**ENVIRONMENTAL
RESTORATION
PROGRAM**

**Sampling Results, DNAPL
Monitoring Well GW-790,
Oak Ridge Y-12 Plant,
Oak Ridge, Tennessee,
First-Third Quarter,
FY 1995**

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Energy Systems Environmental Restoration Program

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PREFACE

This document, *Sampling Results, DNAPL Monitoring Well GW-790, First through Third Quarter, FY 1995, was performed under Work Breakdown Structure 1.4.12.1.1.02 (Activity Data Sheet 2312, "Bear Creek Valley")*. This document provides the Environmental Restoration Program (ER) with groundwater concentrations for nonradionuclides in the vicinity of the Oak Ridge Y-12 Plant Burial Grounds. This data can be used to determine reference concentrations for intermediate and deep groundwater systems.

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EXECUTIVE SUMMARY

In January 1990, dense, non aqueous phase liquids (DNAPLs) were discovered at a depth of approximately 274 ft. below ground surface along the southern border of the Y-12 Plant Burial Grounds. Immediately after the discovery, an investigation was conducted to assess the occurrence of DNAPL at the site and to make recommendations for further action. Results of the preliminary DNAPL investigation are presented in detail in Haase and King (1990a), and a work plan for assessment and characterization of the DNAPL is presented in Haase and King (1990b). A major task in the work plan calls for the construction and installation of five multiport wells. This report summarizes purging and sampling activities for one of these multiport wells, GW-790, and presents analytical results for GW-790.

To date, each of the eleven sampling zones in GW-790 has been sampled for VOCs, metals and anions. Based on the presence of very low levels of benzene within the middle Nolichucky Shale and the presence of very low levels of TCE in the Maynardville Limestone, it is recommended that VOC monitoring of GW-790 be continued; particularly because TCE is detected in the Maynardville Limestone upgradient from this location. Additional data is required in order to statistically confirm the presence or absence of VOCs through the use of "J" qualifiers. Zones 2, 5, 7 and 10 will be resampled in order to confirm or disprove the presence of nitrate in the deeper portions of the borehole. Purging activities will continue for zones 2, 5, 7, 10, and 14 to be followed by a second round of sampling. A comparison of the two sets of sampling results will be used to determine the need for a third round of purging. Any additional sampling from zones at the top of the well will be conducted without further purging, unless there is corroborative evidence that the water sample is not representative of the formation. There is a concern that excessive or unnecessary purging of fractured units with low storativity, such as those in GW-790, will mobilize and extend the contaminant plume.

Ongoing and future tasks are directed toward collecting data that will provide information about: (1) the presence or absence of DNAPL or dissolved phase DNAPL and (2) the nature of the groundwater system so that the potential mobility of the dissolved phase plume can be evaluated. With this information we will be prepared to address concerns about the current extent of the contamination, the potential for continued spread of the contamination, and the need, if any, for implementing a remediation strategy.

LIST OF ACRONYMS AND ABBREVIATIONS

cps	counts per second
DNAPL	Dense Non Aqueous Phase Liquid
GC/MS	Gas Chromatography / Mass Spectroscopy
ICP	Inductively Coupled Plasma (spectroscopy)
IC	Ion Chromatography
MCL	Maximum Contaminant level
mg/L	milligrams per liter
MP	Multiport
ND	Not Detected
OD	Outer Diameter
psi	pounds per square inch
PCE	Tetrachloroethene
TCE	Trichloroethene
TD	Total Depth
TDS	Total Dissolved Solids
VOC	Volatile Organic Compounds
mg/L	micrograms per liter

1.0 INTRODUCTION

1.1 BACKGROUND AND PURPOSE

In January 1990, dense, non aqueous phase liquids (DNAPLs) were discovered at a depth of approximately 274 ft. below ground surface along the southern border of the Y-12 Plant Burial Grounds. Immediately after the discovery, an investigation was conducted to assess the occurrence of DNAPL at the site and to make recommendations for further action. To date, free-phase DNAPL contamination has been encountered in GW-625 (the discovery well), and is suspected to occur in GW-628 and GW-629 (Fig. 1) (Haase and King, 1990a). In addition, groundwater from GW-117 (Fig. 1) shows levels of volatile organic compounds suggestive of a dissolved contaminant plume. Results of the preliminary DNAPL investigation are presented in detail in Haase and King (1990a), and a work plan for assessment and characterization of the DNAPL is presented in Haase and King (1990b). A major task in the work plan calls for the construction and installation of five multiport wells. These wells (GW-726, GW-727, GW-729, GW-730, GW-730 and GW-790) were constructed and instrumented with multiport components from August, 1991 to April, 1993 (Dreier and Caldanaro, 1994). Subsequently, purging and sampling activities were started in each well. This report summarizes purging and sampling activities for GW-790 and presents analytical results for GW-790.

The purpose of the multiport wells is two-fold and addresses specific recommendations made by an independent consultant and previous work (Keuper 1990; Haase and King 1990b):

- 1) Define the deep and intermediate groundwater flow system within the Bear Creek Burial Ground and contiguous areas. Place special emphasis on defining and characterizing major conductive zones through which most of the groundwater flow may be occurring or through which DNAPL migration may have occurred.
- 2) Track the dissolved plume from outside inward. With an understanding of the groundwater flow system, determine a nondetect envelope within which all DNAPL and dissolved DNAPL contamination exists. As such, the wells are intended to serve as an early warning system for dissolved plume migration.

Fig. 1. Y-12 Burial Grounds location map. Dark circles are wells with known DNAPL accumulation or are wells that intercept secondary groundwater contaminant plumes. Black squares are the five multiport DNAPL investigation wells. GW-790 is highlighted. Estimated locations of geologic contacts are shown.

If future technological development provides a feasible method to remove DNAPLs, then data from the multiport wells will provide general knowledge of the DNAPL location. Additionally, the information developed will be necessary to evaluate the effectiveness of the remediation technology (Haase and King, 1990b).

1.2 BOREHOLE INFORMATION

The locations of the five multiport wells (GW-726, GW-727, GW-790, GW-729 and GW-730) are shown in Fig. 1. The rationale for well placement is given in Haase and King (1990b) and Dreier and Caldanaro (1994). Well GW-790 is located down dip from the discovery of free-phase DNAPL and downdip from localities where secondary groundwater contaminant plumes associated with DNAPL accumulations have been intercepted by other groundwater monitoring wells. Construction logs for GW-790 are presented in Science Applications International Corporation report, 1993, and the reader is referred to that report for a detailed construction history of the well. Condensed well construction information is presented in Table 1.

1.3 MULTIPORT WELL DESCRIPTION

The DNAPL investigation multiport wells use components designed by Westbay Instruments Inc. This system isolates zones of interest from each other by a series of packers fitted about a 1.5 in. diameter PVC (MP) casing (Fig. 2) that acts as an inner standpipe. Within specified sampling zones, fluid pressure data and water samples are collected using specialized probes that are lowered down the inner standpipe to the zones of interest. The probes access the zone through a measurement port coupling in the MP casing. Each sampling zone also contain a pumping port, which is used exclusively for purging. Because the packers isolate each sampling zone from the atmosphere, it is not necessary to purge before each sampling event. Purging is only needed to remove fluids that may have been introduced into the zone during drilling and installation operations.

The sampling zones are isolated from each other by one to two additional zones, called QA zones, containing measurement ports, from which only fluid pressure data are collected (Fig. 2). The zones provide added assurance that the sampling zones are isolated from each other. Although, it is possible to obtain water samples from these zones, the zones do not contain pumping ports and it is not possible to purge these intervals. Thus these zones have limited value for characterizing water chemistry.

