

5.0 Five-Year Review Findings

5.1 Five-Year Review Process

The format of the NRF Five-Year Review Document is patterned after the October 1999 EPA guidance document for Five-Year Reviews. Since NRF is an operating DOE facility, some of the suggested text based on the guidance document does not apply to NRF. For example, a formal review team was not created to conduct this work. The primary authors of the NRF Five-Year Review Document were essentially the same as those who designed and implemented the remedies discussed in the ROD. As such, the need to extensively interview individuals associated with original work was not necessary.

There were several main tasks associated with the NRF Five-Year Review, all of which were designed to accomplish one goal; that is, to determine whether the selected remedies remain protective of human health and the environment. There are other associated goals, such as reassessing the monitoring programs to see if the right constituents are being monitored, or if the frequency of sampling and the number of wells are correct. Overall, these goals are subordinate to the one major goal. The steps taken in accomplishing the tasks included an extensive review of past NRF documents, site inspections, risk information review, and an extensive analysis of soil gas and groundwater monitoring data. These are discussed below.

5.2 Site Inspection

5.2.1 Overview of Site Inspection Activities

Since NRF is an active facility, and since all of the sites and activities covered in this report are located at NRF, special efforts for inspecting the various remedies were not necessary. Periodic inspections are performed as a matter of routine. Results of these inspections are discussed below. Many photographs have been taken of the landfill cover, soil gas probes, and monitoring wells. Some of these photographs are presented in Appendix C.

5.2.1.1 Landfill Inspection

Annual landfill cover inspections are required as stated in the O&M Plan that was included in the Final Remedial Action Report for the NRF Inactive Landfill Areas. The following is a summary of the annual inspections performed from 1997 to 1999.

The 1997 annual inspection revealed that all three landfill covers were sparsely vegetated with the required vegetation. Instead, an abundance of weeds were in place which required mowing at all three landfill areas. Therefore, a contract was drafted to re-seed all three landfill areas including the addition of fertilizer. The fertilizing and re-seeding occurred during the fall of 1997.

The 1998 annual inspection that took place during the early fall, revealed that two out of the three landfill areas had adequate vegetation with some weeds. Only minor bare spots in the vegetative cover were observed at both Sites 8-05-51 and 8-06-53. Site 8-06-53 had the best density and the healthiest plants of desired vegetation of all of the landfill areas. Site 8-05-1 was still largely vegetated with weeds, although some of the desired vegetation was starting to take root. Therefore, NRF decided to leave the area alone to see if the desired vegetation would flourish during the next growing season. In addition, the 1998 annual inspection revealed

some minor signs of erosion along the west side slope of the 8-05-01 cover that appeared to be the result of storm water runoff; however, no repairs were warranted.

The 1999 annual inspection, performed during the early fall, showed that sites 8-05-51 and 8-06-53 remained sound, but revealed that Site 8-05-1 was still inadequately vegetated with the desired vegetation. However, a higher density of desired vegetation was observed than the previous year. The majority of the plants were immature except near the top of the cover where more mature plants were observed. NRF decided to inspect the site again during the early summer to see if the desired vegetation density would increase to a more acceptable level before deciding whether to re-seed and fertilize the site. Re-inspection of site 8-05-1 during September 2000 showed that re-seeding would be necessary over at least half the area of the cap. Re-seeding will be done when weather conditions and soil moisture content permit. Inspections also revealed that no increase in erosion from the previous year was observed at any of the landfill cover sites.

Photographs of the landfill covers are shown in Appendix C. A copy of a blank landfill inspection form is located in Appendix D.

5.2.1.2 Groundwater Monitoring Well Inspection

The USGS, the organization contracted to collect NRF groundwater samples, also inspects wells during the sampling process. Any problems with the wells are reported to NRF personnel. Maintenance or repairs are handled through the USGS and their standing arrangement with local well drilling companies under the direction of NRF. More complicated problems are dealt with by NRF directly. NRF personnel also periodically inspect well locations. As of the last inspection, no problems with the wells are known to exist. A photograph showing the physical appearance of a groundwater monitoring well is shown in Appendix C.

5.2.1.3 Soil Gas Monitoring Probe Inspection

Annual inspections of the soil gas monitoring probes and benchmarks are required by the O&M plan. During the inspections that were conducted from 1997 to 1999, the only problems noted included the observation in 1997 that soil gas monitoring probe MW1-2 located at Site 8-05-1 was plugged and that soil gas monitoring probe MW1-1, also located at Site 8-05-1, was partially plugged. Methods for remedying the problems are being investigated. These two probes are located in an area of the site where the least amount of waste was deposited. No other construction related problems of concern were noted. Photographs showing the physical appearance of the soil gas probes are shown in Appendix C.

