does not give specified rules to follow in analyzing data but makes suggestions on several different statistical techniques that are valid when certain conditions hold.

The first step was to plot the constituents in the time-ordered sequence. These plots usually gave a strong indication as to whether or not the data were normally distributed, a requirement for parametric-type statistical testing. Two formal statistical tests were performed to check the data's normality: (1) either the Shapiro-Wilk test or the Kolmogorov test (depending on

the total sample size) from the UNIVARIATE procedure of the SAS software, and (2) a Chi-Square Goodness of Fit test from the CAPABILITY procedure of the SAS software. The options to produce histograms from the CAPABILITY procedure were exercised as well with the fitted normal curve overlayed on the histogram. Other important qualities of the data that were examined were the percentage of nondetects (ND) found in the data and the possibility of the data containing extreme values or outliers.

After performing these basic checks on the data, the next step was to determine which kind of statistical test was valid for the comparison of up-gradient vs. down-gradient wells. In general data following the normal distribution could be tested using a parametric test, while data following some non-normal distribution would require a non-parametric test. Constituents with greater than or equal to 50 percent of the values as NDs would require a test of proportions, where the percentage of NDs for the up-gradient well was compared to the percentage of NDs for the down-gradient wells.

A detailed discussion of the data analysis on each of the eight constituents follows.

DETAILS

1. Barium Content. A plot of the barium data and its associated histogram with an overlayed normal distribution can be found in the attached Figures 1 and 2, respectively. All tests of normality resulted in the conclusion that the data as a whole were not normally distributed. A log-transformation was performed on the data, but this did not change the conclusion of non-normality for the entire set of barium data. However, when looking at the data from the up-gradient well by itself, the log-transformation resulted in a set of data that was normally distributed; none of the down-gradient wells' transformed data were normally distributed. Also the percentage of non-detectable values was small (8.1 percent), as seen in the attached Table 1. PB89-151047 suggested changing the value of the NDs to one-half the detection limit and checking the distribution when such a low percentage of data points were NDs (the ND/2 method). However, this too failed to produce normal data as a whole or by individual wells. Consequently, to make a comparison between the up-gradient and down-gradient wells, the non-parametric Kruskal-Wallis test was performed.

This non-parametric test performed at the overall 95 percent confidence level, indicated that there was a statistical difference between the up-gradient well and each of the down-gradient wells. Of particular interest was the fact that one down-gradient well (GW-155) was judged to have significantly lower barium content than the up-gradient well (GW-159). The other two down-gradient wells (GW-156 and GW-157) were judged to have significantly higher barium than the up-gradient well.

After these results, the question arose as to establishing a limit against which future data points could be compared. Since the data as a whole were not normally distributed, the possibility of using a non-parametric tolerance interval was considered. However, a sample size of at least 59 data points is required in order to establish a one-sided tolerance limit with 95 percent confidence and 95 percent inclusion. This would require grouping all of the barium data together. Since there were significant differences between the wells, grouping the data was not valid. Since the data from the

up-gradient well was normally distributed after performing the log-transformation, it was possible to compute an upper tolerance limit from the log-transformed, up-gradient well's data. After retransforming this value to its original form, the tolerance limit and its associated statistical statement was as follows: **One is 95 percent confident that at least 95 percent of the barium values should fall below 0.2207 mg/l.** This limit should be used as a limit for future data points. Any future values that are larger than 0.2207 mg/l should give evidence that the new barium data are significantly different from the up-gradient well's barium data and that the site may be responsible for contributing barium to the groundwater.

2. **Cadmium (ICP) Content.** A plot of the cadmium data and its associated histogram with an overlaid normal distribution can be found in the attached Figures 3 and 4, respectively. All tests of normality resulted in the conclusion that the data as a whole and by well were not normally distributed. As seen from the attached Table 2, there was a very high percentage of NDs (84.9 percent overall). Based on the recommendation from PB89-151047, a statistical "test of proportions" was made in order to compare the percentage of NDs from the up-gradient well with the percentage of NDs from the down-gradient wells, both as a whole and by individual wells. Individual well comparisons were made at the 99 percent confidence level so as to ensure an overall 95 percent confidence level.