Table 1. GW-790 construction and well design information

BOREHOLE CONSTRUCTION					
Surface Casing (ft bgs)		212.5**			
Total Depth (ft bgs)		1040.3			
SURVEY COORDINATES			ELEVATIONS (ft amsl)		
Grid System	Y-12	Ground surface	909.7		
Northing	28676	Top of concrete pad	NA		
Easting	43041.1	Top of steel casing	911.67		
		Top of MP casing	911.51		
MULTIPOINT DESIGN					
COMPLETION ZONE		MEASUREMENT PORT			PUMPING PORT
Zone Number	Interval depth bgs (ft)	Port depth bgs (ft)	True Port depth from TOMP (ft)	Elevation (amsl) (ft)	Port depth bgs (ft)
1	1036-1041	1036	1035.7	-124.2	
2	1021-1031	1026	1025.7	-114.2	1031
3	1006-1016	1006	1005.7	-94.2	
4	982-1001	982	982.7	-71.2	
5	967-977	972	972.7	-61.2	977
6	947-962	947	947.7	-36.2	
7	932-942	937	937.7	-26.2	942
8	912-927	912	912.7	-1.2	
9	885-907	885	885.7	25.8	
10	870-880	875	875.7	35.8	880
11	850-865	850	850.7	60.8	
12	830-845	830	830.7	80.8	
13	808-825	808	808.7	102.8	
14	793-803	798	798.7	112.8	803
15	768-788	768	768.7	142.8	
16	743-763	743	743.7	167.8	
17	713-738	723	723.7	187.8	
18	703-708	703	703.7	207.8	
19	676-698	686	686.7	224.8	698
20	656-671	656	656.8	254.8	
21	631-651	631	631.8	279.7	
22	596-626	596	596.8	314.7	
23	576-591	586	586.8	324.7	591
NOTE: all depths except for "true depth bgs" are measured along the borehole with no correction for borehole deviation.					
NOTE: samples are only collected from those zones with both measurement and pumping ports, which are marked in bold.					
NOTE: Only depths and not elevations are provided for the pumping ports because samples are not collected from these ports. Samples are collected from measurement ports.					
* MP = Westbay Multipoint Casing, ags = above ground surface.					
* bgs = below ground surface, amsl = above mean sea level.					
*TOMP = Top of MP casing					
** casing is grouted to 40.0' rather than 212.5 ft.					

Table 1. cont.

MULTIPOINT DESIGN					
COMPLETION ZONE		MEASUREMENT PORT			PUMPING PORT
Zone Number	Interval depth bgs (ft)	Port depth bgs (ft)	True Port depth from TOMP (ft)	Elevation (amsl) (ft)	Port depth bgs (ft)
24	546-571	546	546.86	364.65	
25	516-541	516	516.89	394.62	
26	486-511	486	486.91	424.60	
27	461-481	461	461.92	449.59	
28	437-456	437	437.93	473.58	
29	422-432	427	427.94	483.57	432
30	392-417	392	392.95	518.56	
31	358-387	358	359.96	551.55	
32	343-353	348	349.96	561.55	353
33	318-338	318	319.97	591.54	
34	292-313	292	293.97	617.54	
35	277-287	282	283.98	627.53	287
36	260-272	260	261.98	649.53	
37	235-255	235	236.99	674.52	
38	220-230	220	221.99	689.52	
39	198-215	203	204.99	706.52	215

NOTE: all depths except for "true depth bgs" are measured along the borehole with no correction for borehole deviation.

NOTE: samples are only collected from those zones with both measurement and pumping ports, which are marked in bold.

NOTE: Only depths and not elevations are provided for the pumping ports because samples are not collected from these ports. Samples are collected from measurement ports.

* MP = Westbay Multiport Casing, ags = above ground surface.

* bgs = below ground surface, amsl = above mean sea level.

*TOMP = Top of MP casing

** casing is grouted to 40.0' rather than 212.5 ft.

Figure 2. Generalized multiport well design.

1.4 GW-790 SAMPLING ZONES

The multiport completion design for GW-790 is shown in Table 1. On the basis of core samples, geophysical logs and flowmeter results, 11 sampling zones, 10-to-22 ft. long, were selected from GW-790. The reader is referred to Dreier and Caldanaro (1994) for a more detailed description of the technical rationale and component design for each of the DNAPL investigation wells. Table 2 specifically lists criteria for choosing sampling zones and is taken verbatim from Dreier and Caldanaro (1994). The installation history for GW-790 is documented in Westbay Instruments Inc. (1993).

The zones were chosen to sample at least one of the following features, in order of priority. (1) fluids from potential zones of DNAPL migration, (2) fluids from hydraulically conductive fractures or fracture zones, (3) potential changes in fluid chemistry with depth, (4) fluids that show water chemistry signatures associated with a particular rock type, (5) fluids that may show water chemistry correlations between wells, and (6) matrix fluids with long residence times. In general, criteria 3, 4 and 5 can be achieved by having a relatively regular vertical distribution of sampling zones. The spacing between most zones is less than 100 ft, and spacing less than 80 ft is common in potential DNAPL regions.

The stratigraphic positions of the eleven sampling zones in GW-790 are shown in Fig. 3. A zone of potential DNAPL migration, shown as a broad shaded portion, (Dreier and Caldanaro, 1994) was identified before the well was instrumented with Westbay components and is based on stratigraphic correlation with GW-625, GW-628, GW-629 and GW-117. This zone is the oolitic-rich limestone interval that defines the base of the middle Nolichucky Shale (Hatcher et.al, 1992) and is sampled by zones 7 and 10. In addition, two more zones were installed in the underlying strata in order to investigate the potential for migration of DNAPL into the lower Nolichucky Shale.

Table 2. Sampling zones for GW-790^a

Multiport zone ^b	Depth (ft.) ^{c,d}	Samp. port depth (ft.) ^{c,d}	Purpose	Logs/Core
39	40-215 (40-213)	203 (203)	Sample karst feature for Exit Pathway program	core: Cave 200.7-211.6 logs: No fractures identified. stratigraphy: Maynardville Limestone zone 3/4
35	277-287 (277-287)	282 (282)	Sample karst feature for Exit Pathway program	core: Cavity, 282.3-282.5 logs: Temperature 276-283'; sonic stratigraphy: Maynardville Limestone zone 3/4
32	343-353 (343-353)	348 (348)	Sample fracture	core: Fracture; large euhedral calcite ctystals, 348.9-349.3' logs: Fluid resistivity, 346.5-350.0'; sonic stratigraphy: upper Nolichucky Shale
29	422-432 (421-431)	427 (426)	Sample fracture	core: Granular calcite crystals, 426.8' logs: Temperature, 428.5'; fluid resistivity, 427-430.5'. stratigraphy: upper Nolichucky Shale
23	576-591 (580-590)	586 (585)	Sample potential conductive zone.	core: Broken shale, 583.1-588.1' logs: Fluid resistivity, 5866-589.5'; sonic stratigraphy: middle Nolichucky Shale
19	676-698 (675-690)	687 (686)	Sample potential conductive zone.	core: Shale broken and crumbly 678-679.1, 680.0-681.4', 685.5-585.8' shale extremely soft, broken, crumbly and clayey, water seeps out when pressure applied; broken shale 696.7-697.4 logs: Fluid resistivity, 680-699' -- very pronounced at 684-686.5'; sonic anomaly (but not a depth of fluid resisitivity response) stratigraphy: middle Nolichucky Shale
14	793-803 (792-802)	797 (798)	Sample potential fracture	core: Fracture, small euhedral calcite crystals, 797.1' logs: geophysical logs not available stratigraphy: middle Nolichucky Shale

Table 2 (cont.)

10	870-880 (869-879)	875 (874)	Sample potential zone of DNAPL migration at base of middle Nolichucky Shale.	core: Fracture, coated with white calcite, uneven fit between both fracture surfaces 874.3' logs: geophysical logs not available stratigraphy: base of middle Nolichucky Shale
7	932-942 (931-941)	937 (936)	Sample potential zone of DNAPL migration at base of middle Nolichucky Shale.	core: Fracture coated with smooth and granular calcite. Small pyrite crystals show oxidation, 936.7'. logs: geophysical logs not available stratigraphy: base of middle Nolichucky Shale
5	967-977 (966-976)	972 (971)	Sample potential fracture	core: Fracture, incipient, Fractures, open (broken during drilling, coated with smooth calcite, 971.1'. logs: geophysical logs not available stratigraphy: lower Nolichucky Shale
2	1021-1031 (1019-1031)	1026 (1026)	Sample potential conductive zone.	core: Shale, broken, 1024.5-1027.2' logs: geophysical logs not available stratigraphy: lower Nolichucky Shale

^arepeated verbatim from Dreier and Caldanaro (1994), Table 12.