5.3 Data Review

5.3.1 Groundwater Monitoring Results

Since this is the first major Five-Year Review for NRF, this report will present a comprehensive summary of the data. For clarity, data will be presented by category, as inorganic, organic, and radiological data. Each of these categories possesses its own sub-groups. The period of time covered by this report will be from the well's construction or initial inclusion into the monitoring network up through the end of 1999. As discussed in Section 3 of this report, the constituents included for monitoring have changed over the past 10 years. The data presented herein will reflect current constituents. All constituents that were originally included as a groundwater

monitoring constituent at NRF, but then later dropped, occurred at low concentrations or were gathered for information only; therefore, they are not discussed in this report.

5.3.1.1 Inorganic Data

Inorganic data will include three sub-groups: metals, salts, and nutrients. Detailed analysis results and summary statistics are presented in Appendix E. A summary is presented in Tables 8 and 9 below.

5.3.1.1.1 Metals

Constituents included in the metal sub-group are aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium (total), copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc. Results are summarized in Tables 1 and 2 of Appendix E.

5.3.1.1.2 Salts

Constituents included in the salt sub-group are calcium, chloride, magnesium, potassium, sodium, and sulfate. Results are summarized in Table 3 of Appendix E.

5.3.1.1.3 Nutrients

Constituents included in the nutrients sub-group are nitrate (as N), nitrite (as N), Total Kjeldahl Nitrogen (TKN), phosphorus, Total Organic Carbon (TOC), and Total Organic Halogens (TOX). Results are summarized in Table 4 of Appendix E.

5.3.1.2 Organic Data

NRF groundwater samples are analyzed for volatile and semi-volatile constituents once each year. As a rule, most NRF wells are not expected to contain organic constituents; however, in the past, organic compounds were used at NRF and discarded into the Landfill Sites, so monitoring for these compounds is still performed.

Most organic compounds are not present or detectable in water monitored by NRF; however, low levels of some organic compounds were found in water collected from NRF-6, NRF-8, NRF-9, USGS-12, USGS-97, USGS-98, USGS-99 and, USGS-102. These compounds include tetrachloroethylene (PCE), 1,1,1-trichloroethane (TCA), naphthalene, di(2-ethylhexyl)phthalate), and chloroform. Chloroform is a potential degradation product of carbon tetrachloride. Carbon tetrachloride was known to be used in the past at NRF. Naphthalene is a gasoline additive and phthalates are common laboratory contaminants. Dichloromethane, TCA, and 1,2,4-trimethylbenzene occurred at their MDLs, which may indicate uncertain detection. Organic compounds were detected in two quality assurance samples (Field Blanks) collected at NRF-8 and USGS-99 during August 1998 and September 1997, respectively, and one replicate collected at NRF-9 during September 1997. These compounds include dichloromethane, naphthalene, ethylbenzene, toluene, 1,2,4-trimethylbenzene, m- & p-xylenes, and 1,1-dichloropropanone (as a result of a library search; the origin of the compound is unknown). All these compounds (except 1,1-dichloropropanone) are components in, or byproducts of, the combustion of hydrocarbon fuels (gasoline, diesel, and heating oils).

All organic compounds occurred at levels well below any Federal drinking water standards. Many of these compounds were found in samples of soil gas collected from the Landfill Sites,

also in low concentrations. However, because of the infrequent and low-level occurrence of organics in NRF groundwater, a detailed listing of organic results is not presented here. A full accounting of organic data has been published in four USGS Open-File Reports (00-236; 99-272; 97-806; 95-725; and, 93-34). Table 10 is a summary of all detections of organic compounds in NRF groundwater and Quality Assurance samples.

5.3.1.3 Radiological Data

Constituents included in the radiological group are gross alpha (as thorium-230), gross beta (as cesium-137), strontium-90, tritium, and quantitative isotopic gamma. Results (except quantitative isotopic gamma) are provided in Table 5 of Appendix E, and are summarized in Table 9.

Quantitative isotopic gamma results are not presented because detections (other than cesium-137) are sporadic, and then at very low activity levels. They are used by NRF for information. For the purposes of this report, the five radiological parameters shown in Table 9 provide adequate information.

5.3.2 Analysis of Groundwater Data

This section of the Five-Year Review analyzes the NRF groundwater data for trends, abnormalities, and compliance with groundwater regulations. The purpose of these analyses is to determine the effectiveness of the preferred remedy at protecting the environment. The first task will be to perform a statistical review of the data. The next task will be searching the data for trends.

5.3.2.1 Statistical Review

The statistical review presented here will center on comparison of long term monitoring results to several different benchmarks. These benchmarks will be Federal drinking water guidelines, regional background concentrations, and local background concentrations. The purpose of comparing to Federal drinking water levels will be to determine compliance with Federal regulations. Comparison of NRF groundwater quality to various background concentrations is designed to assess the relative impact that NRF operations have had on the aquifer. The results of these comparisons, including trend analyses, will be used to reanalyze risk associated with the selected remedies and to confirm the overall effectiveness of the remedies.