Results of these tests indicated that there was no significant difference between the up-gradient well and the collection of down-gradient wells, nor was there a statistical difference detected between the up-gradient well and any of the individual down-gradient wells. Since no statistical differences existed between the wells, all data were combined and a one-sided non-parametric upper tolerance limit was computed for the cadmium data. The recommended single point value to be used as a comparison to future data is 0.0061 mg/l. **That is, one is 95 percent confident that at least 95 percent of the cadmium values should fall below 0.0061 mg/l.**

3. **Chromium (ICP) Content.** The chromium data fit in the same category as the cadmium data (see section 2 above). The attached Figures 5 and 6 show the plot and non-normal distribution of the data, while the attached Table 3 indicates that 72.1 percent of the chromium data were NDs. Tests of proportions were performed indicating no significant differences between the up-gradient and down-gradient wells (as a whole or individually). Consequently an upper non-parametric tolerance limit was computed resulting in the single point value of 0.038 mg/l to be used as a comparison against future observations. **That is, one is 95 percent confident that at least 95 percent of the chromium values should fall below 0.038 mg/l.**

4. **Mercury Content.** The mercury data fit in the same category as the cadmium and chromium data (see sections 2 and 3 above). The attached Figures 7 and 8 show the plot and non-normal distribution of the data, while the attached Table 4 indicates that 96.4 percent of the mercury data were NDs. Tests of proportions were performed indicating no significant differences between the up-gradient and down-gradient wells (as a whole or individually). Therefore, an upper non-parametric tolerance limit was computed resulting in the single point value of 0.0004 mg/l to be used as a comparison against future mercury data. **That is, one is 95 percent confident that at least 95 percent of the mercury data should fall below 0.0004 mg/l.**

5. Lead Content. The lead data were somewhat similar to the barium data (see section 1 above) in that there were some NDs in the data but not nearly enough to use a test of proportions on the data in order to compare up-gradient and down-gradient wells. The attached Figures 9 and 10 show the data in time order and also show that the data are not normally distributed. The attached Table 5 indicates that there were 24.1 percent NDs in the data, not enough to use the test of proportions (at least 50 percent needed) and too much to use the ND/2 method (less than 15 percent needed). The recommendation from PB89-151047 of performing a non-parametric Analysis of Variance test on the data was done.

The non-parametric Kruskal-Wallis test for the lead data resulted in the conclusion that there was no significant difference between the up-gradient and down-gradient wells, both as a whole and individually. Again, an overall level of 95 percent confidence was upheld by performing individual well comparisons at the 99 percent confidence level. Since no differences were detected, all data were combined in order to calculate a non-parametric upper tolerance limit. The resulting value of 0.190 mg/l should be used as a limit against which future lead values should be compared. **That is, one is 95 percent confident that at least 95 percent of the lead data should fall below 0.190 mg/l.**

6. Nickel Content. The nickel data fit in the same category as the cadmium, chromium, and mercury data (see sections 2 through 4 above) in that a high percentage of the data were NDs. The attached Figures 11 and 12 show the plot and non-normal distribution of the data, while the attached Table 6 indicates that 81.4 percent of the nickel data were NDs. Tests of proportions were performed indicating no significant differences between the up-gradient and down-gradient wells as a whole or individually. Therefore, an upper non-parametric tolerance limit was computed resulting in the single point value of 0.076 mg/l to be used as a comparison against future nickel data. **That is, one is 95 percent confident that at least 95 percent of the nickel data should fall below 0.076 mg/l.**

7. Silver Content. The silver data fit in the same category as the cadmium, chromium, mercury, and nickel data (see sections 2 through 4, and 6 above) in that a high percentage of the data were NDs. The attached Figures 13 and 14 show the plot and non-normal distribution of the data while the attached Table 7 shows that 96.5 percent of the silver values were NDs. Tests of proportions were performed indicating no significant differences between the up-gradient and down-gradient wells as a whole or individually. Consequently an upper non-parametric tolerance limit was computed resulting in the single point value of 0.045 mg/l to be used as a comparison against future silver data. **That is, one is 95 percent confident that at least 95 percent of the silver data should fall below 0.045 mg/l.**

