Third Semi-Annual Groundwater Monitoring Report for the Interim Remedial Action D Area Oil Seepage Basin

by

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DOE Contract No. DE-AC09-96SR18500

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**THIRD SEMI-ANNUAL GROUNDWATER
MONITORING REPORT FOR THE D-AREA OIL
SEEPAGE BASIN INTERIM REMEDIAL ACTION**

WSRC-RP-98-4110

JUNE 18, 1998

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1.0 PURPOSE

The purpose of this report is to evaluate groundwater quality data collected from six downgradient groundwater monitoring wells for potential impact caused by the Interim Remedial Action (IRA) (completed June 1996) at the D-Area Oil Seepage Basin. The US Environmental Protection Agency and South Carolina Department of Health and Environmental Control required post-IRA groundwater monitoring and this report.

2.0 HISTORY

D-Area Oil Seepage Basin (DOSB), Bldg. 631-G is located north of D-Area between Roads A-4.4 and A-4.5 at an elevation approximately 150 feet above mean sea level and 1.9 miles from the nearest SRS boundary (Savannah River). The major surface water drainage system is the Savannah River and associated swamps located approximately 1.3 miles west of the basin. Upper Three Runs Creek is located 1.7 miles to the north-northwest; Fourmile Branch is 1.7 miles to the south-southeast.

A detailed history for the DOSB can be found in the Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation and the Baseline Risk Assessment, WSRC-RP-96-154, Rev. 1. The DOSB was originally constructed in 1952 as a series of unlined trenches to dispose of waste oils and other fluids not suitable for burning in powerhouse boilers. These waste oils included seal oil from the Heavy Water Facility, machine cutting oil, transformer oil and other shop fluids. The waste oils and fluids were collected in 55-gallon drums, transported to the basin, opened and dumped into the trenches. As the trenches filled, they were alternately burned along with general office and cafeteria waste. This practice continued until 1973 when open burning ceased plant wide.

In 1975, the trenches were removed from service and backfilled with soil (WSRC, 1990). Approximately one foot of standing water, plus a number of 55-gallon drums, possibly containing waste oil, remained in the basin as documented in a DOSB photograph (#17-355-40) taken in the 1970s.

3.0 INTERIM REMEDIAL ACTION

An IRA was planned for the first quarter of 1995 to remove the drums, debris, and principal threat source material such as free product and sludge. The IRA was planned for completion before initiation of the remedial investigation. However, due to a higher than expected water table, the IRA was postponed until a plan could be devised to minimize impact from excavation within the shallow water table. Approval of the Remedial Design/Remedial Action work plan (RD/RA) (WSRC-RP-94-1287, Rev. 1.3) was granted in March 1996 and the IRA was completed in June of 1996. The IRA was conducted to reduce the immediate health and environmental contact potential with the contaminant source by uncovering the drums and debris through careful excavation, transferring the drum contents into new drums, and dispositioning of the drum contents and debris in accordance with the approved RDRA.

Metal objects removed during the IRA included partially crushed drums with product and sludge, empty crushed drums, wire, chain, cable, conduit metal shavings, metal strips, glass bottles, light bulbs, reagent bottles, glassware, plastic sheeting, canvas, cloth, bricks, large (8 inch and 4 inch) pipes, rip-rap, channel iron, rebar, etc. Some drums were buried for at least 17 years and were still intact when excavated during the IRA while others were not. Few of the, approximately 60, excavated containers contained free liquids and/or residual sludges (less than 110 gallons).

The excavation method utilized during the IRA was conducted by opening small quadrants (10 x 20 feet) of the waste unit to lessen the potential for environmental impacts due to inadvertent releases (e.g., leakage from drum contents into the shallow water table) of principal threat source material. Soil removed during the excavation process was placed back in the quadrants in a last-out-first-in basis to ensure that the cleanest soil was placed nearest the surface. After all the quadrants were excavated, clean fill was placed on top of the basin area until the soil was approximately one foot above the existing grade. The soils were then graded to reduce water infiltration and seeded to prevent erosion.

Extensive characterization activities have also been completed at the DOSB including four phases of soils and groundwater investigation utilizing the Streamlined Approach for Environmental Restoration (SAFER) and Expedited Site Characterization (ESC) methodology. These characterization activities are documented in detail in the RCRA Facility Investigation/Remedial Investigation and Baseline Risk Assessment Report WSRC-RP-96-154, Rev. 1.

4.0 REGULATORY BASIS FOR GROUNDWATER MONITORING

The regulatory requirements for this groundwater report originate in the RD/RA Work Plan Section 4.2.9. Before the IRA began, concern was expressed by the regulators that the proposed activities during the IRA could potentially degrade DOSB groundwater quality. Specifically, it was known that the water table elevation was above the bottom of the basin trenches and that excavation and drum handling would have to occur within the water table. The proposed excavation and drum removal could potentially cause the drum contents to spill or leak into the groundwater, worsening the existing groundwater quality.

SCDHEC and USEPA mandated that a detailed groundwater monitoring strategy be included in the RD/RA work plan and implemented prior to and following the completion of any excavation at the site to ensure early detection in the event of a release from the IRA.

As a result, a number of operational modifications were made to the excavation and drum handling procedures in the IRA to minimize any leakage of drum contents into the aquifer including a requirement for semi-annual groundwater monitoring after the IRA was completed.

Under the terms of the approved RD/RA work plan sampling and analysis plan:

1. Existing monitoring wells in proximity to the IRA were to be selected for detection monitoring.
2. Since it was known that downgradient groundwater had already been impacted, comparison of background data to downgradient data would not indicate releases from the IRA.
3. Changes in groundwater quality would be indicated by exceeding predicted tolerance intervals and the magnitude of those changes would be assessed and reported to USEPA and SCDHEC.
4. Groundwater would be sampled semi-annually for three years.
5. A report of the groundwater sampling would be presented to USEPA and SCDHEC, semi-annually, summarizing the results of the water quality analysis.

5.0 SAMPLE DESIGN PARAMETERS

Groundwater monitoring wells from the existing monitoring well and piezometer network surrounding DOSB were utilized for detection monitoring before, during and after the IRA.

Groundwater monitoring wells DOB-1, DOB-2, DOB-7, DOB-8, DOB-10 and DOB-12 were selected for monitoring because they are the closest to the excavated area. These wells will be the first to be impacted if a release of hazardous substances occurred during the IRA. These wells are located at the waste unit perimeter directly downgradient and side-gradient of the DOSB and will provide the earliest possible detection of any releases from the IRA. See Figure 5-1.

Table 5-1: Monitoring Well Screen Zones in Feet Above Mean Sea Level (MSL)

Well	Screen Top (MSL)	Screen Bottom (MSL)	Ground Surface (MSL)	Screen Length (ft)	Screen Depth(ft) (Below Surface)
DOB-1	144.7	114.7	149.7	30	5
DOB-2	145.3	115.3	150.3	30	5
DOB-7	145.7	125.7	148.7	20	3
DOB-8	148.3	128.3	151.3	20	3
DOB-10	148.3	128.3	153.5	20	5.2
DOB-12	137.9	132.9	149.6	5	11.7

Because groundwater downgradient of the DOSB is known to be impacted from contaminants previously released from DOSB, comparison of background data to downgradient data would not indicate a release from the IRA. The sampling design for groundwater monitoring is based upon the establishment of background conditions in the above designated down and side-gradient wells. In effect, data collected from each well, prior to and during the IRA, will serve to establish its own background quality.