^bMultiport zone number.

^cDepth measured from ground surface, not corrected for borehole deviation

^dParentheses denote planned depth. Other number is correct downhole depth.

Figure 3. Multiport sampling zones for GW-790. The region marked Potential DNAPL is not meant to imply that DNAPL occurs in this interval at this location. Rather, this zone correlates to the same stratigraphic interval at shallower depths up dip where DNAPL was visually observed and where dissolved phase plumes were identified. The shaded portion above zone 39 represents the true thickness of the sampling zone. Because of difficulties encountered during installation, it was not possible to seat the upper packer of this zone.

2.0 PURGING AND SAMPLING ACTIVITIES

2.1 PURGING

Initial purging of the sample zones in GW-790 began in August, 1994, several months after hydraulic heads had stabilized from multiport installation, and continued through April, 1995 (Table 3). During purging, an appropriate volume of water is extracted from the inner standpipe so that the hydraulic head in the standpipe is lower than the hydraulic head in the sampling zone. This induces water to flow from the formation and annular space through the open purge port into the inner standpipe. Recommended purge volumes are calculated at three times the annular volume of the sampling zone (Table 3). The rate at which this volume is produced is a function of the rock permeability and can vary considerably. In particular, it was found that very low permeability zones could take several months or longer to produce the requisite volumes. Because of this, purging procedures were modified so that sampling activities could fit into a reasonable scheduling framework. At present, each zone is purged for one month or until the recommended volume of water is produced, whichever occurs first. The zone is then sampled. If the zone does not produce enough water during the first round of purging, purging is continued for another month, to be followed by a second round of sampling. Additional purging requirements will be determined on a case-by-case basis, but in general, the removal of one annular volume for very low permeability zones at the base of the borehole may be considered adequate in the future.

Of eleven sampling zones in GW-790, five produced the requisite three annular volumes within a month of purging. These zones (zones 19, 23, 29, 32, 35 and 39) are in the upper portion of the well and may indicate that permeability decreases with increasing depth. In addition, although zone 39 at the top of the well did not produce 3 volumes of water, the relatively low production is not related to low permeability. Rather, this zone is unusually large because of problems encountered during installation (Dreier and Caldanaro, 1994), and the increased thickness was not taken into account in calculating purge volumes. Note (Table 3) that zone 39 easily produced almost 50 gals in one day. The zone includes several karst features (Dreier and Caldanaro, 1994) and should be self-purging because of the large flux of groundwater that is transmitted through cavities. Of the remaining 5 zones at the base of the well, zone 2 produced at least one annular volume. Zones 5, 7, 10 and 15 were open for approximately one month and did not produce one annular volume. However, they did produce approximately between 0.3 and 0.8 annular volumes in one month. Therefore it is anticipated that with one or two more rounds of month-long purging, these zones will be able to produce at least one annular volume.

Table 3. GW-790 purge history

Zone	Packed-off Sampling Zone Height (ft)	Recom. purge volume (gals)*	1st Purge Date Opened	1st Purge Date Closed	Produced purge vol. (gals)	Total no. annular vols.	Difference of actual (-) recom. (gals)
2	11	14	3/7/95	4/10/95	5.3	1.1	-8.6
5	11	14	1/31/95	3/7/95	1.6	0.3	-12.3
7	11	14	12/20/94	1/31/95	1.7	0.4	-12.2
10	11	14	11/23/94	12/20/94	3.8	0.8	-10.1
14	11	14	10/27/94	11/23/94	2.5	0.5	-11.4
19	23	29	9/7/94	10/5/94	30.0	3.1	1.0
23	16	20	10/5/94	10/27/94	24.7	3.7	4.5
29	11	14	9/1/94	9/1/94	30.4	6.6	16.5
32	11	14	8/30/94	9/1/94	23.7	5.1	9.8
35	11	14	8/30/94	8/30/94	30.6	6.6	16.7
39	176	222	8/29/94	8/29/94	47.7	0.6	-174.1
<p>* Zones that require additional purging are shown in bold</p> <p>* PURGE VOLUME CALCULATION:</p> <p>Recommended purge volume = 3 annular volumes</p> <p>3.7" diameter borehole and 1.81" OD MP casing</p> <p>"= 0.42 gal/ft for one annular volume or 1.26 gal/ft for three annular volumes"</p> <p>Zones shown in bold did not produce the requisite three annular volumes of formation water</p>							

2.2 SAMPLING

Samples are collected in two evacuated (under vacuum) stainless steel 250 ml sample bottles that are attached in tandem and threaded to a sampling probe. The sample bottles are lowered to the desired zone and water is extracted through the measurement port valve. All equipment is designed specifically for and dedicated to Westbay type multiport wells. Additional information on Westbay-specific sampling procedures is in the Westbay Operation Manuals, which are available from the authors of this report.

The field sampling protocol is given in Table 4. Initially, each zone is sampled for anions, metals, VOCs and field parameters (pH, specific conductance and temperature). The normal suite of anion analysis includes Cl, F, NO₃, and SO₄. If the specific conductance is greater than 2000 umho/cm, Br is added to the suite since its concentration may be above detection at elevated specific conductance levels. Additional sampling events are based on initial analytical results and are determined at the discretion of the project manager or project technical lead.

Using two sample bottles, a maximum sample volume of 500 ml can be obtained each time bottles are lowered to a port (a sample run) (Table 4). In general, either two or three runs are needed to collect the required sample volume, depending on the desired analysis. Two different protocols are used based on the suspected permeability of the sampling zone. For high to moderate permeability zones, the first run is used to collect field parameters and to rinse the sample bottles with formation water. If both inorganic (major and trace elements) and organic constituents are being sampled, the second run is used for the major and trace inorganic water samples and the third run is used for the VOC sample. VOCs are collected last to maximize the number of sample bottle rinses with formation water.

As of February, 1995, several types of control samples are collected during sampling: (1) A trip blank sample is obtained each time a VOC sample is collected; (2) A field blank is prepared for 10% of the VOC sampling events; (3) A duplicate sample is collected for 10% of all sampling events. (4) An equipment rinsate, consisting of the final DI water rinse from the inside of the sample bottle, is collected for 10% of all sampling events. Zones 2, 5, 7 and 10 were sampled after February 1995, but these samples were not part of the 10% population used for duplicates or equipment rinsates.

Table 4. Sampling and analysis plan.

High to Moderate Permeability								
Sample Run No.	Bottle No.	Parameter	Container Type	Volume (ml)	Filtered	Preservative	EPA Procedure No.	Analytical Method
1	1	pH	N/A	<250	YES	N/A	EPA-150.1	pH meter
1	1	Specific Conductance	N/A	<250	YES	N/A	EPA-120.1	conductivity meter
1	1	Temperature	N/A	<250	YES	N/A	EPA-170.1	thermometer
1	2	rinsate/discard	N/A	N/A	YES	N/A	N/A	N/A
2	1	Metals	Plastic	100	YES	HNO3 (<2pH)	EPA-6010	ICP
2	1	Anions (Br*, Cl, F, NO3, SO4)	Plastic	100	YES	NONE	EPA-300.0	IC
2	2	Alkalinity	Plastic	100	YES	NONE	EPA-310.1	titration
3	1	VOC	Amber/Glass	40X2	NO	NONE	OLMO1.8	GC/MS