8. Uranium Content. The uranium data were similar to the lead data (see section 5 above) in that there were some NDs in the data but not nearly enough to use a test of proportions on the data in order to compare up-gradient and down-gradient wells. The attached Figures 15 and 16 show the data in time order and that the data are not normally

distributed. The attached Table 8 shows that there were 35.0 percent NDs in the data, not enough to use the test of proportion and too much to use the ND/2 method as noted in Chapter 8 of PB89-151047. The recommendation from this publication of performing a non-parametric Analysis of Variance test on the data was followed.

The non-parametric Kruskal-Wallis test for the uranium data resulted in the conclusion that there was a significant difference between the up-gradient and down-gradient wells, both for all down-gradient wells collectively and for individual comparisons between the up-gradient and down-gradient wells. In fact, down-gradient wells GW-155 and GW-157 were judged to have significantly lower uranium content than the up-gradient well (down-gradient well GW-156 was judged to have significantly higher uranium content than the up-gradient well). Again, an overall level of 95 percent confidence was upheld by performing individual well comparisons at the 99 percent confidence level.

Since differences between the wells were detected, it was not appropriate to combine all data in order to calculate a non-parametric upper tolerance limit. The log-transformation did not convert the data into a normal distribution either (as a whole or by wells). The range of data was from <0.001 to 0.009 mg/l. A possible limit to be used against future uranium data might be the maximum observed value from this historical data set, 0.009 mg/l. However, based on the plot of the data (see Figure 15), it is obvious that the data are highly variable and that a future uranium concentration of greater than 0.009 mg/l would not be surprising.

Table 1 - Percentage of Non-Detects for BARIUM

WELL	# NON-DETECTS	# DETECTS	TOTAL #
GW-159	2 (8.7 %)	21 (91.3 %)	23
GW-155	2 (8.7 %)	21 (91.3 %)	23
GW-156	2 (10.0 %)	18 (90.0 %)	20
GW-157	1 (5.0 %)	19 (95.0 %)	20
ALL DATA	7 (8.1 %)	79 (91.9 %)	86

Table 2 - Percentage of Non-Detects for CADMIUM

WELL	# NON-DETECTS	# DETECTS	TOTAL #
GW-159	18 (78.3 %)	5 (21.7 %)	23
GW-155	19 (82.6 %)	4 (17.4 %)	23
GW-156	17 (85.0 %)	3 (15.0 %)	20
GW-157	19 (95.0 %)	1 (5.0 %)	20
ALL DATA	73 (84.9 %)	13 (15.1 %)	86

Table 3 - Percentage of Non-Detects for CHROMIUM

WELL	# NON-DETECTS	# DETECTS	TOTAL #
GW-159	18 (78.3 %)	5 (21.7 %)	23
GW-155	19 (82.6 %)	4 (17.4 %)	23
GW-156	9 (45.0 %)	11 (55.0 %)	20
GW-157	16 (80.0 %)	4 (20.0 %)	20
ALL DATA	62 (72.1 %)	24 (27.9 %)	86

Table 4 - Percentage of Non-Detects for MERCURY

WELL	# NON-DETECTS	# DETECTS	TOTAL #
GW-159	22 (100.0 %)	0 (0.0 %)	22
GW-155	21 (95.5 %)	1 (4.5 %)	22
GW-156	17 (89.5 %)	2 (10.5 %)	19
GW-157	20 (100.0 %)	0 (0.0 %)	20
ALL DATA	80 (96.4 %)	3 (3.6 %)	83

Table 5 - Percentage of Non-Detects for LEAD

WELL	# NON-DETECTS	# DETECTS	TOTAL #
GW-159	8 (36.4 %)	14 (63.6 %)	22
GW-155	7 (31.8 %)	15 (68.2 %)	22
GW-156	4 (21.1 %)	15 (78.9 %)	19
GW-157	1 (5.0 %)	19 (95.0 %)	20
ALL DATA	20 (24.1 %)	63 (75.9 %)	83