Prior to the beginning and during the IRA, 10 background samples were collected and analyzed from each well from April 4, 1996, to June 5, 1996. The results for each constituent and each well were used to calculate a predicted tolerance level (upper confidence level). The tolerance interval was calculated at the n-1, 0.05 (95%) level of significance and was one-tailed (+), except for pH which was two-tailed (+/-). The level of significance is consistent with RCRA requirements (RCRA 264.1066, Appendix IV).

The tolerance interval was computed by:

$$PTI = X_{\bar{bar}} \pm t * \frac{SD}{\sqrt{n}}$$

Where:

TI = Tolerance Interval

X_{bar} = Sample Mean

t = t value based on degrees of freedom (n-1) and alpha = .05 with one tail (pH was computed as two-tailed, +/-)

SD = Population Standard Deviation

n = Number of samples

After background conditions have been calculated for each well, groundwater samples are to be collected on a semi-annual basis for a three year period of time following completion of the IRA and compared to the tolerance interval. Exceedance of the tolerance interval could indicate a change in groundwater quality; however, it may also reflect change due to statistical aberrations or be attributable to temporal variability or sample collection and measurement error. Therefore, the exceedance of a tolerance interval would not necessarily trigger further groundwater investigation. Exceedance of a tolerance interval would necessitate an evaluation of the body of data to determine if the impact to groundwater quality was positive or negative.

A three year monitoring duration was estimated based upon the distance from the center (75 feet) and far edge (150 feet) of the IRA excavation area and the range of groundwater flow velocities found at DOSB. The following was used to estimate the three-year sampling duration.

$$V \approx \frac{K \cdot \left(\frac{\Delta h}{\Delta l} \right)}{n_e}$$

$$V \approx \frac{9.7 \text{ to } 32.0 \text{ ft / day} \cdot (.003)}{.24} \approx 0.12 \text{ to } 0.40 \text{ ft / day}$$

$$D \approx 0.12 \text{ to } 0.40 \text{ ft / day} \cdot (365 \text{ days / year}) \approx 44 \text{ to } 146 \text{ feet / year}$$

$$T_1 = 75 \text{ feet (midpoint of excavated area to well)} / 44 \text{ to } 146 \text{ ft/yr}$$

$$T_1 = 0.51 \text{ to } 1.7 \text{ years travel time (high range estimate)}$$

$$T_2 = 150 \text{ feet (far edge of excavated area to well)} / 44 \text{ to } 146 \text{ ft/yr}$$

$$T_2 = 1.02 \text{ to } 3.4 \text{ years travel time (low range estimate)}$$

Assuming:

V = Average linear velocity feet per day

K = Hydraulic conductivity range 18.8 to 32.0 feet/day

h = height feet

l = length feet

n_e = effective porosity .24%

D = distance plume has migrated in feet per year

T_1 = Travel Time range estimate from midpoint in years

T_2 = Travel Time range estimate from far edge in years

The monitoring data results from each semi-annual sampling event will be compared to the tolerance intervals. If the tolerance interval is exceeded, then the magnitude of the change will be assessed with respect to the overall body of data and trending. The results will be reported to the South Carolina Department of Health and Environmental Control and the US Environmental Protection Agency twice each year.

The constituents selected for monitoring include Target Compound List Volatile Organic Compounds (TCL-VOCs), Target Analyte List Metals (TAL) and indicator parameters pH, specific conductance, Chemical Oxygen Demand (COD), nitrates, sulfates, chlorides, Total Organic Carbon (TOC), and Total Organic Halogens (TOX). These analytes were selected for monitoring

because they represent the waste sources characteristic of DOSB and because they are the most mobile, with the exception of TAL metals. Therefore, the analyte list has been specifically tuned to be representative and responsive to detection during compliance monitoring.

6.0 BACKGROUND GROUNDWATER CONCENTRATIONS

Ten background groundwater samples were collected from each of six downgradient wells from April 4, 1996, to June 5, 1996. Ten samples were selected for collection to reduce statistical error and reasonably limit the upper-bound. The monitoring wells sampled included DOB-1, DOB-2, DOB-7, DOB-8, DOB-10 and DOB-12 and are the wells closest to the waste unit.

All samples were analyzed in accordance with SW-846 methods. All data used in this evaluation is definitive level validated data. Because groundwater downgradient of DOSB is impacted from previous releases, a method to measure change in water quality in the wells post-IRA is by comparing post-IRA sample results to a 95% tolerance interval.

Excluding quality assurance/quality control (QA/QC) samples, the background data set consisted of 3973 lines of analytical data. The data set was purged to eliminate QA/QC samples, replicates, and rejected data. Background groundwater statistics including the average and 95% tolerance levels were calculated for the analyte concentrations in each well. Where a sample result included a "U" qualifier, indicating analyte concentrations were below sample quantitation limits in one or more background samples, a surrogate value of one-half the sample quantitation limit was used to calculate the average for that analyte. Where a particular analyte was not detected in any of the background samples, the background concentration for comparison purposes was set to zero, to guarantee that any detection in post-IRA samples would be addressed. Simple summary statistics were then generated for each analytical fraction by well. The results of the background summary statistics are presented on Tables 6-1, 6-2 and 6-3.

Background groundwater samples were analyzed for 20 metals, as shown on Table 6-1. In background samples, 19 of the 20 analytes (excepting only silver) were detected.

Background groundwater samples were analyzed for 34 TCL VOCs, as shown on Table 6-2. In the background samples, 17 of the 34 analytes (excepting 1,1,1-trichloroethane, 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, 1,1-dichloroethane, 1,2-dichloropropane, 2-hexanone, bromodichloromethane, bromoform, bromomethane, chloroethane, chloromethane, cis-1,3-dichloropropene, dibromochloromethane, methyl isobutyl ketone, styrene, trans-1,3-dichloropropene, and vinyl acetate) were detected.

Background groundwater samples were analyzed for 8 indicator parameters as shown on Table 6-3. All indicator parameters were measured in the background samples.

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Table 6-1: Background Concentrations of TAL Metals, µg/L