5.3.2.1.1 Background Concentration Determination and Discussion

Researchers at the INEEL (Orr et al, 1991; Knobel et al, 1992) have collected thousands of groundwater data points from many parts of the upper Snake River Plain, both on and off the INEEL. These data were used to establish background concentration levels for various groundwater constituents found at the INEEL. These data, collectively termed regional background, are the broadest measure for comparison applicable to NRF. The benefit of this comparison is to allow NRF groundwater data to be easily compared with groundwater quality data at other INEEL sites. The problem with this comparison, however, is that regional background is derived from data collected over such a large area that it may not accurately reflect water quality directly upgradient or adjacent to NRF.

To concentrate on the NRF area specifically, local background (upgradient) values were determined. Several difficulties were encountered in determining local background constituent

Table 8 Statistical Summary of Groundwater Data (Metals µg/L)

Well Number	Date Sampled	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
NRF-6	Mean	49	0.8	4.0	85	2.5	0.6	45.5	2.6	782	2.5	10.3	0.1	18.8	3.1	0.8	0.7	14.3
	Std. Dev.	38	0.5	0.7	14	4.0	0.4	67.6	2.3	1081	8.7	7.7	0.0	12.3	1.3	0.3	2.0	7.9
	Max	100	2.5	5.0	100	10.0	1.0	400.0	10.0	5100	50.0	35.9	0.2	48.0	5.0	1.0	8.6	37.0
	Min	10	0.2	3.0	58	0.0	0.0	1.0	1.0	70	0.4	1.4	0.0	4.0	1.9	0.2	0.1	2.7
NRF-7	Mean	148	0.7	2.5	76	2.5	0.6	11.5	5.9	600	2.6	10.5	0.1	6.1	2.2	0.8	0.3	18.7
	Std. Dev.	127	0.3	1.5	22	4.0	0.4	3.9	14.4	1019	8.4	6.3	0.0	2.5	1.8	0.3	0.2	24.3
	Max	560	1.1	5.0	100	10.0	1.0	27.0	67.0	4800	50.0	24.0	0.2	11.0	5.0	1.0	0.5	120.0
	Min	44	0.2	1.0	51	0.5	0.1	1.0	1.0	70	0.4	3.3	0.1	1.0	0.9	0.2	0.0	5.1
NRF-8	Mean	92	0.6	3.0	121	0.6	0.5	6.6	4.7	140	4.3	6.2	0.2	5.4	3.5	0.6	0.2	11.9
	Std. Dev.	116	0.2	1.6	15	0.3	0.3	1.2	3.7	168	12.2	4.2	0.1	3.9	1.4	0.3	0.2	6.9
	Max	500	1.0	5.0	140	1.7	1.0	9.5	10.0	570	50.0	10.0	0.2	10.0	5.0	1.0	0.5	25.0
	Min	10	0.5	1.0	100	0.5	0.0	5.0	1.7	10	0.2	0.7	0.1	1.0	2.0	0.1	0.0	3.1
NRF-9	Mean	69	0.6	2.9	127	0.6	0.5	11.3	4.6	110	4.0	6.7	0.2	5.4	3.3	0.6	0.2	14.9
	Std. Dev.	38	0.2	1.7	17	0.3	0.3	3.0	3.8	106	12.3	3.9	0.0	4.0	1.4	0.3	0.2	6.2
	Max	110	1.0	5.0	150	1.6	1.0	21.0	10.0	450	50.0	10.0	0.2	10.0	5.0	1.0	0.5	24.0
	Min	10	0.5	1.0	100	0.5	0.0	8.2	2.0	18	0.3	1.2	0.1	1.0	2.0	0.1	0.0	4.8
NRF-10	Mean	403	0.6	3.5	127	0.6	0.4	13.2	5.7	553	4.5	15.5	0.2	16.8	3.3	0.6	0.2	15.2
	Std. Dev.	565	0.2	2.2	16	0.3	0.3	3.1	7.5	806	12.6	17.3	0.0	9.5	1.4	0.2	0.2	9.2
	Max	2000	1.0	9.0	150	1.8	1.0	20.0	30.0	2900	50.0	60.0	0.2	34.0	5.0	1.0	0.5	38.0
	Min	43	0.5	1.3	100	0.5	0.0	9.5	1.1	38	0.4	0.7	0.1	3.0	1.6	0.2	0.0	4.9

Table 8 Statistical Summary of Groundwater Data (Metals µg/L) (continued)