Low Permeability**								
Sample Run No.	Bottle No.	Parameter	Container Type	Volume (ml)	Filtered	Preservative	EPA Procedure No.	Analytical Method
1	1	Alkalinity	Plastic	50-100	YES	NONE	done in field OR EPA-310.1	titration
1	1	Anions (Br*, Cl, F, NO3, SO4)	Plastic	100	YES	NONE	EPA-300.0	ICP
1	2	pH	N/A	<250	YES	N/A	EPA-150.1	pH meter
1	2	Specific Conductance	N/A	<250	YES	N/A	EPA-120.1	conductivity meter
1	2	Temperature	N/A	<250	YES	N/A	EPA-170.1	thermometer
2	1	Metals	Plastic	100	YES	HNO3 (<2pH)	EPA-6010	ICP
2	2	VOC	Amber/Glass	40X2	NO	NONE	OLMO1.8	GC/MS

* Br analysis is requested if specific conductance is greater than 2000 umho/cm

**Nitrogen gas used to aid sampling.

•All samples cooled to 4 degrees celsius unless otherwise noted

A common occurrence with sampling low permeability zones is that the O-ring seal is compromised around the measurement port. This can be determined by monitoring the water level in the MP casing. A drop in water level is attributed to water from the MP casing that moves past the O-rings, through the sample probe, and into the sample bottles. The resultant sample is a mixture of water from the annular space and from the MP casing. If this happens, the zone is treated as a "low permeability zone" and both the sampling order and collection method is modified (Table 4). Field parameters will be collected from the first run second (lower) bottle. This bottle will have the least amount of rinsing with formation waters. Alkalinity and anions will be collected from the first run first (upper) bottle. The remainder of the sample will be collected from the second run. As before, VOCs will not be sampled from the first run to assure that the sample bottle is rinsed with formation water. If a O-ring seal is broken during sampling, water collected from the first run, second bottle will be used to re-rinse the bottle.

In low-permeability zones, the seal around the measurement port may be broken because: (1) the zone could not produce enough water to maintain a sufficient fluid pressure; and (2) there is a large pressure differential between the sample bottles, the MP casing water and the formation water. The purpose of the modified sampling collection procedure is to reduce the pressure differential between the sample bottles and the pressure in the MP casing. This is accomplished by pressurizing the sample bottles with inert nitrogen gas between 50 and 110 psi. This pressure is well below the fluid pressure in the MP casing and the formation, yet is sufficient enough to maintain the integrity of the seal around the measurement port valve allowing water to be drawn from the formation. To date, this method has been successful when used in low permeability zones.

The sampling history for GW-790 is given in Table 5. No sampling zones show the low permeability characteristics mentioned above. This is in contrast with results from other multiport monitoring wells in the area (GW-727 and GW-730) where there is an excellent correspondance between the zones that showed sampling difficulties and the zones that did not produce the requisite purge water volumes in four weeks of purging.

Table 5. GW-790 sampling history.

Zone	Date	Parameters	Comments
2	4/23/95	VOC Metals, Anions, Alk. field parameters	Bromide included with Anions
5	4/23/95	VOC Metals, Anions, Alk. field parameters	Bromide included with Anions
7	4/23/95	VOC Metals, Anions, Alk. field parameters	Bromide included with Anions
10	4/23/95	VOC Metals, Anions, Alk. field parameters	Bromide included with Anions
14	12/13/94	VOC Metals, Anions, Alk. field parameters	Bromide included with Anions
19	12/13/94	VOC Metals, Anions, Alk. field parameters	Bromide included with Anions
23	12/14/94	VOC Metals, Anions, Alk. field parameters	
29	12/14/94	VOC Metals, Anions, Alk. field parameters	
32	12/14/94	VOC Metals, Anions, Alk. field parameters	
35	12/14/94	VOC Metals, Anions, Alk. field parameters	Water is very muddy
39	12/14/94	VOC Metals, Anions, Alk. field parameters	Water is very gray

3.0 ANALYTICAL RESULTS

3.1 VOLATILE ORGANIC COMPOUNDS

A sample was collected for VOC analysis for each zone (Table 5). Trip blanks were collected on 12/13/94 and 4/23/95 and their results are listed in Appendix A. No VOCs were detected in the trip blanks (Appendix A). Laboratory blank data are given in Appendix B and show a detect with a "J" qualifier for acetone on 4/25/95. "J" qualifiers indicate that the stated VOC levels are estimated at values that are below the detection limit. In addition, the 4/25/95 laboratory blank sample had a detect for 2-Butanone of 13.0 $\mu\text{g/L}$.

VOC results from the sample zones are presented in Appendix C and a list of 12 VOCs detects is given in Table 6. Ten of the twelve detectable values are flagged with a "J" qualifier and represent low (1.0 - 10.0 $\mu\text{g/L}$) but discernible responses from the analytical instrumentation. Of the 12 VOC detects, 3 corresponded to detects in the lab or trip blanks associated with the sample. The remaining detects with "J" qualifiers include one for styrene in zone 32, benzene is observed in all of the zones below and including zone 23, and trichloroethene (TCE) is observed in zone 35. Based on results from GW-727 (Dreier and Caldanaro in prep), and GW-730 (Dreier and Caldanaro in prep), benzene appears to be a common VOC detected in the low-permeability, deeper portions of the DNAPL monitoring wells and has been observed in the upper, middle and lower Nolichucky Shale as well as the Maryville Formation. It is possible the pervasive presence of benzene in trace amounts is due to the occurrence of natural hydrocarbons. However, benzene is a VOC of concern because it does occur in more than 5% of wells associated with the Y-12 Burial Grounds (HSW, 1994). Although TCE is observed in very low estimated quantities (1 mg/L) in zone 35, TCE is a VOC contaminant of concern in Bear Creek Valley that may be coming from an upstream source in the Maynardville Limestone. Zone 35 samples a hydraulically active fracture/cavity at the base of the Maynardville Limestone (Table 2).

Table 6. GW-790 VOC analytical results that are tagged with a "J" qualifier.

Lab	Zone							
Sample No.	Zone No.	Date Sampled	Analysis	Result	Tag	Units	Date Analyzed	Depth (ft.)
950424-066	2	23-Apr-95	Acetone	10.00	B	ug/L	25-Apr-95	1026
950424-066	2	23-Apr-95	Benzene	1.00	J	ug/L	25-Apr-95	1026
950424-065	5	23-Apr-95	Acetone	8.00	JB	ug/L	25-Apr-95	973
950424-065	5	23-Apr-95	Benzene	3.00	J	ug/L	25-Apr-95	973
950424-064	7	23-Apr-95	2-Butanone	14.00	B	ug/L	25-Apr-95	938
950424-064	7	23-Apr-95	Benzene	2.00	J	ug/L	25-Apr-95	938
950424-063	10	23-Apr-95	Benzene	1.00	J	ug/L	25-Apr-95	876
941215-027	14	13-Dec-94	Benzene	2.00	J	ug/L	16-Dec-94	799
941215-028	19	13-Dec-94	Benzene	1.00	J	ug/L	16-Dec-94	687
941215-029	23	14-Dec-94	Benzene	2.00	J	ug/L	19-Dec-94	587
941215-031	32	14-Dec-94	Styrene	1.00	J	ug/L	19-Dec-94	350
941215-032	35	14-Dec-94	Trichloroethene	1.00	J	ug/L	19-Dec-94	284
J = estimated								
B = analyte found at same concentration in blank as in sample								

3.2 TRACE METALS

One sample per zone was collected for metal analysis (Table 5). Metal concentrations were determined by ICP spectroscopy and are listed in Appendix D. Available background screening levels listed in the GWQAR for Bear Creek Valley (HSW, 1994) are also listed in Appendix D, and detection limits are given as less than (<) values in Appendix D. Samples from zones 19 and below were diluted because of high ionic concentrations. All of these zones showed TDS values greater than 3000 mg/L and dilution rates vary as a function of TDS: Zones 14 and 19 (TDS = 3278 - 4749 mg/L) had the least dilution with a dilution factor of 10, and zone 2 (TDS = 91695 mg/L) had the greatest dilution with a dilution factor of 100. As a result of the dilutions, detection limits are raised and some are raised above the background screening levels listed in the GWQAR for Bear Creek Valley (HSW, 1994). This is the case for antimony, beryllium, cadmium, cobalt, lead, molybdenum, thorium, and vanadium (see Appendix D). Note also in Appendix D that the undiluted sample detection limits listed for antimony, lead, molybdenum, and thorium are equivalent to the background screening level for that constituent. Nevertheless, except for molybdenum, all analytical results for constituents with background screening levels below detection limits are below the detection limit, even though concentrations are expected to rise with an increase in TDS (TDS values are listed in Appendix E).