well_name		DOB 1	DOB 2	DOB 7	DOB 8	DOB 10	DOB 12	Summary
Analyte	Data							
Aluminum	Total Samples	10	11	10	10	10	10	61
	Hits	7	6	7	7	8	7	42
	Minimum Detection	47.5	16	77	30.1	12.6	16.6	12.6
	Maximum Detection	774	107	138	180	2170	179	2170
	Mean	213.06	42.09	90.28	73.32	284.97	53.59	124.84
Antimony	Total Samples	10	10	10	10	10	10	60
	Hits	2	0	0	0	0	0	2
	Minimum Detection	1.38	0	0	0	0	0	1.38
	Maximum Detection	1.64	0	0	0	0	0	1.64
	Mean	2.30	2.50	2.50	2.50	2.50	2.50	2.47
Arsenic	Total Samples	10	10	10	10	10	10	60
	Hits	1	1	0	0	1	0	3
	Minimum Detection	2.11	2.03	0	0	1.99	0	0
	Maximum Detection	2.11	2.03	0	0	1.99	0	2.11
	Mean	2.46	2.45	2.50	2.50	2.45	2.50	2.48
Barium	Total Samples	10	10	10	10	10	10	60
	Hits	10	10	10	10	10	10	60
	Minimum Detection	10.9	26.2	43.5	14	15.1	16.8	10.9
	Maximum Detection	16.2	31	52.2	23.2	33.5	20.7	52.2
	Mean	14.10	28.34	47.19	18.40	19.40	19.10	24.42
Beryllium	Total Samples	10	10	10	10	10	10	60
	Hits	0	2	0	1	0	4	7
	Minimum Detection	0	0.017	0	0.015	0	0.108	0
	Maximum Detection	0	0.026	0	0.015	0	0.211	0.211
	Mean	0.61	0.33	0.62	0.47	0.76	0.40	0.54
Cadmium	Total Samples	10	10	10	10	10	10	60
	Hits	1	1	6	1	0	0	9
	Minimum Detection	0.099	0.109	0.107	0.319	0	0	0
	Maximum Detection	0.099	0.109	0.23	0.319	0	0	0.319
	Mean	0.91	0.91	0.42	0.93	1.00	1.00	0.86
Chromium	Total Samples	10	10	10	10	10	10	60
	Hits	5	4	4	5	6	8	32
	Minimum Detection	0.974	0.851	0.714	0.651	0.709	0.782	0.651
	Maximum Detection	2.53	2.14	2.63	1.98	7.73	2.67	7.73
	Mean	1.74	1.73	1.64	1.52	2.01	1.57	1.70
Cobalt	Total Samples	10	10	10	10	10	10	60
	Hits	3	5	6	5	4	6	29
	Minimum Detection	0.196	0.286	0.284	0.208	0.181	0.323	0.181
	Maximum Detection	0.239	0.672	0.558	0.523	0.324	0.932	0.932
	Mean	1.16	0.72	0.75	0.65	0.78	0.79	0.81
Copper	Total Samples	10	10	10	10	10	10	60
	Hits	10	7	5	5	5	5	37
	Minimum Detection	37.8	0.592	0.616	0.558	1.24	1.84	0.558
	Maximum Detection	96.2	2.74	2.27	3.33	17.4	12.3	96.2
	Mean	52.09	1.98	1.40	1.54	4.41	3.32	10.79
Iron	Total Samples	10	11	10	10	10	10	61
	Hits	9	11	7	8	8	9	52
	Minimum Detection	30.6	55.5	10.1	10.8	12.6	14.2	10.1
	Maximum Detection	955	542	39.1	110	654	130	955
	Mean	220.94	163.46	15.70	33.09	86.98	52.52	96.56
Lead	Total Samples	10	10	10	10	10	10	60
	Hits	6	2	2	0	4	0	14
	Minimum Detection	1.37	2.1	3.47	0	1.35	0	1.35
	Maximum Detection	5.06	2.26	3.77	0	16.3	0	16.3
	Mean	2.62	2.28	2.55	2.32	4.67	2.50	2.82
Magnesium	Total Samples	10	10	10	10	10	10	60
	Hits	10	10	10	10	10	10	60
	Minimum Detection	7850	1750	3890	694	1800	765	694
	Maximum Detection	11400	2070	4520	905	2350	929	11400
	Mean	8,785.00	1,931.00	4,163.00	775.10	2,001.00	875.20	3,088.38

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Table 6-1: Background Concentrations of TAL Metals, µg/L (continued)

well name		DOB 1	DOB 2	DOB 7	DOB 8	DOB 10	DOB 12	Summary
Analyte	Data							
Manganese	Total Samples	10	11	10	10	10	10	61
	Hits	10	11	10	10	10	10	61
	Minimum Detection	2.37	12.1	146	1.55	6.93	58.8	1.55
	Maximum Detection	8.92	17.6	177	9.68	14.3	70.1	177
	Mean	4.74	13.94	158.70	4.24	9.85	64.06	42.12
Mercury	Total Samples	10	10	10	10	10	10	60
	Hits	1	1	2	1	2	4	11
	Minimum Detection	0.049	0.436	0.042	0.373	0.015	0.025	0
	Maximum Detection	0.049	0.436	0.224	0.373	0.215	0.112	0.436
	Mean	0.06	0.10	0.10	0.10	0.09	0.07	0.08
Nickel	Total Samples	10	10	10	10	10	10	60
	Hits	3	5	3	1	2	8	22
	Minimum Detection	0.89	0.884	0.808	1.17	1.23	0.867	0
	Maximum Detection	1.93	2.51	1.2	1.17	5.14	2.43	5.14
	Mean	3.89	3.44	3.80	4.62	4.64	2.24	3.77
Selenium	Total Samples	10	10	10	10	10	10	60
	Hits	0	0	0	1	0	0	1
	Minimum Detection	0	0	0	1.45	0	0	0
	Maximum Detection	0	0	0	1.45	0	0	1.45
	Mean	2.33	2.50	2.41	2.23	2.39	2.41	2.38
Thallium	Total Samples	10	10	10	10	10	10	60
	Hits	0	0	0	1	0	0	1
	Minimum Detection	0	0	0	2.48	0	0	0
	Maximum Detection	0	0	0	2.48	0	0	2.48
	Mean	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Vanadium	Total Samples	10	10	10	10	10	10	60
	Hits	9	5	3	5	5	5	32
	Minimum Detection	0.856	0.28	0.266	0.316	0.254	0.35	0.254
	Maximum Detection	4.16	0.816	0.387	0.818	1.18	1.87	4.16
	Mean	2.26	1.81	3.11	0.85	1.37	2.40	1.97
Zinc	Total Samples	10	10	10	10	10	10	60
	Hits	6	6	5	4	5	8	34
	Minimum Detection	7.6	7.8	2.83	2.92	3.19	6.39	0
	Maximum Detection	14.5	67.3	9.27	7.22	17.3	20.9	67.3
	Mean	8.55	14.24	3.38	3.18	5.10	10.77	7.54
Total Samples		190	193	190	190	190	190	1143
Total Hits		93	87	80	75	80	94	509

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Table 6-2: Background Concentrations for TCL Volatile Organic Compounds, µg/L