Well	Date	Number Sampled	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
NRF-11	Mean	92	0.6	3.7	129	0.5	0.5	17.9	6.2	181	4.1	5.6	0.3	10.4	3.5	0.7	0.6	14.9	
	Std. Dev.	46	0.2	2.1	18	0.0	0.3	3.9	6.9	182	12.2	3.9	0.4	4.7	1.4	0.7	1.3	6.5	
	Max	220	1.0	9.0	150	0.5	1.0	25.0	28.0	680	50.0	10.0	1.7	20.0	5.0	3.0	5.2	31.0	
	Min	40	0.5	1.7	100	0.5	0.2	13.5	2.0	37	0.3	1.0	0.1	3.0	2.0	0.1	0.0	5.5	
NRF-12	Mean	75	0.8	3.0	154	0.5	0.5	45.1	4.9	256	4.1	6.0	0.2	19.1	3.2	0.7	0.2	14.1	
	Std. Dev.	35	0.6	1.6	30	0.0	0.3	85.4	3.7	465	12.2	3.9	0.0	16.5	1.4	0.6	0.2	5.7	
	Max	120	2.8	5.0	200	0.5	1.0	360.0	10.0	1900	50.0	10.0	0.2	50.0	5.0	2.0	0.5	23.0	
	Min	10	0.5	1.4	100	0.5	0.0	14.1	2.0	10	0.3	0.2	0.1	1.0	1.8	0.1	0.0	6.3	
NRF-13	Mean	4002	0.6	3.2	104	0.5	0.4	42.6	6.8	4485	4.8	67.0	0.2	16.6	2.8	0.9	0.2	19.1	
	Std. Dev.	5172	0.2	1.7	19	0.0	0.4	21.1	6.8	5512	12.1	79.8	0.0	14.0	1.8	0.7	0.2	17.2	
	Max	19200	1.0	5.0	150	0.5	1.0	92.0	30.0	20500	50.0	300.0	0.2	41.8	5.0	2.0	0.5	70.0	
	Min	10	0.5	1.0	79	0.5	0.1	25.0	1.4	820	0.3	2.4	0.1	0.0	0.9	0.5	0.0	9.1	
USGS-12	Mean	51	0.7	2.6	120	4.5	0.7	6.7	1.9	215	2.3	8.3	0.1	2.9	2.6	0.9	0.3	14.0	
	Std. Dev.	42	0.3	1.5	24	4.8	0.4	1.3	1.8	507	7.7	4.6	0.0	3.3	1.3	0.2	0.2	14.2	
	Max	100	1.0	5.8	200	10.0	1.0	10.0	10.0	3000	50.0	20.0	0.2	10.0	5.0	1.0	0.5	80.0	
	Min	10	0.5	1.0	100	0.5	0.0	4.0	1.0	10	0.3	0.8	0.1	0.5	1.0	0.5	0.0	2.9	
USGS-97	Mean	57	0.8	2.4	123	2.6	0.7	6.7	2.7	283	55.8	8.1	0.1	2.9	2.7	0.8	0.3	110.8	
	Std. Dev.	40	0.6	1.3	29	4.0	0.4	2.3	2.0	656	339.0	4.5	0.0	3.3	1.2	0.3	0.3	25.0	
	Max	110	3.2	5.0	200	10.0	1.0	19.0	10.0	3600	2200.0	20.0	0.2	10.0	5.0	1.0	1.0	190.0	
	Min	10	0.4	1.0	100	0.5	0.0	3.0	1.0	9	1.0	0.4	0.1	0.4	1.0	0.1	0.0	80.0	

Table 8 Statistical Summary of Groundwater Data (Metals µg/L) (continued)

Well Number	Date Sampled	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
USGS-98	Mean	53	0.7	2.5	78	2.6	2.1	5.7	4.3	228	6.1	7.6	0.1	2.6	2.0	0.8	0.3	159.2
	Std. Dev.	42	0.3	1.4	25	4.0	3.5	1.4	6.8	431	7.9	3.8	0.1	3.2	1.7	0.3	0.2	31.6
	Max	100	1.0	5.0	100	10.0	10.0	9.0	36.0	2400	50.0	10.0	0.4	10.0	5.0	1.0	0.5	210.0
	Min	10	0.5	1.0	45	0.5	0.2	3.0	1.0	19	1.0	0.7	0.1	0.4	1.0	0.1	0.0	100.0
USGS-99	Mean	75	0.7	2.2	105	2.5	1.1	5.7	24.0	408	3.5	10.5	0.1	2.9	2.3	0.9	0.3	111.2
	Std. Dev.	109	0.3	1.6	20	4.0	2.1	1.9	107.3	870	9.0	6.9	0.0	3.1	1.6	0.2	0.2	45.8
	Max	500	1.0	5.0	200	10.0	11.0	15.0	550.0	5100	60.0	30.0	0.2	10.0	5.0	1.0	0.5	310.0
	Min	10	0.5	1.0	93	0.5	0.1	3.0	0.9	40	1.0	1.3	0.0	1.0	1.0	0.1	0.0	70.0
USGS-102	Mean	52	0.7	2.4	113	2.5	0.7	6.7	3.7	573	2.4	8.0	0.1	2.9	2.6	0.8	0.3	13.4
	Std. Dev.	39	0.3	1.3	21	4.0	0.4	1.3	3.3	1878	7.6	4.5	0.1	3.2	1.3	0.3	0.2	7.4
	Max	100	1.0	5.0	200	10.0	1.0	10.0	10.0	12000	50.0	20.0	0.9	10.0	5.0	1.0	0.5	39.0
	Min	10	0.2	1.0	100	0.5	0.0	4.0	1.0	10	0.3	0.7	0.1	0.5	1.0	0.3	0.0	7.3