Boron, molybdenum, zinc, iron, manganese, nickel and strontium are above background screening levels for selected zones. The uppermost zones that sample shale-rich lithologies in the Nolichucky Shale (zones 23, 29 and 32)) show boron levels above the background screening levels listed in the GWQAR for Bear Creek Valley (HSW, 1994). Boron values noticeably decrease with increase in depth and corresponding increase in TDS. Zone 23 shows a molybdenum value above the background screening level, and the remaining lower zones have a detection limit for molybdenum that is above the background screening level. Except for zone 5, all the zones below a depth of 790 ft at the base of the borehole show elevated values of zinc that are above the background screening level of 0.079 mg/L. Iron, manganese and nickel values are above background screening levels for zone 2. This zone shows the highest TDS value in the borehole (TDS = 91695 mg/L).

Strontium also shows concentrations above the background screening level. The elevated concentrations occur in the deepest 6 zones (zones 2, 5, 7, 10, 14, 19) where there is also a corresponding increase in TDS. These zones show TDS values greater than 3000 mg/L. The increase in strontium is apparently related to the increase in TDS as is suggested by the proportional correspondence between calcium and strontium concentrations (Fig. 4). Strontium will commonly substitute for calcium because they have the same valence state and a similar ionic radius.

3.3 MAJOR ELEMENT WATER CHEMISTRY

Major element water chemistry and field parameters are given in Appendix E and charge balance information is given in Appendix F. Of immediate note is the potential presence of nitrate in zones 2, 5, 7, 10 and 35. However, it is important to understand that ion chromatography, the analytical technique used for anion analysis, may give misleading results for high chloride waters, which is the water-type for zones 2, 5, 7 and 10 (Fig. 5). These zones will be resampled specifically for nitrate analysis, and an analytical technique will be used where there is no interference between chloride and nitrate values. Zone 35 samples a relatively low TDS mixed cation- HCO_3 -type water. At present, there is no compelling reason to doubt the presence of nitrate in zone 35 and the source of the nitrate is probably the S-3 Ponds, located to the east of GW-790. Nevertheless, zone 35 will also be resampled to verify the nitrate values.

In general, ionic concentrations are given with two significant digits. Note, however, that for chloride, the significant digits range from two to four. At present, the reason for this change has not been determined and is being investigated with the K-25 Analytical Laboratory. Only seven of the eleven zones showed a charge balance that is less than 10%. The other four zones (zones 2, 5, 7 and 10) had balances between 10% and 13%. The reason for the poor charge balances has not been determined. Based on results from GW-730 (Dreier and Caldanaro, in prep), it is not directly due to high TDS and associated dilution of the sample because GW-730 had several samples with dilution factors of 100 that showed charge balances less than 10%.

Figure 4. Plot of strontium vs. calcium concentrations from GW-790. The Sr/Ca ratio average is 0.09 and ranges from 0.01 - 0.13.

Figure 5. Piper diagram of GW-790 water chemistry. It should be noted that zones 2, 5, 7, and 10 were plotted for comparison purposes only. Both had charge balances greater than $\pm 10\%$.

Water chemistry types are shown in Fig. 5. There is a systematic change in water type with depth from a relatively shallow mixed cation- HCO_3 type water to a deep Na-Cl type water. The upper two zones (zones 35 and 39 which show a depth range of 200 - 300 ft) sample the Maynardville Limestone and are a Ca(Mg)-HCO_3 to a mixed-cation- HCO_3 type water. The upper three zones in the Nolichucky Shale (zones 12, 29 and 32 which show a depth ranges of 300 - 600 feet) show a change to a Na- HCO_3 type water. The lowest six zones (zones 2, 5, 7, 10, 14 and 19 which show a depth range of 650 - 1050 ft) are a Na-Cl type water. The change in water type with depth also corresponds to an approximate increase in TDS with depth (Fig. 5) and in part to those zones that did not produce a sufficient volume of purge water within one month.

4.0 SUMMARY / FUTURE WORK

Ongoing and future tasks are directed toward collecting data that will provide information about: (1) the presence or absence of DNAPL or dissolved phase DNAPL and (2) the nature of the groundwater system so that the potential mobility of the dissolved phase plume can be evaluated. With this information we will be prepared to address concerns about the current extent of the contamination, the potential for continued spread of the contamination, and the need, if any, for implementing a remediation strategy.

To date, each of the eleven sampling zones in GW-790 has been sampled for VOCs, metals and anions. Based on the presence of very low levels of benzene within the middle Nolichucky Shale and the presence of very low levels of TCE in the Maynardville Limestone, it is recommended that VOC monitoring of GW-790 be continued; particularly because TCE is detected in the Maynardville Limestone upgradient from this location. Additional data is required in order to statistically confirm the presence or absence of VOCs through the use of "J" qualifiers. Zones 2, 5, 7 and 10 will be resampled in order to confirm or disprove the presence of nitrate in the deeper portions of the borehole. Purging activities will continue for zones 2, 5, 7, 10, and 14 to be followed by a second round of sampling. A comparison of the two sets of sampling results will be used to determine the need for a third round of purging. Any additional sampling from zones at the top of the well will be conducted without further purging, unless there is corroborative evidence that the water sample is not representative of the formation. There is a concern that excessive or unnecessary purging of units with low storativity, such as those in GW-790, will mobilize and extend the contaminant plume.

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Appendix A

TRIP BLANK VOC ANALYTICAL RESULTS.

GW-790 Trip Blank VOC Analytical Results.

Sample Number:	941215-034	950424-067
Trip Date:	12/13/94	4/23/95
Date Analyzed:	12/19/94	4/25/95
Units:	µg/L	µg/L
1,1,1-Trichloroethane	< 10.0	< 10.0
1,1,2,2-Tetrachloroethane	< 10.0	< 10.0
1,1,2-Trichloroethane	< 10.0	< 10.0
1,1-Dichloroethane	< 10.0	< 10.0
1,1-Dichloroethene	< 10.0	< 10.0
1,2-Dichloroethane	< 10.0	< 10.0
1,2-Dichloroethene (total)	< 10.0	< 10.0
1,2-Dichloropropane	< 10.0	< 10.0
2-Butanone	< 10.0	< 10.0
2-Hexanone	< 10.0	< 10.0
4-Methyl-2-pentanone	< 10.0	< 10.0
Acetone	< 10.0	< 10.0
Benzene	< 10.0	< 10.0
Bromodichloromethane	< 10.0	< 10.0
Bromoform	< 10.0	< 10.0
Bromomethane	< 10.0	< 10.0
Carbon Disulfide	< 10.0	< 10.0
Carbon Tetrachloride	< 10.0	< 10.0
Chlorobenzene	< 10.0	< 10.0
Chloroethane	< 10.0	< 10.0
Chloroform	< 10.0	< 10.0
Chloromethane	< 10.0	< 10.0
Dibromochloromethane	< 10.0	< 10.0
Ethylbenzene	< 10.0	< 10.0
Methylene Chloride	< 10.0	< 10.0
Styrene	< 10.0	< 10.0
Tetrachloroethene	< 10.0	< 10.0
Toluene	< 10.0	< 10.0
Trichloroethene	< 10.0	< 10.0
Vinyl Acetate	< 10.0	< 10.0
Vinyl Chloride	< 10.0	< 10.0
Xylene (total)	< 10.0	< 10.0
cis-1,3-Dichloropropene	< 10.0	< 10.0
trans-1,3-Dichloropropene	< 10.0	< 10.0

Appendix B

LABORATORY BLANK VOC ANALYTICAL RESULTS.

GW-790 Laboratory Blank VOC Analytical Results.