Analyte	well_name	DOB 1	DOB-2	DOB-7	DOB-8	DOB-10	DOB-12	Summary
	Data							
1,1-Dichloroethylene	Total Samples	10	10	10	10	10	10	60
	Hits	7	0	6	0	0	0	13
	Minimum Detection	0.15	0.00	0.25	0.00	0.00	0.00	0.15
	Maximum Detection	0.42	0.00	0.42	0.00	0.00	0.00	0.42
	Mean	0.44	0.22	0.44	0.22	0.22	0.22	0.29
1,2-Dichloroethane	Total Samples	10	10	10	10	10	10	60
	Hits	2	0	0	0	0	0	2
	Minimum Detection	0.26	0.00	0.00	0.00	0.00	0.00	0.26
	Maximum Detection	0.96	0.00	0.00	0.00	0.00	0.00	0.96
	Mean	0.36	0.22	0.27	0.22	0.22	0.22	0.25
1,2-Dichloroethylene	Total Samples	10	10	10	10	10	10	60
	Hits	9	0	9	8	0	9	35
	Minimum Detection	3.74	0.00	5.80	0.09	0.00	3.49	0.09
	Maximum Detection	9.27	0.00	10.90	24.70	0.00	5.80	24.70
	Mean	6.13	0.24	7.38	9.82	0.24	3.88	4.62
Acetone	Total Samples	10	10	10	10	10	10	60
	Hits	3	3	1	3	3	3	16
	Minimum Detection	3.49	5.09	17.70	3.99	5.27	5.85	3.49
	Maximum Detection	18.00	7.57	17.70	9.57	36.00	22.20	36.00
	Mean	9.47	4.91	9.75	6.56	9.29	7.34	7.88
Benzene	Total Samples	10	10	10	10	10	10	60
	Hits	5	0	6	1	0	0	12
	Minimum Detection	0.05	0.00	0.10	0.05	0.00	0.00	0.05
	Maximum Detection	0.08	0.00	0.13	0.05	0.00	0.00	0.13
	Mean	0.53	0.40	0.77	0.38	0.40	0.40	0.48
Carbon disulfide	Total Samples	10	10	10	10	10	10	60
	Hits	2	0	0	0	0	0	2
	Minimum Detection	0.15	0.00	0.00	0.00	0.00	0.00	0.15
	Maximum Detection	0.59	0.00	0.00	0.00	0.00	0.00	0.59
	Mean	1.32	0.90	1.80	0.90	0.90	0.90	1.12
Carbon tetrachloride	Total Samples	10	11	10	10	10	10	61
	Hits	0	0	0	0	0	8	8
	Minimum Detection	0.00	0.00	0.00	0.00	0.00	0.13	0.13
	Maximum Detection	0.00	0.00	0.00	0.00	0.00	0.27	0.27
	Mean	0.24	0.29	0.27	0.22	0.22	0.34	0.26
Chlorobenzene	Total Samples	10	10	10	10	10	10	60
	Hits	0	0	0	0	0	4	4
	Minimum Detection	0.00	0.00	0.00	0.00	0.00	0.08	0.08
	Maximum Detection	0.00	0.00	0.00	0.00	0.00	0.11	0.11
	Mean	0.24	0.22	0.27	0.22	0.22	0.25	0.24
Chloroethene	Total Samples	10	10	10	10	10	10	60
	Hits	6	0	6	0	0	1	13
	Minimum Detection	0.33	0.00	0.84	0.00	0.00	0.15	0.15
	Maximum Detection	1.87	0.00	2.49	0.00	0.00	0.15	2.49
	Mean	1.01	0.24	1.22	0.24	0.24	0.25	0.53

Table 6-2: Background Concentrations for TCL Volatile Organic Compounds, µg/L
(cont'd)

Analyte	well_name	DOB 1	DOB-2	DOB-7	DOB-8	DOB-10	DOB-12	Summary
Analyte	Data							
Chloroform	Total Samples	10	11	10	10	10	10	61
	Hits	0	8	0	0	8	8	24
	Minimum Detection	0.00	0.16	0.00	0.00	0.12	0.11	0.11
	Maximum Detection	0.00	0.40	0.00	0.00	0.22	0.27	0.40
	Mean	0.24	0.48	0.27	0.22	0.34	0.33	0.32
Dichloromethane	Total Samples	10	10	10	10	10	10	60
	Hits	7	6	8	5	6	7	39
	Minimum Detection	0.68	0.54	0.55	0.57	0.43	0.52	0.43
	Maximum Detection	3.60	1.19	14.80	1.34	1.26	2.64	14.80
	Mean	2.06	1.24	3.05	1.19	1.18	1.49	1.70
Ethylbenzene	Total Samples	10	10	10	10	10	10	60
	Hits	0	1	0	0	0	1	2
	Minimum Detection	0.00	0.16	0.00	0.00	0.00	1.63	0.16
	Maximum Detection	0.00	0.16	0.00	0.00	0.00	1.63	1.63
	Mean	0.24	0.23	0.27	0.22	0.22	0.28	0.24
Methyl ethyl ketone	Total Samples	10	10	10	10	10	10	60
	Hits	1	3	2	0	2	1	9
	Minimum Detection	0.92	1.08	1.31	0.00	0.87	7.94	0.87
	Maximum Detection	0.92	2.48	2.80	0.00	1.54	7.94	7.94
	Mean	1.39	1.32	2.11	0.90	1.04	1.64	1.40
Tetrachloroethylene	Total Samples	10	11	10	10	10	10	61
	Hits	10	0	10	9	0	10	39
	Minimum Detection	5.39	0.00	8.60	0.06	0.00	0.64	0.06
	Maximum Detection	13.70	0.00	16.40	5.07	0.00	1.35	16.40
	Mean	8.46	0.29	12.47	2.17	0.22	0.95	4.03
Toluene	Total Samples	10	10	10	10	10	10	60
	Hits	6	4	6	4	5	7	32
	Minimum Detection	0.07	0.07	0.07	0.07	0.05	0.06	0.05
	Maximum Detection	0.70	1.22	0.70	0.24	0.24	4.41	4.41
	Mean	0.38	0.44	0.63	0.35	0.33	0.66	0.46
Trichloroethylene	Total Samples	10	11	10	10	10	10	61
	Hits	10	0	10	6	0	10	36
	Minimum Detection	41.80	0.00	62.30	0.13	0.00	1.83	0.13
	Maximum Detection	87.50	0.00	118.00	0.74	0.00	3.61	118.00
	Mean	58.72	0.29	80.96	0.48	0.22	2.40	23.46
Xylenes	Total Samples	10	10	10	10	10	10	60
	Hits	1	2	0	2	2	3	10
	Minimum Detection	0.06	0.18	0.00	0.07	0.06	0.06	0.06
	Maximum Detection	0.06	0.21	0.00	0.21	0.24	3.66	3.66
	Mean	0.33	0.28	0.40	0.27	0.28	0.54	0.35
Total Samples		170	174	170	170	170	170	1024
Total Hits		69	27	64	38	26	72	296

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Table 6-3: Background Concentrations for Indicator Parameters, µg/L