Table 9 Statistical Summary of Groundwater Data (Salts, Nutrients, (µg/L), and Radionuclides (pCi/L))

Well Number	Date Sampled	NO ₂ + NO ₃											Gross					
		Calcium	Potassium	Magnesium	Sodium	Chloride	Sulfate	NO ₂	as N	TKN	TOX	P as P	TOC	SR-90	CS-137	Alpha	Beta	Tritium
NRF-6	Mean	114664	4694	32919	98816	223588	198656	49.4	1765	373	24.7	83	1093	0.19	0.50	2.99	7.00	82.92
	Std. Dev.	34594	467	2916	17421	24780	52127	141.9	260	164	13.6	41	975	0.19	1.30	1.92	2.81	20.72
	Max	141000	5700	37000	130000	270000	270000	500.0	2000	500	59.0	200	5100	0.57	3.95	7.96	16.70	124.80
	Min	9630	3700	26600	54000	176000	35000	2.1	470	88	12.0	10	260	-0.05	-1.36	-1.38	0.34	54.00
NRF-7	Mean	2697	2967	9263	8649	5135	14820	35.4	487	364	27.8	40	512	0.20	0.22	1.60	4.18	1.62
	Std. Dev.	2744	195	407	998	576	3735	92.8	76	190	7.0	43	367	0.22	0.55	0.82	1.46	14.01
	Max	31500	3300	9800	11000	6700	35000	330.0	720	500	30.0	170	1000	0.72	1.67	5.41	7.61	38.28
	Min	21000	2720	8300	4500	4000	13000	1.8	380	94	7.9	10	100	0.00	-0.55	0.70	1.73	29.20
NRF-8	Mean	71913	2299	23513	14781	35681	35575	16.1	2088	360	42.5	47	885	0.13	0.54	2.64	4.24	56.37
	Std. Dev.	3006	159	766	768	2006	1138	26.6	145	172	63.0	40	1111	0.14	0.91	1.15	2.51	15.33
	Max	76300	2600	24600	16300	41700	37500	100.0	2300	500	230.0	180	4900	0.41	2.71	4.61	11.40	94.34
	Min	66700	2000	22000	13000	34000	34000	2.0	1900	100	3.9	10	200	-0.12	-0.39	0.30	0.81	24.10
NRF-9	Mean	75356	2425	23900	17788	47244	46644	15.4	2269	402	26.9	49	646	0.19	0.33	3.27	8.38	109.44
	Std. Dev.	3910	219	972	1020	1875	2792	26.8	135	171	20.0	44	287	0.20	0.65	1.08	14.97	27.10
	Max	80200	2800	25200	19700	51000	51000	100.0	2500	500	69.0	200	1000	0.54	1.74	5.24	64.00	159.00
	Min	68000	2000	22000	16000	42400	42400	2.0	2000	79	4.0	10	220	-0.01	-0.36	1.26	0.81	45.40
NRF-10	Mean	73120	2563	23633	15620	44433	42867	15.4	1913	411	22.4	65	793	0.07	0.20	2.84	4.15	131.34
	Std. Dev.	4463	262	1120	1175	2169	2225	26.8	130	170	16.1	54	393	0.13	0.47	0.92	1.86	23.62
	Max	84000	3100	25100	18900	50000	46000	100.0	2200	500	55.0	210	1700	0.26	0.90	5.13	8.82	184.00
	Min	66900	2200	21700	14000	41700	39500	2.0	1800	63	2.8	17	100	-0.19	-0.60	1.70	1.64	103.00

Table 9 Statistical Summary of Groundwater Data (Salts, Nutrients, (µg/L), and Radionuclides (pCi/L)) (continued)