Table 6 - Percentage of Non-Detects for NICKEL

WELL	# NON-DETECTS	# DETECTS	TOTAL #
GW-159	19 (82.6 %)	4 (17.4 %)	23
GW-155	21 (91.3 %)	2 (8.7 %)	23
GW-156	14 (70.0 %)	6 (30.0 %)	20
GW-157	16 (80.0 %)	4 (20.0 %)	20
ALL DATA	70 (81.4 %)	16 (18.6 %)	86

Table 7 - Percentage of Non-Detects for SILVER

WELL	# NON-DETECTS	# DETECTS	TOTAL #
GW-159	23 (100.0 %)	0 (0.0 %)	23
GW-155	23 (100.0 %)	0 (0.0 %)	23
GW-156	20 (100.0 %)	0 (0.0 %)	20
GW-157	17 (85.0 %)	3 (15.0 %)	20
ALL DATA	83 (96.5 %)	3 (3.5 %)	86

Table 8 - Percentage of Non-Detects for URANIUM

WELL	# NON-DETECTS	# DETECTS	TOTAL #
GW-159	6 (28.6 %)	15 (71.4 %)	21
GW-155	14 (66.7 %)	7 (33.3 %)	21
GW-156	1 (5.6 %)	17 (94.4 %)	18
GW-157	7 (35.0 %)	13 (65.0 %)	20
ALL DATA	28 (35.0 %)	52 (65.0 %)	80

Chestnut Ridge Sediment Disposal Basin – Barium

Curve: — Normal (Mu=0.0406 Sigma=0.0841)

FIGURE 2

Chestnut Ridge Sediment Disposal Basin

Up-Gradient vs. Down-Gradient Wells

Constituent Analyzed: Cadmium

Chestnut Ridge Sediment Disposal Basin – Cadmium

FIGURE 4

Chestnut Ridge Sediment Disposal Basin

Up-Gradient vs. Down-Gradient Wells

Constituent Analyzed: Chromium

Date of Sample

LOCATION * * * DOWN-GRADIENT * * * UP-GRADIENT

Chestnut Ridge Sediment Disposal Basin – Chromium

Curves: — Normal ($\mu=0.0126$ $\sigma=0.006$)

Chestnut Ridge Sediment Disposal Basin

Up-Gradient vs. Down-Gradient Wells

Constituent Analyzed: Mercury

Date of Sample

LOCATION + + + DOWN-GRADIENT □ □ □ UP-GRADIENT

Chestnut Ridge Sediment Disposal Basin – Mercury

Curve: — Normal ($\mu=0.0002$ $\sigma=326E-7$)

Chestnut Ridge Sediment Disposal Basin

Up-Gradient vs. Down-Gradient Wells

Constituent Analyzed: Lead

DATE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
0.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date of Sample

LOCATION + + + DOWN-GRADIENT □ □ □ UP-GRADIENT

Chestnut Ridge Sediment Disposal Basin - Lead

Curve: — Normal (Mu=0.0218 Sigma=0.0372)

FIGURE 10

Chestnut Ridge Sediment Disposal Basin

Up-Gradient vs. Down-Gradient Wells

Constituent Analyzed: Nickel

Date of Sample

LOCATION	+	+	+	DOWN-GRADIENT	UP-GRADIENT

FIGURE 11.

Chestnut Ridge Sediment Disposal Basin – Nickel

Curve: — Normal ($\mu=0.0154$ $\sigma=0.0126$)

Chestnut Ridge Sediment Disposal Basin

Up-Gradient vs. Down-Gradient Wells

Constituent Analyzed: Silver

LOCATION + + + DOWN-GRADIENT □ □ □ UP-GRADIENT

Chestnut Ridge Sediment Disposal Basin – Silver

Curve: — Normal($\mu=0.007$ $\sigma=0.0048$)