well name		DOB 1	DOB 2	DOB 7	DOB 8	DOB 10	DOB 12	Summary
Analyte	Data							
Chemical oxygen demand	Total Samples	10	10	10	10	10	10	60
	Hits	7	8	9	3	6	3	36
	Minimum Detection	7,530	5,270	7,600	6,280	6,110	6,110	5,270.
	Maximum Detection	57,300	27,200	29,700	12,600	18,600	324,000	324,000
	Mean	16,383.00	11,040	17,865	3,232	8,423	39,691	16,105.67
Chloride	Total Samples	10	10	10	10	10	10	60
	Hits	10	10	10	10	10	10	60
	Minimum Detection	1,210.00	4,920.00	1,930.00	1,140.00	3,810.00	5,240.00	1,140.00
	Maximum Detection	1,440.00	6,050.00	2,670.00	3,820.00	4,340.00	5,770.00	6,050.00
	Mean	1,283.00	5,415.00	2,335.00	2,220.00	3,996.00	5,505.00	3,459.00
Nitrate-nitrite as nitrogen	Total Samples	7	7	7	7	7	7	42
	Hits	7	7	7	6	7	7	41
	Minimum Detection	350.00	660.00	160.00	100.00	540.00	1,040.00	100.00
	Maximum Detection	800.00	1,210.00	530.00	1,730.00	1,180.00	1,350.00	1,730.00
	Mean	535.71	884.29	237.14	855.71	720.00	1,237.14	745.00
Nitrate as nitrogen	Total Samples	3	3	3	3	3	3	18
	Hits	3	3	3	3	3	3	18
	Minimum Detection	797.00	617.00	128.00	33.80	562.00	1,100.00	33.80
	Maximum Detection	1,110.00	719.00	150.00	39.40	664.00	1,140.00	1,140.00
	Mean	972.33	657.67	142.33	36.20	623.00	1,116.67	591.37
pH	Total Samples	10	10	10	10	10	10	60
	Hits	10	10	10	10	10	10	60
	Minimum Detection	6.20	5.04	4.70	4.92	5.17	5.33	4.70
	Maximum Detection	6.71	5.31	5.02	7.01	5.72	5.73	7.01
	Mean	6.43	5.19	4.91	5.24	5.45	5.56	5.46
Specific conductance	Total Samples	10	10	10	10	10	10	60
	Hits	10	10	10	10	10	10	60
	Minimum Detection	21.60	57.30	78.50	17.20	49.00	62.40	17.20
	Maximum Detection	142.00	70.40	94.60	56.40	59.30	70.30	142.00
	Mean	103.06	62.59	86.03	39.32	54.07	67.54	68.77
Sulfate	Total Samples	10	10	10	10	10	10	60
	Hits	10	10	10	10	10	10	60
	Minimum Detection	11,500.00	9,210.00	21,700.00	5,200.00	6,970.00	6,990.00	5,200.00
	Maximum Detection	14,400.00	11,700.00	28,000.00	8,150.00	9,850.00	9,390.00	28,000.00
	Mean	12,800.00	10,443.00	24,000.00	7,064.00	7,943.00	8,376.00	11,771.00
Total organic carbon	Total Samples	10	11	10	10	10	10	61
	Hits	10	11	10	8	10	10	59
	Minimum Detection	1,390.00	2,380.00	572.00	413.00	1,910.00	1,040.00	413.00
	Maximum Detection	18,800.00	4,150.00	7,980.00	1,660.00	7,590.00	2,630.00	18,800.00
	Mean	6,316.00	3,312.73	6,257.20	897.15	2,919.00	1,355.00	3,506.29
Total organic halogens	Hits	10	11	10	10	10	10	61
	Minimum Detection	10	10	10	4	8	6	48
	Maximum Detection	23.60	8.88	38.90	5.16	2.32	6.64	2.32
	Mean	54.90	86.10	76.60	56.90	96.80	21.60	96.80
	MEAN	37.46	20.78	55.45	12.94	18.39	7.95	25.42
Total Samples		80	82	80	80	80	80	482
Total Hits		77	79	79	64	74	69	442

7.0 COMPARISON OF POST-IRA SAMPLES TO BACKGROUND VALUES

Post-IRA samples for the third monitoring event were collected from all six downgradient wells on 12/01/97. The results of the third semi-annual post-IRA sampling are presented on Table 7-1. The maximum concentration for each analyte from each well from the post-IRA samples was then compared to the tolerance interval. The results of the comparison are presented in Table 7-2. The following interprets the third semi-annual post-IRA sampling results.

TAL Metals

Aluminum exceeded the tolerance interval in DOB-10. Arsenic exceeded the tolerance interval in DOB-2. Lead was not detected in any sample from any of the wells. Chromium was only detected in DOB-2 at 1.3 µg/L but did not exceed the tolerance interval. Copper concentrations exceeded the tolerance intervals in DOB-1, 2, 7, 8, 10 and 12. Barium concentrations exceeded the tolerance intervals in DOB-7, 10 and 12. Iron concentrations exceeded the tolerance interval in DOB-2, 7, 8 and 10. Magnesium was not detected in any sample from any of the wells. Manganese concentrations exceeded the tolerance interval in DOB-2, 7, 10 and 12. Mercury exceeded its tolerance interval in DOB-2. Zinc also exceeded its tolerance interval in DOB-1, 2, 7 and 10.

Of the 120 tolerance intervals calculated for TAL metals, only 27 (or 19%) were exceeded. Conversely, 77.5% of the TAL metal concentrations were either less than the predicted tolerance interval or were not present at all in groundwater samples. Antimony, cadmium, lead, nickel, selenium, silver, vanadium and thallium, which were all detected at least once during background sampling, disappeared completely from the list of analytes detected in the 4Q97 post-IRA samples. No MCLs were exceeded for any of the TAL metals.

There does not appear to be any consistent pattern or trend for the presence of metal analytes in DOSB groundwater. Concentrations of some of the metals such as arsenic, cadmium, copper, silver, cobalt, lead, mercury, vanadium, zinc and beryllium appear to spike sporadically and then return to levels below detection limits. There appears to be a pattern of random distribution within the wells, indicating that analyte presence may be the result of sampling or measurement error. No long-term trend can be discerned from the data.

TCL Volatiles

1,2-Dichloroethylene (DCE) exceeded the tolerance interval in DOB-2. Benzene exceeds the tolerance interval in DOB 2 and 10. Chloroethene exceeded the tolerance interval in DOB-2, 10 and 12. Ethylbenzene exceeded the tolerance interval in DOB-10. Tetrachloroethylene (PCE) exceeded the tolerance intervals in DOB-10 (7.34 µg/L) and 12 (9.12 µg/L). Trichloroethylene (TCE) exceeded the predicted tolerance intervals in DOB-2 (21.6 µg/L), DOB-10 (39.1 µg/L) and DOB-12 (8.14 µg/L). Xylene exceeded the tolerance interval in DOB-10 (0.614 µg/L).

Of the 204 tolerance intervals calculated for TCL VOCs only 15 (or 7%) were exceeded. Conversely, 93% of the TCL VOC concentrations were either less than the predicted tolerance interval or were not present at all in groundwater samples. 1,1-Dichloroethylene, 1,2-dichloroethane, acetone, carbon disulfide, carbon tetrachloride, chloroform, Dichloromethane and methyl ethyl ketone, which were all detected at least once in background sampling, disappeared completely from the list of analytes detected in the 4Q97 post-IRA samples.

The results indicate that Chloroethene (vinyl chloride), has reappeared as a contaminant in groundwater. The maximum concentration was 39.1 µg/L in DOB-10. The reappearance of chloroethene correlates to the shutdown of the bio-vent system. Its presence is interpreted to mean that DOSB has returned to anoxic condition and indigenous bioremediation has resumed. Additionally, the only MCLs exceeded for TCL VOCs was for PCE (MCL=5.0 µg/L) in DOB-10

(7.34 µg/L) and DOB-12 (9.2 µg/L) and TCE (MCL = 5.0 µg/L) also in DOB-10 (39.1 µg/L), DOB-12 (8.14 µg/L) and DOB-2 (21.6 µg/L). Dichloromethane, a final CM-COC, was not detected in groundwater at all. The absence of dichloromethane is an indication that the testing of the bio-vent was successful in destroying this contaminant from basin soils.

Indicator Parameters

Indicator parameters cannot be interpreted in the same manner as the chemical parameters. By evaluating the relative levels of indicator parameters, it is possible to predict broad changes in the geochemistry and biochemistry of a water system and make general qualitative statements as to the overall nature of the water quality. Depending upon the parameter, a quantitative increase can indicate a positive, negative or neutral trend. Therefore, the following interpretation of indicator parameters will be qualitative.

Chemical oxygen demand (COD) is a measure of the amount of oxygen required to chemically oxidize organics dissolved in the groundwater. COD levels have increased in 3 of the 6, downgradient wells (maximum concentration 37.4 mg/L) but are still relatively low compared to municipal sewage or landfill leachate. Since these levels have increased slightly, it appears that oxygen levels have decreased in the groundwater. The increase in COD levels is related to the discontinuation of the bio-vent since an empirical relationship exists between COD and BOD (biological oxygen demand) levels.