Well Number	Date Sampled	NO ₂ + NO ₃												Gross				
		Calcium	Potassium	Magnesium	Sodium	Chloride	Sulfate	NO ₂	as N	TKN	TOX	P as P	TOC	SF-90	CS-137	Alpha	Beta	Tritium
NRF-11	Mean	72625	2620	23406	18313	45025	45006	16.8	2113	406	25.1	47	1160	0.13	0.38	3.26	4.77	212.92
	Std. Dev.	3799	190	868	902	1636	3051	26.3	154	150	16.8	42	951	0.13	0.84	1.23	1.82	78.74
	Max	80300	3000	25000	20500	48000	50000	100.0	2400	500	66.0	200	3500	0.52	2.51	6.58	8.03	942.40
	Min	65000	2280	21900	16800	42900	41400	4.0	1900	79	6.5	10	330	-0.16	-0.45	1.55	0.82	91.71
NRF-12	Mean	77525	2719	24606	23031	59781	56844	16.7	2113	418	18.6	46	942	0.38	0.22	2.37	4.80	62.71
	Std. Dev.	3605	227	1022	1408	3244	4744	26.3	126	159	12.3	53	605	0.63	1.07	1.34	2.24	10.08
	Max	82300	3100	26300	25700	64600	62000	100.0	2400	550	42.0	240	2500	2.26	2.37	4.40	10.10	76.80
	Min	69000	2300	23000	21000	53400	47800	4.9	1900	99	5.0	10	310	-0.10	-2.19	-0.34	2.14	41.60
NRF-13	Mean	74750	4448	21400	14649	65550	76925	13.3	844	415	16.2	185	802	0.06	0.197	2.65	7.00	41.46
	Std. Dev.	11382	569	3654	12675	6217	6419	14.8	97	122	7.9	214	414	0.17	1.29	1.23	4.61	9.84
	Max	103000	6000	32600	62000	61200	86900	60.0	1100	500	30.0	900	1800	0.50	3.03	5.03	17.00	59.27
	Min	61800	3870	16900	9590	57000	67000	6.4	740	200	6.0	51	200	-0.13	-2.87	0.32	-2.62	23.60
USGS-12	Mean	64235	2004	20776	14327	31283	31783	14.2	1779	402	30.7	35	1069	0.13	-0.14	2.52	3.38	59.46
	Std. Dev.	5838	170	2103	2344	9393	5530	20.2	380	145	12.2	35	2167	0.10	1.43	1.03	1.65	14.65
	Max	77000	2300	24000	17700	42000	38000	100.0	2200	500	55.0	170	14000	0.29	1.01	4.18	7.45	86.40
	Min	56000	1700	17700	7700	6300	15000	1.1	820	120	5.6	5	300	-0.01	-4.59	0.00	0.70	32.00
USGS-97	Mean	72412	2078	23600	14300	34276	34833	11.9	1989	445	31.1	40	638	0.17	0.38	2.94	3.74	57.51
	Std. Dev.	6777	166	1101	1550	4159	2818	14.2	335	122	14.5	42	566	0.22	1.29	1.34	2.00	20.11
	Max	92000	2400	25200	16900	41600	38000	100.0	2400	500	73.0	210	3700	0.76	4.30	7.84	9.03	105.60
	Min	59000	1800	21000	11000	14400	21400	0.9	330	180	10.6	10	200	-0.04	-0.49	1.32	0.70	19.20

Table 9 Statistical Summary of Groundwater Data (Salts, Nutrients, (µg/L), and Radionuclides (pCi/L)) (continued)

Well Number	Date Sampled	Calcium	Potassium	Magnesium	Sodium	Chloride	Sulfate	NO ₂	as N	TKN	TOX	P as P	TOC	SR-90	CS-137	Gross		
																Alpha	Beta	Tritium
USGS-98	Mean	52218	2060	19365	9327	15085	21818	11.9	1179	436	29.2	41	790	0.17	0.28	1.88	3.15	21.64
	Std. Dev.	10573	137	6292	1014	2475	3851	14.6	319	147	21.2	42	2165	0.13	1.02	0.75	1.66	10.27
	Max	92000	2300	37000	11000	28000	37000	100.0	3000	500	90.0	210	14000	0.39	2.46	3.66	7.85	51.20
	Min	42000	1800	1700	4800	13000	11000	0.9	960	72	4.0	10	100	0.01	-0.51	-0.15	0.90	6.40
USGS-99	Mean	61682	1750	21918	13117	21293	26481	18.9	1605	464	24.0	41	1180	0.07	0.15	2.56	3.33	31.69
	Std. Dev.	3033	140	640	1630	3437	3667	26.8	123	97	9.6	31	2904	0.13	2.24	1.30	2.01	7.99
	Max	65600	2000	23200	15800	40000	47000	100.0	2000	500	30.0	150	19000	0.26	6.21	7.15	9.65	45.00
	Min	55000	1500	21000	8800	16000	18000	0.7	1400	180	4.8	10	100	-0.08	-3.85	0.50	1.24	12.80
USGS-102	Mean	71753	2365	23276	13427	33815	34454	16.4	1907	439	21.0	38	805	0.14	0.69	3.08	4.09	55.34
	Std. Dev.	4348	703	1121	1792	3943	3421	26.5	317	223	10.7	38	1062	0.10	0.84	1.86	2.20	15.84
	Max	77000	5000	25000	16300	46000	46000	100.0	2400	890	30.0	190	5600	0.31	2.62	8.64	9.78	95.23
	Min	62000	2000	21000	7500	23000	23000	1.1	300	76	3.0	10	200	-0.01	-0.53	1.47	0.84	26.00

Table 10 Occurrence of Organic Compounds in NRF Groundwater from 1997 through 1999

	1997					1998					1999			
	NRF-5	NRF-8	USGS-12	USGS-97	USGS-98	USGS-99	USGS-102	QAS-55	QAS-56	NRF-6	QAS-64	NRF-6	NRF-9	USGS-97
Chloroform (0.1)	0.27										0.3	0.2		
Dichloromethane (0.5)											0.5			
1,1-Dichloropropanone**											21.0			
Ethylbenzene (0.1)											0.3			
Naphthalene (0.2)		2.6			0.96		0.59	9.6						
Tetrachloroethene (0.2)	0.47									0.5	3.6	0.3		
Toluene (0.5)														
1,1,1-Trichloroethane (0.1)										0.1				
1,2,4-Trimethylbenzene (0.1)											0.1			
m- & p-Xylenes (0.2)											0.6			
Di(2-ethylhexyl)phthalate (0.6)			5.60	1.50		4.70	0.70						0.60	1.20