Sample Number:	941216-092	941219-047	950425-005
Date Completed:	12/16/94	12/19/94	4/25/95
Units:	µg/L	µg/L	µg/L
1,1,1-Trichloroethane	< 10.0	< 10.0	< 10.0
1,1,2,2-Tetrachloroethane	< 10.0	< 10.0	< 10.0
1,1,2-Trichloroethane	< 10.0	< 10.0	< 10.0
1,1-Dichloroethane	< 10.0	< 10.0	< 10.0
1,1-Dichloroethene	< 10.0	< 10.0	< 10.0
1,2-Dichloroethane	< 10.0	< 10.0	< 10.0
1,2-Dichloroethene (total)	< 10.0	< 10.0	< 10.0
1,2-Dichloropropane	< 10.0	< 10.0	< 10.0
2-Butanone	< 10.0	< 10.0	13.0
2-Hexanone	< 10.0	< 10.0	< 10.0
4-Methyl-2-pentanone	< 10.0	< 10.0	< 10.0
Acetone	< 10.0	< 10.0	9.0 J
Benzene	< 10.0	< 10.0	< 10.0
Bromodichloromethane	< 10.0	< 10.0	< 10.0
Bromoform	< 10.0	< 10.0	< 10.0
Bromomethane	< 10.0	< 10.0	< 10.0
Carbon Disulfide	< 10.0	< 10.0	< 10.0
Carbon Tetrachloride	< 10.0	< 10.0	< 10.0
Chlorobenzene	< 10.0	< 10.0	< 10.0
Chloroethane	< 10.0	< 10.0	< 10.0
Chloroform	< 10.0	< 10.0	< 10.0
Chloromethane	< 10.0	< 10.0	< 10.0
Dibromochloromethane	< 10.0	< 10.0	< 10.0
Ethylbenzene	< 10.0	< 10.0	< 10.0
Methylene Chloride	< 10.0	< 10.0	< 10.0
Styrene	< 10.0	< 10.0	< 10.0
Tetrachloroethene	< 10.0	< 10.0	< 10.0
Toluene	< 10.0	< 10.0	< 10.0
Trichloroethene	< 10.0	< 10.0	< 10.0
Vinyl Acetate	< 10.0	< 10.0	< 10.0
Vinyl Chloride	< 10.0	< 10.0	< 10.0
Xylene (total)	< 10.0	< 10.0	< 10.0
cis-1,3-Dichloropropene	< 10.0	< 10.0	< 10.0
trans-1,3-Dichloropropene	< 10.0	< 10.0	< 10.0

Appendix C
VOC ANALYTICAL RESULTS.

GW-790 VOC Analytical Results

Well/Zone Number:	GW-790-2	GW-790-5	GW-790-7	GW-790-10
Sample Number:	950424-066	950424-065	950424-064	950424-063
Date Sampled:	4/23/95	4/23/95	4/23/95	4/23/95
Date Analyzed:	4/25/95	4/25/95	4/25/95	4/25/95
Corresponding Trip Blank:	950424-067	950424-067	950424-067	950424-067
Corresponding Lab Blank:	950425-005	950425-005	950425-005	950425-005
VOLATILE ORGANICS (µg/L)				
1,1,1-Trichloroethane	< 10.0	< 10.0	< 10.0	< 10.0
1,1,2,2-Tetrachloroethane	< 10.0	< 10.0	< 10.0	< 10.0
1,1,2-Trichloroethane	< 10.0	< 10.0	< 10.0	< 10.0
1,1-Dichloroethane	< 10.0	< 10.0	< 10.0	< 10.0
1,1-Dichloroethene	< 10.0	< 10.0	< 10.0	< 10.0
1,2-Dichloroethane	< 10.0	< 10.0	< 10.0	< 10.0
1,2-Dichloroethene (total)	< 10.0	< 10.0	< 10.0	< 10.0
1,2-Dichloropropane	< 10.0	< 10.0	< 10.0	< 10.0
2-Butanone	< 10.0	< 10.0	14.0 B	< 10.0
2-Hexanone	< 10.0	< 10.0	< 10.0	< 10.0
4-Methyl-2-pentanone	< 10.0	< 10.0	< 10.0	< 10.0
Acetone	10.0 B	8.0 JB	< 10.0	< 10.0
Benzene	1.0 J	3.0 J	2.0 J	1.0 J
Bromodichloromethane	< 10.0	< 10.0	< 10.0	< 10.0
Bromoform	< 10.0	< 10.0	< 10.0	< 10.0
Bromomethane	< 10.0	< 10.0	< 10.0	< 10.0
Carbon Disulfide	< 10.0	< 10.0	< 10.0	< 10.0
Carbon Tetrachloride	< 10.0	< 10.0	< 10.0	< 10.0
Chlorobenzene	< 10.0	< 10.0	< 10.0	< 10.0
Chloroethane	< 10.0	< 10.0	< 10.0	< 10.0
Chloroform	< 10.0	< 10.0	< 10.0	< 10.0
Chloromethane	< 10.0	< 10.0	< 10.0	< 10.0
Dibromochloromethane	< 10.0	< 10.0	< 10.0	< 10.0
Ethylbenzene	< 10.0	< 10.0	< 10.0	< 10.0
Methylene Chloride	< 10.0	< 10.0	< 10.0	< 10.0
Styrene	< 10.0	< 10.0	< 10.0	< 10.0
Tetrachloroethene	< 10.0	< 10.0	< 10.0	< 10.0
Toluene	< 10.0	< 10.0	< 10.0	< 10.0
Trichloroethene	< 10.0	< 10.0	< 10.0	< 10.0
Vinyl Acetate	< 10.0	< 10.0	< 10.0	< 10.0
Vinyl Chloride	< 10.0	< 10.0	< 10.0	< 10.0
Xylene (total)	< 10.0	< 10.0	< 10.0	< 10.0
cis-1,3-Dichloropropene	< 10.0	< 10.0	< 10.0	< 10.0
trans-1,3-Dichloropropene	< 10.0	< 10.0	< 10.0	< 10.0

(Continued...)

GW-790 VOC Analytical Results

Well/Zone Number:	GW-790-14	GW-790-19	GW-790-23	GW-790-29
Sample Number:	941215-027	941215-028	941215-029	941215-030
Date Sampled:	12/13/94	12/13/94	12/14/94	12/14/94
Date Analyzed:	12/16/94	12/16/94	12/19/94	12/19/94
Corresponding Trip Blank:	941215-034	941215-034	941215-034	941215-034
Corresponding Lab Blank:	941216-092	941216-092	941219-047	941219-047
VOLATILE ORGANICS (µg/L)				
1,1,1-Trichloroethane	< 10.0	< 10.0	< 10.0	< 10.0
1,1,2,2-Tetrachloroethane	< 10.0	< 10.0	< 10.0	< 10.0
1,1,2-Trichloroethane	< 10.0	< 10.0	< 10.0	< 10.0
1,1-Dichloroethane	< 10.0	< 10.0	< 10.0	< 10.0
1,1-Dichloroethene	< 10.0	< 10.0	< 10.0	< 10.0
1,2-Dichloroethane	< 10.0	< 10.0	< 10.0	< 10.0
1,2-Dichloroethene (total)	< 10.0	< 10.0	< 10.0	< 10.0
1,2-Dichloropropane	< 10.0	< 10.0	< 10.0	< 10.0
2-Butanone	< 10.0	< 10.0	< 10.0	< 10.0
2-Hexanone	< 10.0	< 10.0	< 10.0	< 10.0
4-Methyl-2-pentanone	< 10.0	< 10.0	< 10.0	< 10.0
Acetone	< 10.0	< 10.0	< 10.0	< 10.0
Benzene	2.0 J	1.0 J	2.0 J	< 10.0
Bromodichloromethane	< 10.0	< 10.0	< 10.0	< 10.0
Bromoform	< 10.0	< 10.0	< 10.0	< 10.0
Bromomethane	< 10.0	< 10.0	< 10.0	< 10.0
Carbon Disulfide	< 10.0	< 10.0	< 10.0	< 10.0
Carbon Tetrachloride	< 10.0	< 10.0	< 10.0	< 10.0
Chlorobenzene	< 10.0	< 10.0	< 10.0	< 10.0
Chloroethane	< 10.0	< 10.0	< 10.0	< 10.0
Chloroform	< 10.0	< 10.0	< 10.0	< 10.0
Chloromethane	< 10.0	< 10.0	< 10.0	< 10.0
Dibromochloromethane	< 10.0	< 10.0	< 10.0	< 10.0
Ethylbenzene	< 10.0	< 10.0	< 10.0	< 10.0
Methylene Chloride	< 10.0	< 10.0	< 10.0	< 10.0
Styrene	< 10.0	< 10.0	< 10.0	< 10.0
Tetrachloroethene	< 10.0	< 10.0	< 10.0	< 10.0
Toluene	< 10.0	< 10.0	< 10.0	< 10.0
Trichloroethene	< 10.0	< 10.0	< 10.0	< 10.0
Vinyl Acetate	< 10.0	< 10.0	< 10.0	< 10.0
Vinyl Chloride	< 10.0	< 10.0	< 10.0	< 10.0
Xylene (total)	< 10.0	< 10.0	< 10.0	< 10.0
cis-1,3-Dichloropropene	< 10.0	< 10.0	< 10.0	< 10.0
trans-1,3-Dichloropropene	< 10.0	< 10.0	< 10.0	< 10.0