Groundwater analyses indicate an increase in the levels of chloride in 3 of the downgradient wells. Chloride is produced as an end product of the biodegradation of chlorinated solvents. This indicates a probable combination of aerobic and anaerobic conditions still continuing to degrade the residual chlorinated solvents. The presence of sulfate is attributed to microbial degradation of petroleum compounds. Sulfate concentrations increased significantly in DOB-10 and 12 on the west side of the basin and are interpreted as very positive groundwater quality trends. Nitrates can exist in seven oxidation states in nature which can make nitrate data difficult to interpret. At DOSB the nitrate results are neutral, with two wells showing an increase in nitrate levels and four wells showing a decrease in nitrate levels. The probable explanation for the mixed results is a transition in the groundwater from an aerobic to an anaerobic system caused by discontinuing the testing of the bio-vent. Where nitrate levels are low may reflect where locations have greater numbers of aerobic nitrifying bacteria. Where nitrate levels are higher may indicate where anaerobic conditions still prevail and are associated with low dissolved oxygen (DO) levels.

There has been an increase in the total organic carbon concentration that is indicative of the use of organic carbon by microorganisms as a nutrient substrate. This is interpreted as a negative groundwater quality trend and is indicative of the system becoming more anaerobic, thus lowering biodegradation rates. Total Organic Halogen (TOX) levels have increased in 3 of the 6, downgradient wells. This is also a negative indication that biodegradation rates have slowed digestion of organic halogen compounds in groundwater. As a result, concentrations of PCE can be expected to decrease, while concentrations of VC can be expected to increase because of anaerobic digestion processes will predominate the system.

The results of indicator parameters reflect flux in the DOSB groundwater system again. It is apparent from the results, that the groundwater system is changing from an aerobic system to an anaerobic system and from an oxidizing system to a reducing system. The results are interpreted to indicate that the change in the groundwater system is attributable to the discontinuation of the bio-vent testing. Further chemical evidence is available to support this hypothesis. Table 7-3 illustrates a comparison of the pre-IRA maximum concentration of each analyte by well to the post-IRA maximum concentration of each analyte by well. The results are important in that the reappearance of chloroethene is directly related to the increase in anaerobic degradation within the system, especially on the west side of the basin which was the most contaminated portion of DOSB. Generally, PCE concentrations have decreased which is also

indicative of increased anaerobic conditions within the system. COD and total organic carbon (TOC) levels have also increased in three of the downgradient wells also located on the west side of the basin and is clear evidence of the impact of the discontinuation of the bio-vent. Because biodegradation rates are slower under anaerobic conditions the rate of digestion of TOC will also be slower. There still appears to be significant indigenous anaerobic microbial degradation occurring since chloride levels have significantly increased indicating destruction of chlorinated solvents.

8.0 CONCLUSION

It is concluded from evaluation of the chemical data, from the time of the IRA to the 4Q97 post-IRA samples, that there is no significant evidence of negative impact or release of hazardous substances to the groundwater caused by the IRA. Based upon the chemical data, it appears that groundwater quality is still significantly improved since the time of the IRA. This is evidenced by the fact that there were no MCL exceedances for any of the TAL metals and the complete disappearance of dichloromethane, a CM-COC, in groundwater. Maximum concentrations of other organic compounds, such as TCE and PCE, have significantly decreased since the time of the IRA. The maximum concentration of 4Q97 samples of PCE compared to pre-IRA samples has decreased from 16.4 $\mu\text{g/L}$ to 9.12 $\mu\text{g/L}$ and the maximum concentration of TCE has decreased from 118 $\mu\text{g/L}$ to 39.1 $\mu\text{g/L}$.

The only compound that counters this trend is chloroethene (VC). VC was not detected in any of the 2Q97 groundwater samples while the bio-vent was being testing. VC was not disposed in the DOSB and its presence is attributable to the anaerobic degradation of TCE and PCE. Under anaerobic conditions PCE is degraded and concentrations will decrease based upon first-order biodegradation rates. The degradation chain then becomes PCE-TCE-DCE-VC. This is also referred to as reductive dechlorination. Under aerobic conditions PCE is not degraded and concentrations remain constant. The degradation chain then becomes TCE-DCE-ethylene.

Since bio-vent testing was discontinued, VC has reappeared as a contaminant in groundwater (maximum concentration of 47.2 $\mu\text{g/L}$ in DOB-10). The production of VC at DOSB is a predictable biochemical process caused by reductive dechlorination under anoxic conditions. Since the production rates for VC under anoxic conditions is low, and the destruction rates for VC were high during bio-vent testing, VC disappeared. Since bio-vent testing has been terminated, VC concentrations will return and remain persistent under anoxic conditions.

However, DOSB still evidences indigenous anaerobic biodegradation and overall groundwater quality should improve with time.

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TABLE 7-1: MAXIMUM CONCENTRATIONS DETECTED IN POST-IRA GROUNDWATER SAMPLES, µg/L