All Concentrations are in ug/L

- 1) Numbers in parenthesis after constituent names are the constituent's MDL
 - 2) Constituents in blue occurred in concentrations at the MDL
 - 3) Constituents in yellow occurred at concentrations above the MDL
 - 4) QAS-55 is a quality assurance sample (Field Blank) collected at USGS-99 in September 1997.
 - 5) QAS-56 is a quality assurance sample (Replicate) collected at NRF-9 in September 1997.
 - 6) QAS-64 is a quality assurance sample (Field Blank) collected at NRF-8 on August 5, 1998.
- ** 1,1-dichloropropanone was found in this sample as a result of a library search, which is the laboratory looking for compounds not included in the list of targeted analytes.

concentrations. NRF has two wells in its monitoring network that are believed to sample NRF background (upgradient) groundwater constituent concentrations. These wells are USGS-12 and NRF-7 (Appendix A, Figure 1). Both wells have problems that limit their usefulness as background monitoring wells. These problems are documented in the Comprehensive RI/FS for NRF, and include multiple completion levels, improper grouting, and possible corrosion problems with carbon steel in contact with the water. Nevertheless, these wells supply valuable information to the NRF groundwater monitoring program, and are logical choices for local upgradient constituent concentrations. For this report, data from NRF-7 was considered for all constituents except aluminum and chromium, due to inconsistencies with USGS-12 data for these two metals. For future reviews, inclusion of NRF-7 data will be determined on a case-by-case basis, and will be based on continued statistical consistency with data from USGS-12.

Data have been collected from USGS-12 since 1989 and from NRF-7 since 1995. Appendix G, Tables 1 through 5 summarize the average concentrations (with associated standard deviations) for all constituents currently monitored by NRF at USGS-12 and NRF-7 respectively. These concentrations are estimates of true background since they are derived, for the most part, from a single well (either USGS-12 or NRF-7, where appropriate) and since sample collection is currently ongoing. Additionally, the Method Detection Limits (MDLs) for the constituents of concern have changed over time because several different analytical laboratories have been used to perform data analysis. In some cases, the MDL is an order of magnitude different between laboratories. To mitigate the effects of widely varying MDL values, some data values with high MDLs were not used in calculating the estimated constituent background concentration.

Based on data in Table 11 and general principles of geochemistry, it appears that beryllium, cadmium, copper, lead, mercury, silver, thallium, zinc, NO₂, and TKN do not occur naturally in the aquifer, or they occur at levels consistently below the MDLs. The long term average of six other constituents, although not occurring consistently below the MDL concentrations, are below the levels occurring in most other NRF groundwater monitoring wells. These constituents are aluminum, zinc, calcium, magnesium, phosphorus and TOC. The remaining constituent concentrations are sometimes higher and sometimes lower than concentrations found in the remaining wells. A more detailed discussion of background concentrations is presented in Appendix A, which is a discussion of NRF hydrogeology.

5.3.2.1.2 Upgradient to Downgradient Groundwater Comparisons

As previously mentioned, NRF divides its groundwater monitoring wells in four groups, each representing a particular portion of the SRPA. From most upgradient to most downgradient these groups are Regional Upgradient, Effluent System Monitoring, Site Downgradient, and Regional Downgradient. As the names imply, each well group serves a particular function. Regional Upgradient wells sample water that is either physically upgradient to NRF or is of background quality. USGS-12, located three miles upgradient of NRF activities, is not influenced by NRF. NRF-7, located near NRF, was considered a background well for this report, since it does not appear to be influenced by the IWD or sewage lagoon to any statistically detectable extent. The Effluent System Monitoring wells are designed to sample portions of the aquifer that are impacted by discharge from the NRF Industrial Waste Ditch. The Site Downgradient wells are hydrologically downgradient to NRF, and are designed to detect potential contaminants emanating from NRF before they leave the NRF property. Finally, Regional Downgradient wells are used as a baseline for comparison with other groundwater results, and to provide another measure of the potential impact of NRF operations on the SRPA.