(Continued...)

GW-790 VOC Analytical Results

Well/Zone Number:	GW-790-32	GW-790-35	GW-790-39
Sample Number:	941215-031	941215-032	941215-033
Date Sampled:	12/14/94	12/14/94	12/14/94
Date Analyzed:	12/19/94	12/19/94	12/19/94
Corresponding Trip Blank:	941215-034	941215-034	941215-034
Corresponding Lab Blank:	941219-047	941219-047	941219-047
VOLATILE ORGANICS (µg/L)			
1,1,1-Trichloroethane	< 10.0	< 10.0	< 10.0
1,1,2,2-Tetrachloroethane	< 10.0	< 10.0	< 10.0
1,1,2-Trichloroethane	< 10.0	< 10.0	< 10.0
1,1-Dichloroethane	< 10.0	< 10.0	< 10.0
1,1-Dichloroethene	< 10.0	< 10.0	< 10.0
1,2-Dichloroethane	< 10.0	< 10.0	< 10.0
1,2-Dichloroethene (total)	< 10.0	< 10.0	< 10.0
1,2-Dichloropropane	< 10.0	< 10.0	< 10.0
2-Butanone	< 10.0	< 10.0	< 10.0
2-Hexanone	< 10.0	< 10.0	< 10.0
4-Methyl-2-pentanone	< 10.0	< 10.0	< 10.0
Acetone	< 10.0	< 10.0	< 10.0
Benzene	< 10.0	< 10.0	< 10.0
Bromodichloromethane	< 10.0	< 10.0	< 10.0
Bromoform	< 10.0	< 10.0	< 10.0
Bromomethane	< 10.0	< 10.0	< 10.0
Carbon Disulfide	< 10.0	< 10.0	< 10.0
Carbon Tetrachloride	< 10.0	< 10.0	< 10.0
Chlorobenzene	< 10.0	< 10.0	< 10.0
Chloroethane	< 10.0	< 10.0	< 10.0
Chloroform	< 10.0	< 10.0	< 10.0
Chloromethane	< 10.0	< 10.0	< 10.0
Dibromochloromethane	< 10.0	< 10.0	< 10.0
Ethylbenzene	< 10.0	< 10.0	< 10.0
Methylene Chloride	< 10.0	< 10.0	< 10.0
Styrene	1.0 J	< 10.0	< 10.0
Tetrachloroethene	< 10.0	< 10.0	< 10.0
Toluene	< 10.0	< 10.0	< 10.0
Trichloroethene	< 10.0	1.0 J	< 10.0
Vinyl Acetate	< 10.0	< 10.0	< 10.0
Vinyl Chloride	< 10.0	< 10.0	< 10.0
Xylene (total)	< 10.0	< 10.0	< 10.0
cis-1,3-Dichloropropene	< 10.0	< 10.0	< 10.0
trans-1,3-Dichloropropene	< 10.0	< 10.0	< 10.0

Appendix D
TRACE METAL ANALYTICAL RESULTS.

Trace Metal Analytical Results

Well/Zone Number:		GW-790-2	GW-790-5	GW-790-7	GW-790-10	GW-790-14	GW-790-19
Date Sampled:		4/23/95	4/23/95	4/23/95	4/23/95	12/13/94	12/13/94
METALS (mg/L)	Background Screening levels*						
Aluminum	7.9	< 2.0 d	0.49	< 0.4 d	< 0.4 d	< 0.2 d	< 0.2 d
Antimony	0.05	< 5.0 d	< 1.0 d	< 1.0 d	< 1.0 d	< 0.5 d	< 0.5 d
Arsenic		< 5.0 d	< 1.0 d	< 1.0 d	< 1.0 d	< 0.5 d	< 0.5 d
Barium		220.0	5.4	5.4	8.7	1.2	0.56
Beryllium	0.0019	< 0.03 d	< 0.006 d	< 0.006 d	< 0.006 d	< 0.003 d	< 0.003 d
Boron	0.57	< 0.4 d	0.15	0.19	0.32	0.32	0.36
Cadmium	0.005	< 0.3 d	< 0.06 d	< 0.06 d	< 0.06 d	< 0.03 d	< 0.03 d
Chromium		10.0	< 0.2 d	< 0.2 d	< 0.2 d	< 0.1 d	< 0.1 d
Cobalt	0.025	< 0.5 d	< 0.1 d	< 0.1 d	< 0.1 d	< 0.05 d	< 0.05 d
Copper	0.3	< 0.4 d	< 0.08 d	< 0.08 d	< 0.08 d	< 0.04 d	< 0.04 d
Iron	13.0	70.0	0.23	0.96	0.56	< 0.05 d	< 0.05 d
Lead	0.05	< 5.0 d	< 1.0 d	< 1.0 d	< 1.0 d	< 0.5 d	< 0.5 d
Lithium		5.1	1.1	1.2	1.6	0.77	0.57
Manganese	2.7	8.0	0.18	0.18	0.17	0.029	0.017
Molybdenum	0.01	< 1.0 d	< 0.2 d	< 0.2 d	< 0.2 d	< 0.1 d	< 0.1 d
Nickel	0.33	12.0	< 0.2 d	< 0.2 d	< 0.2 d	< 0.1 d	< 0.1 d
Selenium		< 5.0 d	< 1.0 d	< 1.0 d	< 1.0 d	< 0.5 d	< 0.5 d
Silver		< 0.6 d	< 0.12 d	< 0.12 d	< 0.12 d	< 0.06 d	< 0.06 d
Strontium	0.83	980.0	26.0	34.0	63.0	4.7	1.5
Thorium	0.2	< 20.0 d	< 4.0 d	< 4.0 d	< 4.0 d	< 2.0 d	< 2.0 d
Vanadium	0.058	< 0.5 d	< 0.1 d	< 0.1 d	< 0.1 d	< 0.05 d	< 0.05 d
Zinc	0.079	0.36	< 0.04 d	0.2	0.18	0.19	< 0.02 d
Dilution factor		100	20	20	20	10	10

* Background screening levels obtained from HSW Environmental Consultants, 1994. Levels listed are for ORR Aquitards. Where blank, there is no background screening level listed.