		well_name						
analyte_name	Data	DOB 1	DOB 2	DOB 7	DOB 8	DOB 10	DOB 12	Grand Total
1,2-Dichloroethylene	Total Detections	1	1	1	1	1	1	1
	Maximum Concentration	ND	11.7	ND	ND	ND	ND	11.7
Aluminum, total recoverable	Total Detections	1	1	1	1	1	1	4
	Maximum Concentration	118	15.8	66.8	ND	6930	ND	6930
Arsenic, total recoverable	Total Detections	1	1	1	1	1	1	1
	Maximum Concentration	ND	4.2	ND	ND	ND	ND	4.2
Barium, total recoverable	Total Detections	1	1	1	1	1	1	6
	Maximum Concentration	7.48	29	56.9	10.6	107	31.4	107
Benzene	Total Detections	1	1	1	1	1	1	2
	Maximum Concentration	ND	0.266	ND	ND	1.44	ND	1.44
Beryllium, total recoverable	Total Detections	1	1	1	1	1	1	1
	Maximum Concentration	ND	ND	ND	ND	0.64	ND	0.64
Calcium, total recoverable	Total Detections	1	1	1	1	1	1	6
	Maximum Concentration	3360	2800	3490	1450	19000	4060	19000
Chemical oxygen demand	Total Detections	1	1	1	1	1	1	5
	Maximum Concentration	10000	37400	13000	ND	28000	10000	37400
Chloride	Total Detections	1	1	1	1	1	1	6
	Maximum Concentration	1320	4180	2830	672	5240	6600	6600
Chlorobenzene	Total Detections	1	1	1	1	1	1	2
	Maximum Concentration	ND	1.1	ND	ND	ND	0.412	1.1
Chloroethene (Vinyl chloride)	Total Detections	1	1	1	1	1	1	3
	Maximum Concentration	ND	2.2	ND	ND	47.2	2.29	47.2
Chromium, total recoverable	Total Detections	1	1	1	1	1	1	1
	Maximum Concentration	ND	1.3	ND	ND	ND	ND	1.3
Cobalt, total recoverable	Total Detections	1	1	1	1	1	1	1
	Maximum Concentration	ND	ND	ND	ND	7.15	ND	7.15
Copper, total recoverable	Total Detections	1	1	1	1	1	1	6
	Maximum Concentration	84.3	6.83	2.76	6.18	6.19	14.5	84.3
Ethylbenzene	Total Detections	1	1	1	1	1	1	1
	Maximum Concentration	ND	ND	ND	ND	0.202	ND	0.202
Iron, total recoverable	Total Detections	1	1	1	1	1	1	5
	Maximum Concentration	90.7	339	219	117	23300	ND	23300
Manganese, total recoverable	Total Detections	1	1	1	1	1	1	6
	Maximum Concentration	2.58	13.1	172	2.67	669	107	669
Mercury, total recoverable	Total Detections	1	1	1	1	1	1	1
	Maximum Concentration	ND	0.216	ND	ND	ND	ND	0.216
Nickel, total recoverable	Total Detections	1	1	1	1	1	1	2
	Maximum Concentration	ND	2.9	ND	ND	28.3	ND	28.3
Nitrate-nitrite as nitrogen	Total Detections	1	1	1	1	1	1	4
	Maximum Concentration	726	805	349	ND	ND	946	946
pH	Total Detections	1	1	1	1	1	1	6
	Maximum Concentration	6.7	5.2	5.1	5.2	4.4	5.5	6.7
Potassium, total recoverable	Total Detections	1	1	1	1	1	1	6
	Maximum Concentration	3220	2230	3770	2040	3670	3020	3770
Sodium, total recoverable	Total Detections	1	1	1	1	1	1	6
	Maximum Concentration	860	2370	2450	567	6070	5640	6070
Specific conductance	Total Detections	1	1	1	1	1	1	5
	Maximum Concentration	78	49	80	ND	419	78	419
Sulfate	Total Detections	1	1	1	1	1	1	6
	Maximum Concentration	7200	7970	25100	5850	188000	12300	188000
Tetrachloroethylene	Total Detections	1	1	1	1	1	1	5
	Maximum Concentration	0.495	2.59	3.02	ND	7.34	9.12	9.12
Toluene	Total Detections	1	1	1	1	1	1	1
	Maximum Concentration	ND	ND	ND	ND	0.208	ND	0.208
Total organic carbon	Total Detections	1	1	1	1	1	1	4
	Maximum Concentration	ND	10000	5000	ND	16000	9000	16000
Total organic halogens	Total Detections	1	1	1	1	1	1	6
	Maximum Concentration	26.3	44.3	19.7	9.74	210	38.4	210
Trichloroethylene	Total Detections	1	1	1	1	1	1	5
	Maximum Concentration	0.762	21.6	3.96	ND	39.1	8.14	39.1
Xylenes	Total Detections	1	1	1	1	1	1	1
	Maximum Concentration	ND	ND	ND	ND	0.614	ND	0.614
Zinc, total recoverable	Total Detections	1	1	1	1	1	1	5
	Maximum Concentration	33.5	27.8	22.5	ND	107	12.4	107
Total Detections		18	27	19	11	26	19	120

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TABLE 7-2: COMPARISON OF POST-IRA SAMPLES TO PREDICTED TOLERANCE INTERVALS, µg/L

ANALYTE	DOB 1		DOB 2		DOB 7		DOB 8		DOB 10		DOB 12	
	Max	95 UCL	Max	95 UCL	Max	95 UCL	Max	95 UCL	Max	95 UCL	Max	95 UCL
Volatile Organic Compounds, µg/L												
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethylene	ND	0.61	ND	ND	ND	0.60	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	0.60	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethylene	ND	7.56	11.7	ND	ND	9.00	ND	15.29	ND	ND	ND	4.60
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Hexanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	ND	14.58	ND	6.47	ND	16.23	ND	8.93	ND	16.35	ND	11.75
Benzene	ND	0.96	0.266	ND	ND	1.31	ND	0.56	1.44	ND	ND	ND
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	ND	2.18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.54
Chlorobenzene	ND	ND	1.1	ND	ND	ND	ND	ND	ND	ND	0.412	0.47
Chloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethene	ND	1.34	2.2	ND	ND	1.55	ND	ND	47.2	ND	2.29	0.47
Chloroform	ND	ND	ND	0.66	ND	ND	ND	ND	ND	0.53	ND	0.53
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichloromethane	ND	3.03	ND	1.99	ND	5.47	ND	1.96	ND	1.93	ND	2.24
Ethylbenzene	ND	ND	ND	0.46	ND	ND	ND	ND	0.202	ND	ND	0.59
Methyl ethyl ketone	ND	2.22	ND	1.84	ND	3.09	ND	ND	ND	1.50	ND	2.94
Methyl isobutyl ketone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethylene	0.495	10.08	2.59	ND	3.02	13.85	ND	3.13	7.34	ND	9.12	1.10
Toluene	ND	0.59	ND	0.64	ND	1.04	ND	0.54	0.208	0.53	ND	1.40
trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	0.762	66.39	21.6	ND	3.96	90.14	ND	0.68	39.1	ND	8.14	2.70
Vinyl acetate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylenes	ND	0.55	ND	0.49	ND	ND	ND	0.48	0.614	0.49	ND	1.16
Metals, µg/L												
Aluminum	118	340.02	15.8	55.37	66.8	107.17	ND	99.68	6930	650.92	ND	81.76
Antimony	ND	2.53	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	ND	2.53	4.2	2.54	ND	ND	ND	ND	ND	2.54	ND	ND
Barium	7.48	15.33	29	29.50	56.9	48.89	10.6	21.09	107	23.17	31.4	20.09
Beryllium	ND	ND	ND	0.67	ND	ND	ND	ND	0.64	ND	ND	0.72
Cadmium	ND	1.07	ND	1.07	ND	0.64	ND	1.05	ND	ND	ND	ND
Chromium	ND	2.03	1.3	1.96	ND	1.99	ND	1.83	ND	3.16	ND	1.92
Cobalt	ND	1.65	ND	1.10	ND	1.12	ND	1.05	7.15	1.24	ND	1.06
Copper	84.3	62.54	6.83	2.37	2.76	1.76	6.18	2.02	6.19	7.40	14.5	5.16
Iron	90.7	374.77	339	236.36	219	20.82	117	49.59	23300	197.01	ND	78.42
Lead	ND	3.37	ND	2.55	ND	2.98	ND	ND	ND	7.42	ND	ND
Magnesium	ND	9478	ND	1998	ND	4293	ND	822	ND	2110	ND	903.27
Manganese	2.58	5.83	13.1	14.75	172	164.39	2.67	6.03	669	11.02	107	66.11
Mercury	ND	0.08	0.216	0.17	ND	0.14	ND	0.16	ND	0.12	ND	0.10
Nickel	ND	4.88	2.9	4.37	ND	4.86	ND	5.28	28.3	5.30	ND	3.08
Selenium	ND	2.63	ND	ND	ND	ND	ND	2.55	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Thallium	ND	ND	ND	ND	ND	ND	ND	2.50	ND	ND	ND	ND
Vanadium	ND	2.98	ND	3.03	ND	4.45	ND	1.66	ND	2.44	ND	3.66
Zinc	33.5	10.57	27.8	24.89	22.5	4.59	ND	4.10	107	7.69	12.4	13.92
Indicator Parameters, µg/L												
Chemical oxygen demand	10000	25567.97	37400	16299.16	13000	22031.56	ND	5787.01	28000	12036.07	10000	95670.54
Chloride	1320	1323.16	4180	5649.25	2830	2487.88	672	2817.41	5240	4097.57	6600	5621.40
Nitrate as nitrogen	ND	663.51	ND	1030.47	ND	326.55	ND	1370.02	ND	866.72	ND	1321.49
Nitrate-nitrite as nitrogen	726	1149.66	805	717.62	349	156.11	ND	39.40	ND	682.74	946	1139.76
pH (pH units)	6.7	6.34 - 6.53	5.2	5.14 - 5.24	5.1	4.84 - 4.98	5.2	4.81 - 5.66	4.4	5.35 - 5.54	5.5	5.48 - 5.64
Specific conductance (USCM)	78	121.13	49	64.72	80	88.62	ND	46.22	419	55.91	78	69.10
Sulfate	7200	13360.19	7970	10949.61	25100	25154.94	5850	7628.64	188000	8480.19	12300	8788.75
Total organic carbon	7000	8853.21	10000	3626.07	5000	7388.66	ND	1140.75	16000	3846.49	9000	1611.22
Total organic halogens	26.3	44.07	44.3	32.71	19.7	61.39	9.74	22.13	210	33.95	38.4	10.81

ND=Analyzed but not detected.