Chestnut Ridge Sediment Disposal Basin

Up-Gradient vs. Down-Gradient Wells

Constituent Analyzed: Uranium

Date of Sample

LOCATION + + + DOWN-GRADIENT □ □ □ UP-GRADIENT

APPENDIX

CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN

WELL IDENTITY	LOCATION	DATE SAMPLED	BARIUM ICAP (MG/L)	CADMIUM ICAP (MG/L)	CADMIUM AAS (MG/L)	CHROMIUM ICAP (MG/L)	CHROMIUM AAS (MG/L)	MERCURY CVAA (MG/L)	LEAD AAS (MG/L)	NICKEL ICAP (MG/L)	SILVER ICAP (MG/L)	URANIUM FLUORIMETRIC (MG/L)
GW-159	UPGRADIENT	.	0.017	<0.003	.	<0.01	.	.	.	<0.01	<0.006	.
		02/19/86	0.019	<0.003	.	0.031	.	<0.0002	0.013	<0.01	<0.006	<0.001
		04/22/86	0.0027	<0.003	.	<0.01	.	<0.0002	0.007	<0.01	<0.006	0.006
		08/19/86	0.0049	<0.003	.	<0.01	.	<0.0002	<0.004	<0.01	<0.006	0.002
		12/05/86	0.015	<0.003	.	0.019	.	<0.0002	<0.004	<0.01	<0.006	0.003
		02/11/87	0.0078	<0.003	.	<0.01	.	<0.0002	0.007	<0.01	<0.006	<0.001
		07/03/87	<0.1	<0.003	.	<0.01	.	<0.0002	<0.004	<0.05	<0.01	0.003
		10/03/87	0.0081	0.0047	.	0.011	.	<0.0002	0.047	0.018	<0.006	0.003
		11/04/87	0.233	<0.005	.	<0.01	.	<0.0002	0.0284	<0.04	<0.01	.
		12/10/87	0.0074	0.0051	.	<0.01	.	<0.0002	0.005	<0.01	<0.006	0.005
		03/23/88	0.0067	<0.003	.	<0.01	.	<0.0002	<0.004	<0.01	<0.006	<0.001
		06/23/88	0.053	<0.003	.	<0.01	.	<0.0002	0.0051	<0.01	<0.006	0.001
		08/23/88	<0.001	0.0041	.	0.025	.	<0.0002	0.065	0.025	<0.006	0.006
		11/01/88	0.013	<0.003	.	<0.01	.	<0.0002	0.0061	<0.01	<0.006	<0.001
		03/03/89	0.015	<0.003	.	<0.01	.	<0.0002	0.0061	<0.01	<0.006	<0.001
		06/23/89	0.021	<0.003	.	<0.01	.	<0.0002	<0.004	<0.01	<0.006	0.002
		08/25/89	0.033	<0.003	.	<0.01	.	<0.0002	0.029	<0.01	<0.006	0.003
		11/13/89	0.02	0.0047	.	<0.01	.	<0.0002	<0.004	<0.01	<0.006	<0.001
		03/09/90	0.025	<0.003	<0.002	<0.01	<0.01	<0.0002	<0.004	<0.01	<0.006	0.003
		06/05/90	0.016	0.0038	<0.002	<0.01	<0.01	<0.0002	0.011	<0.01	<0.006	0.001