** italicized values show a detection limit that is above the recommended background screening level.

*** bold face values show levels that are above the detection limit and the background screening level.

Trace Metal Analytical Results

Well/Zone Number:		GW-790-23	GW-790-29	GW-790-32	GW-790-35	GW-790-39
Date Sampled:		12/14/94	12/14/94	12/14/94	12/14/94	12/14/94
METALS (mg/L)	Background Screening levels*					
Aluminum	7.9	0.021	0.032	< 0.02	0.03	< 0.02
Antimony	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Arsenic		< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Barium		0.043	0.044	0.052	0.092	0.031
Beryllium	0.0019	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003
Boron	0.57	0.91	2.1	2.0	0.084	0.18
Cadmium	0.005	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Chromium		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cobalt	0.025	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Copper	0.3	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Iron	13.0	0.038	0.068	0.033	0.09	0.032
Lead	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Lithium		0.15	0.18	0.14	0.005	0.007
Manganese	2.7	0.0016	< 0.0011	< 0.0016	< 0.0038	0.011
Molybdenum	0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Selenium		< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Silver		< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Strontium	0.83	0.12	0.1	0.22	0.18	0.033
Thorium	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Vanadium	0.058	< 0.005	< 0.005	< 0.005	< 0.005	0.005
Zinc	0.079	0.022	0.021	0.017	0.034	0.0027
Dilution factor		1	1	1	1	1

* Background screening levels obtained from HSW Environmental Consultants, 1994. Levels listed are for ORR Aquitards. Where blank, there is no background screening level listed.

** italicized values show a detection limit that is above the recommended background screening level.

*** bold face values show levels that are above the detection limit and the background screening level.

Appendix E

MAJOR ANIONS AND CATIONS AND FIELD PARAMETERS.

Major Anions and Cations and Field Parameters.

Well/Zone Number:	GW-790-2	GW-790-5	GW-790-7	GW-790-10	GW-790-14	GW-790-19	GW-790-23
Date Sampled:	4/23/95	4/23/95	4/23/95	4/23/95	12/13/94	12/13/94	12/14/94
ANIONS (mg/L)							
Alkalinity (K-25 Lab)	32.0	65.0	65.0	105.0	98.0	121.0	431.0
Alkalinity-HCO ₃ *	39.0	79.0	79.0	128.0	119.0	148.0	504.0
Alkalinity-CO ₃ *	0.0	0.0	0.0	0.0	0.0	0.0	10.0
Bromide	< 100.0 d	< 100.0 d	< 100.0 d	< 100.0 d	21.0	13.0	na
Chloride IC	52000.0	6600.0	6400.0	7200.0	2833.0	1876.0	104.0
Fluoride SIE	0.53	1.5	1.2	1.0	2.2	2.2	6.3
Nitrate	490.0	110.0	110.0	120.0	< 1.0	< 1.0	< 1.0
Sulfate	< 100.0 d	< 100.0 d	< 100.0 d	< 100.0 d	3.0	< 1.0	9.2
CATIONS (mg/L)							
Calcium	7500.0	230.0	290.0	500.0	42.0	18.0	1.7
Iron	70.0	0.23	0.96	0.56	< 0.05 d	< 0.05 d	0.038
Magnesium	1500.0	64.0	80.0	120.0	12.0	5.7	0.45
Potassium	95.0	21.0	20.0	23.0	16.0	16.0	2.8
Sodium	30000.0	5300.0	4900.0	5300.0	1700.0	1200.0	270.0
TDS (mg/L)†	91694.5	12406.0	11881.0	13392.6	4748.7	3278.4	909.3
FIELD PARAMETERS							
pH	6.5	7.0	6.0	7.0	8.0	7.5	8.7
Temperature (°C)	14.0	15.0	16.0	16.0	12.0	12.0	10.0
Conductivity (µmho/cm)	50000.0	18000.0	15000.0	16500.0	6000.0	4000.0	850.0

*values determined by speciating total alkalinity (CaCO₃) from K-25 labs, based on pH of water sample.

†Sum of major anions and cations (mg/L).

d = indicates sample diluted for analysis.

na = not analyzed

Major Anions and Cations and Field Parameters.

Well/Zone Number:	GW-790-29	GW-790-32	GW-790-35	GW-790-39
Date Sampled:	12/14/94	12/14/94	12/14/94	12/14/94
ANIONS (mg/L)				
Alkalinity (K-25 Lab)	131.0	333.0	789.0	749.0
Alkalinity-HCO ₃ *	695.0	517.0	240.0	79.0
Alkalinity-CO ₃ *	7.0	0.0	0.0	0.0
Bromide	na	na	na	na
Chloride IC	12.0	16.0	15.0	16.0
Fluoride SIE	6.0	4.9	0.1	0.5
Nitrate	< 1.0	< 1.0	68.0	1.5
Sulfate	41.0	13.0	25.0	< 1.0
CATIONS (mg/L)				
Calcium	1.2	2.4	71.0	5.3
Iron	0.068	0.033	0.09	0.032
Magnesium	0.47	1.2	19.0	7.7
Potassium	2.1	2.7	1.9	3.0
Sodium	280.0	200.0	11.0	18.0
TDS (mg/L)†	1045.2	757.2	451.3	131.3
FIELD PARAMETERS				
pH	8.5	8.0	7.0	7.5
Temperature (°C)	12.0	13.0	14.0	13.5
Conductivity (µmho/cm)	890.0	600.0	410.0	140.0

*values determined by speciating total alkalinity (CaCO₃) from K-25 labs, based on pH of water sample.

†Sum of major anions and cations (mg/L).

d = indicates sample diluted for analysis.

na = not analyzed

Appendix F

CHARGE BALANCE CALCULATIONS.

Charge Balance Calculations

Well/Zone Number:	GW-790-23	GW-790-29	GW-790-32	GW-790-35	GW-790-39
Date Sampled:	12/14/94	12/14/94	12/14/94	12/14/94	12/14/94
ANIONS (meq/L)					
Alkalinity-HCO ₃	8.3	11.4	8.5	3.9	1.3
Alkalinity-CO ₃	0.3	0.2	0.0	0.0	0.0
Bromide	0.0	0.0	0.0	0.0	0.0
Chloride IC	2.9	0.3	0.5	0.4	0.5
Fluoride SIE	0.3	0.3	0.3	0.0	0.0
Nitrate	0.0	0.0	0.0	1.1	0.0
Sulfate IC	0.2	0.9	0.3	0.5	0.0
Total Anions	12.1	13.1	9.5	6.0	1.8
CATIONS (meq/L)					
Calcium	0.1	0.1	0.1	3.5	0.3
Iron	0.0	0.0	0.0	0.0	0.0
Magnesium	0.0	0.0	0.1	1.6	0.6
Potassium	0.1	0.1	0.1	0.0	0.1
Sodium	11.7	12.2	8.7	0.5	0.8
Total Cations	11.9	12.3	9.0	5.6	1.8
CHARGE BALANCE (%)	-1	-3	-3	-3	-1

Charge Balance Calculations

Well/Zone Number:	GW-790-2	GW-790-5	GW-790-7	GW-790-10	GW-790-14	GW-790-19
Date Sampled:	4/23/95	4/23/95	4/23/95	4/23/95	12/13/94	12/13/94
ANIONS (meq/L)						
Alkalinity-HCO ₃	0.6	1.3	1.3	2.1	2.0	2.4
Alkalinity-CO ₃	0.0	0.0	0.0	0.0	0.0	0.0
Bromide	0.0	0.0	0.0	0.0	0.3	0.2
Chloride IC	1466.6	186.1	180.5	203.1	79.9	52.9
Fluoride SIE	0.0	0.1	0.1	0.1	0.1	0.1
Nitrate	7.9	1.8	1.8	1.9	0.0	0.0
Sulfate IC	0.0	0.0	0.0	0.0	0.1	0.0
Total Anions	1475.1	189.3	183.6	207.1	82.3	55.6
CATIONS (meq/L)						
Calcium	374.3	11.5	14.5	25.0	2.1	0.9
Iron	3.8	0.0	0.1	0.0	0.0	0.0
Magnesium	123.4	5.3	6.6	9.9	1.0	0.5
Potassium	2.4	0.5	0.5	0.6	0.4	0.4
Sodium	1304.5	230.5	213.1	230.5	73.9	52.2
Total Cations	1808.3	247.8	234.7	265.9	77.4	54.0
CHARGE BALANCE (%)	10	13	12	12	-3	-2

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