Red font indicates maximum concentration exceeds 95th UCL.

**THIRD SEMI-ANNUAL GROUNDWATER MONITORING
REPORT FOR THE INTERIM REMEDIAL ACTION
D-AREA OIL SEEPAGE BASIN**

WSRC-RP-98-4110

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TABLE 7-3: COMPARISON OF MAXIMUM CONCENTRATION DETECTED IN POST-IRA SAMPLES TO MAXIMUM CONCENTRATION IN PRE-IRA SAMPLES, µg/L

ANALYTE	DOB 1		DOB 2		DOB 7		DOB 8		DOB 10		DOB 12	
Volatile Organic Compounds, µg/L	Post-IRA	Pre-IRA	Post-IRA	Pre-IRA	Post-IRA	Pre-IRA	Post-IRA	Pre-IRA	Post-IRA	Pre-IRA	Post-IRA	Pre-IRA
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethylene	ND	0.42	ND	ND	ND	0.42	ND	ND	ND	0.45	ND	0.45
1,2-Dichloroethane	ND	0.96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethylene	ND	9.27	11.7	ND	ND	10.90	ND	24.70	ND	ND	ND	5.80
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Hexanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	ND	18.00	ND	7.57	ND	17.70	ND	9.57	ND	36.00	ND	22.20
Benzene	ND	0.08	0.226	ND	ND	0.13	ND	0.05	1.44	ND	ND	ND
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	ND	0.59	ND	1.36	ND	2.83	ND	1.36	ND	1.36	ND	1.36
Carbon tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.27
Chlorobenzene	ND	ND	1.1	ND	ND	ND	ND	ND	ND	ND	0.412	0.11
Chloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethene	ND	1.87	2.2	ND	ND	2.49	ND	ND	47.2	ND	2.29	0.15
Chloroform	ND	ND	ND	0.40	ND	ND	ND	ND	ND	0.22	ND	0.27
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichloromethane	ND	3.60	ND	1.19	ND	14.80	ND	1.34	ND	1.26	ND	2.64
Ethylbenzene	ND	ND	ND	0.16	ND	ND	ND	ND	0.202	ND	ND	1.63
Methyl ethyl ketone	ND	0.92	ND	2.48	ND	2.80	ND	ND	ND	1.54	ND	7.94
Methyl isobutyl ketone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethylene	0.495	13.70	2.59	ND	3.02	16.40	ND	5.07	7.34	ND	9.12	1.35
Toluene	ND	0.70	ND	1.22	ND	0.07	ND	0.24	0.208	0.24	ND	4.41
trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	0.762	87.50	21.6	ND	3.96	118.00	ND	0.74	39.1	ND	8.14	3.61
Vinyl acetate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylenes	ND	0.55	ND	0.49	ND	0.63	ND	0.48	0.614	0.49	ND	1.16
Metals, µg/L	Post-IRA	Pre-IRA	Post-IRA	Pre-IRA	Post-IRA	Pre-IRA	Post-IRA	Pre-IRA	Post-IRA	Pre-IRA	Post-IRA	Pre-IRA
Aluminum	118	774	15.8	107	66.8	138	ND	180	6930	2170	ND	179
Antimony	ND	1.64	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	ND	2.11	4.2	2.03	ND	ND	ND	ND	ND	1.99	ND	ND
Barium	7.48	16.2	29	31	56.9	52.2	10.6	23.2	107	33.5	31.4	20.7
Beryllium	ND	ND	ND	0.026	ND	ND	ND	0.015	0.64	ND	ND	0.211
Cadmium	ND	0.099	ND	0.109	ND	0.23	ND	0.319	ND	ND	ND	ND
Chromium	ND	2.53	1.3	2.14	ND	2.63	ND	1.98	ND	7.73	ND	2.67
Cobalt	ND	0.239	ND	0.672	ND	0.558	ND	0.523	7.15	0.324	ND	0.932
Copper	84.3	96.2	6.83	2.74	2.76	2.27	6.18	3.33	6.19	17.4	14.5	12.3
Iron	90.7	955	339	542	219	39.1	117	110	23300	654	ND	130
Lead	ND	5.06	ND	2.26	ND	3.77	ND	ND	ND	16.3	ND	ND
Magnesium	ND	11400	ND	2070	ND	4520	ND	905	ND	2350	ND	929
Manganese	2.58	8.92	13.1	17.6	172	177	2.67	9.68	669	14.3	107	70.1
Mercury	ND	0.049	0.216	0.436	ND	0.224	ND	0.373	ND	0.215	ND	0.112
Nickel	ND	1.93	2.9	2.51	ND	1.2	ND	1.17	28.3	5.14	ND	2.43
Selenium	ND	ND	ND	ND	ND	ND	ND	1.45	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Thallium	ND	ND	ND	ND	ND	ND	ND	2.48	ND	ND	ND	ND
Vanadium	ND	4.16	ND	0.816	ND	0.387	ND	0.818	ND	1.18	ND	1.87
Zinc	33.5	14.50	27.8	67.30	22.5	9.27	ND	7.22	107	17.3	12.4	20.9
Indicator Parameters, µg/L	Post-IRA	Pre-IRA	Post-IRA	Pre-IRA	Post-IRA	Pre-IRA	Post-IRA	Pre-IRA	Post-IRA	Pre-IRA	Post-IRA	Pre-IRA
Chemical oxygen demand	10000	57300	37400	27200	13000	29700	ND	12600	28000	18600	10000	324000
Chloride	1320	1440	4108	6050	2830	2670	672	3820	5240	4340	6600	5770
Nitrate as nitrogen	ND	800	ND	1210	ND	530	ND	1730	ND	1180	ND	1350
Nitrate-nitrite as nitrogen	726	1110	805	719	349	150	ND	39.40	ND	664	946	1140
pH (pH units)	6.7	6.71	5.2	5.31	5.1	5.02	5.2	7.01	4.4	5.72	5.5	5.73
Specific conductance (USCM)	78	142	49	70.40	80	94.60	ND	56.40	419	59.30	78	70.30
Sulfate	7200	14400	7970	11700	25100	28000	5850	8150	188000	9850	1230	9390
Total organic carbon	ND	18800	10000	4150	5000	7980	ND	1660	16000	7590	9000	2630
Total organic halogens	26.3	54.90	44.3	86.10	19.7	76.60	9.74	56.90	210	96.80	38.4	21.60

ND=Analyzed but not detected.

Green font indicates decreasing concentration.

Red font indicates increasing concentration.