		08/10/90	0.022	<0.003	<0.002	<0.01	<0.01	<0.0002	0.01	<0.01	<0.006	0.002
		11/08/90	0.03	<0.003	<0.002	<0.01	<0.01	<0.0002	0.014	0.015	<0.006	0.003
		02/28/91	0.023	<0.003	<0.002	0.015	<0.01	<0.0002	<0.004	0.011	<0.006	0.002
GW-155	DOWNGRADIENT	.	0.014	<0.003	.	<0.01	.	.	.	<0.01	<0.006	.
		02/19/86	0.0051	<0.003	.	0.026	.	<0.0002	0.052	0.031	<0.006	0.002
		05/05/86	0.01	<0.003	.	<0.01	.	<0.0002	0.011	<0.01	<0.006	<0.001
		09/08/86	0.013	<0.003	.	<0.01	.	<0.0002	0.016	<0.01	<0.006	0.002
		12/03/86	0.0075	<0.003	.	0.021	.	<0.0002	0.01	<0.01	<0.006	0.002
		02/10/87	0.0049	<0.003	.	<0.01	.	<0.0002	0.006	<0.01	<0.006	0.002
		07/13/87	0.0089	<0.003	.	<0.01	.	<0.0002	0.018	<0.01	<0.006	<0.001
		10/02/87	0.0038	<0.003	.	<0.01	.	<0.0002	<0.004	<0.01	<0.006	<0.001
		11/04/87	<0.2	<0.005	.	<0.01	.	<0.0002	0.184	<0.04	<0.01	.
		12/10/87	0.33	<0.003	.	<0.01	.	<0.0002	0.015	<0.01	<0.006	0.001
		03/23/88	<0.001	<0.003	.	0.017	.	0.0084	0.19	0.076	<0.006	<0.001
		06/22/88	0.0096	<0.003	.	<0.01	.	<0.0002	0.004	<0.01	<0.006	<0.001
		08/24/88	0.0052	<0.003	.	<0.01	.	<0.0002	<0.004	<0.01	<0.006	0.002
		11/01/88	0.0035	<0.003	.	<0.01	.	<0.0002	0.0047	<0.01	<0.006	<0.001
		03/02/89	0.0076	<0.003	.	0.015	.	<0.0002	<0.004	<0.01	<0.006	<0.001
		06/23/89	0.0096	0.0037	.	<0.01	.	<0.0002	<0.004	<0.01	<0.006	<0.001
		08/25/89	0.0069	0.004	.	<0.01	.	<0.0002	0.034	<0.01	<0.006	0.002
		11/13/89	0.0067	<0.003	.	<0.01	.	<0.0002	<0.004	<0.01	<0.006	<0.001
		03/10/90	0.0073	<0.003	<0.002	<0.01	<0.01	<0.0002	<0.004	<0.01	<0.006	<0.001
		06/06/90	0.0069	0.0031	<0.002	<0.01	0.018	<0.0002	0.005	<0.01	<0.006	<0.001
		08/11/90	0.0063	0.0048	<0.002	<0.01	<0.01	<0.0002	0.013	<0.01	<0.006	<0.001
		11/12/90	0.0071	<0.003	<0.002	<0.01	<0.01	<0.0002	0.004	<0.01	<0.006	<0.001
		02/28/91	0.018	<0.003	<0.002	<0.01	<0.01	<0.0002	<0.004	<0.01	<0.006	<0.001

CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN

WELL IDENTITY	LOCATION	DATE SAMPLED	BARIUM ICAP (MG/L)	CADMIUM ICAP (MG/L)	CADMIUM AAS (MG/L)	CHROMIUM ICAP (MG/L)	CHROMIUM AAS (MG/L)	MERCURY CYAA (MG/L)	LEAD AAS (MG/L)	NICKEL ICAP (MG/L)	SILVER ICAP (MG/L)	URANIUM FLUORIMETRIC (MG/L)
GW-156	DOWNGRADIENT	.	0.029	<0.003	.	0.011	.	.	.	<0.01	<0.006	.
		02/22/86	0.017	<0.003	.	<0.01	.	<0.0002	0.005	<0.01	<0.006	0.005
		04/18/86	0.0066	<0.003	.	<0.01	.	<0.0002	0.004	<0.01	<0.006	0.006
		08/19/86	0.015	<0.003	.	0.012	.	<0.0002	0.004	<0.01	<0.006	0.005
		12/05/86	0.015	<0.003	.	0.012	.	<0.0002	<0.004	<0.01	<0.006	0.009
		02/10/87	0.01	<0.003	.	<0.01	.	<0.0002	0.006	<0.01	<0.006	0.005
		07/03/87	<0.1	<0.003	.	0.038	.	0.0003	0.042	0.056	<0.01	0.008
		10/02/87	0.0078	0.0042	.	0.029	.	<0.0002	0.078	0.041	<0.006	0.004
		11/04/87	<0.2	<0.005	.	0.0154	.	<0.0002	0.0992	<0.04	<0.01	.
		12/10/87	0.54	<0.003	.	0.018	.	<0.0002	0.18	0.034	<0.006	0.006
		03/23/88	0.016	<0.003	.	<0.01	.	<0.0002	0.004	<0.01	<0.006	0.003
		06/22/88	0.064	<0.003	.	0.019	.	0.0004	0.091	0.022	<0.006	0.007
		08/24/88	0.017	<0.003	.	<0.01	.	<0.0002	0.033	<0.01	<0.006	<0.001
		11/01/88	0.024	<0.003	.	<0.01	.	<0.0002	0.036	<0.01	<0.006	0.002
		03/08/89	0.38	<0.003	.	<0.01	.	<0.0002	0.0054	<0.01	<0.006	0.009
		03/10/90	0.03	<0.003	<0.002	0.012	<0.01	<0.0002	<0.004	<0.01	<0.006	0.003
		06/06/90	0.023	0.0046	<0.002	<0.01	<0.01	<0.0002	0.006	<0.01	<0.006	0.003
		08/11/90	0.02	0.0037	<0.002	<0.01	<0.01	<0.0002	<0.004	<0.01	<0.006	0.003
		11/13/90	0.023	<0.003	<0.002	0.011	<0.01	<0.0002	<0.004	0.021	<0.006	0.005
		02/28/91	0.041	<0.003	<0.002	0.027	0.014	<0.0002	0.021	0.03	<0.006	0.004
GW-157	DOWNGRADIENT	.	.	.	.	.	.	.	.	.	.	.
		02/21/86	0.022	<0.003	.	<0.01	.	<0.0002	0.007	<0.01	0.045	0.002
		04/30/86	0.022	<0.003	.	<0.01	.	<0.0002	0.029	<0.01	<0.006	0.002
		08/25/86	0.025	<0.003	.	0.01	.	<0.0002	0.027	0.018	<0.006	0.004
		12/05/86	0.025	<0.003	.	0.026	.	<0.0002	0.008	<0.01	<0.006	0.004
		02/10/87	0.011	<0.003	.	<0.01	.	<0.0002	0.011	<0.01	<0.006	0.001
		07/03/87	<0.1	<0.003	.	<0.01	.	<0.0002	0.006	<0.05	<0.01	0.001
		10/02/87	0.013	<0.003	.	<0.01	.	<0.0002	0.016	<0.01	<0.006	<0.001
		12/10/87	0.059	<0.003	.	0.033	.	<0.0002	0.048	0.035	<0.006	0.005
		03/23/88	0.015	<0.003	.	<0.01	.	<0.0002	0.005	<0.01	<0.006	<0.001
		06/23/88	0.027	<0.003	.	<0.01	.	<0.0002	0.0056	<0.01	<0.006	0.003
		08/24/88	0.015	<0.003	.	<0.01	.	<0.0002	0.0095	<0.01	0.026	0.001
		11/02/88	0.03	<0.003	.	0.013	.	<0.0002	0.026	0.012	<0.006	<0.001
		03/02/89	0.031	<0.003	.	<0.01	.	<0.0002	0.0006	<0.01	<0.006	0.001
		08/28/89	0.015	<0.003	.	<0.01	.	<0.0002	0.0004	0.01	<0.006	<0.001
		11/13/89	0.017	<0.003	.	<0.01	.	<0.0002	<0.004	<0.01	<0.006	<0.001
		03/12/90	0.015	<0.003	<0.002	<0.01	<0.01	<0.0002	0.0041	<0.01	<0.006	0.001
		06/05/90	0.017	0.0061	<0.002	<0.01	<0.01	<0.0002	0.03	<0.01	0.0064	<0.001
		08/10/90	0.021	<0.003	<0.002	<0.01	<0.01	<0.0002	0.017	<0.01	<0.006	0.001
		11/12/90	0.031	<0.003	<0.002	<0.01	<0.01	<0.0002	0.022	<0.01	<0.006	0.002
		02/28/91	0.018	<0.003	<0.002	<0.01	<0.01	<0.0002	0.0057	<0.01	<0.006	<0.001

Chestnut Ridge Sediment Disposal Basin – Uranium

Curve: — Normal ($\mu=0.0025$ $\sigma=0.002$)

FIGURE 16.

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