Table 11 Estimated NRF Background Groundwater Concentrations (ppb unless noted)

	Spec. Cond.								
	pH	(µS/cm)	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium
MCL	6.5 to 8.5 (a)	(b)	200	6	50	2000	4	5	100
Mean	8.06	423	<<51	<<0.7 ^(c)	<2.6	<100	<<.5	<<0.6 ^(c)	6.7
Std. Dev.	0.28	167	42	0.3	1.4	32	0.1	0.4	1.3
Max	8.72	610	100	1.1	5.8	200	1.1	1.0	10.0
Min	7.47	210	<10	<0.2	1.0	51	0.5	0.0	4.0
	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Thallium
MCL	1300	300(a)	15	50(a)	2	100	50	100(a)	2
Mean	<<1.7 ^(c)	<389	<1.1 ^(c)	<9.3	<<0.12 ^(c)	<3.61	<2.5	<<0.8 ^(c)	<<.32 ^(c)
Std. Dev.	0.7	799	0.5	5.5	0.0	2.8	1.6	0.2	0.2
Max	4.0	4800	4.0	24.0	0.2	11.0	5.0	1.0	0.5
Min	1.0	<10	0.3	0.8	0.1	0.5	0.9	0.2	0.0
	Zinc	Calcium	Potassium	Magnesium	Sodium	Chloride	Sulfate	NO2	NO2 + NO3
MCL	5000 (a)	(b)	(b)	(b)	(b)	250000 (a)	250000 (a)	1000	10000
Mean	<<12.4	45603	2486	15020	11712	19429	23971	<<9	1184
Std. Dev.	6.1	19439	521	6031	3391	14818	9751	3	707
Max	37.0	77000	3300	24000	17700	42000	38000	20	2200
Min	2.9	21000	1700	8300	4500	4000	13000	1	380
	TKN	TOX	P as P	TOC	Strontium-90	Cesium-137	Gross Alpha	Gross Beta	Tritium (2)
					pCi/L	pCi/L	pCi/L	PCi/L	pCi/L
MCL	(b)	(b)	(b)	(b)	8.0 pCi/L	(b)	15.0 pCi/L	4 mRem/yr	20000 pCi/L
Mean	<<383	<29	<29	<596	0.29	0.02	1.96	3.73	28
Std. Dev.	166	10	16	424	0.66	0.85	0.68	1.59	19
Max	500	55	70	2000	2.53	1.67	4.18	7.61	82
Min	94	6	5	100	0.00	-4.59	0.00	0.70	-29

- < A significant portion of the data used to create this value are at or below the MDL
- << Most of the data used to create this value are at or below the MDL .
- (a) Secondary MCL (this is not an enforceable value, but rather a recommendation)
- (b) MCL not determined
- (c) Two or more MDLs were used in the creation of this number.
- (d) Three anomalous values were used in the creation of this number.

Groundwater data from the various groups were statistically compared using both analysis of variance and non-parametric methods. Comparisons included all applicable data from the first date of data collection to the end of 1999. The approach used here was to compare only a select group of constituents. These constituents were chosen for one or more of the following reasons. One, the constituent was historically released in quantity to the environment at NRF. Two, the constituent frequently occurs in groundwater at elevated levels and it is not naturally occurring in quantity. Third, the constituent is a good indicator species or tracer. Based on these criteria, modeled constituents include aluminum, chromium, iron, nickel, calcium, chloride, nitrite plus nitrate, TOC, gross beta, and tritium.

The tests discussed above produce the results "PC" for possible contamination and "NC" for no contamination. For each group to group comparison, there is a null hypothesis that states that the groups are statistically the same, and an alternative hypothesis that states the groups are not statistically the same. If the test statistic does not exceed a threshold value (contained in a statistical table), the null hypothesis is accepted and the answer is "NC". If the threshold value is exceeded, the alternative hypothesis is accepted and the answer is "PC". A detailed description of the use of these methods, including formulas, is contained in Section IX-3 of Appendix IX to the IWD RI/FS (WEC, 1994).

Before comparing groups, general statistical parameters were calculated for each group. This includes mean, standard deviation, normality using D'Agostino's Analysis, and outliers using the Rosner Test for outliers. The results are summarized in Table 12 below.

Several observations can be made from the data in this table. First, the mean concentrations for most constituents detected in the System Effluent Monitoring wells are higher than results from the other groups. This is not unexpected, since historically the IWD was the primary discharge point for chemicals (non-radioactive effluents) at NRF. Current water softening salt discharge to the IWD, coupled with the leaching of contaminants released in the past, contributes to the results seen in the table.

Second, most of the data are not distributed normally based on tests that indicate the normality or non-normality of the data. Of all constituents, calcium and chloride were the data most consistently distributed normally. According to these same tests, chromium, iron, and TOC were never normally distributed at the 95% and 99% confidence levels. It should be noted that these tests are only indicators and do not definitively define the distribution. For the purposes of this report, the data will be tested using analysis of variance as though the data were normally distributed. The purpose for doing this is the uncertainty associated with the normality test.

To account for the uncertainty in the data's distribution, a non-parametric analysis (which is independent of data distribution) using the Kruskal-Wallis method was performed.

Finally, the results of the test for outliers show that data from five constituents did not contain outliers. These constituents were calcium, chloride, chromium, nickel, and NO_2+NO_3 . Aluminum, TOC, gross alpha, and tritium data across all well groups contained up to a maximum of four outliers. Iron data is a special case. Iron typically has demonstrated a very high variability; therefore, the method used to pick outliers does not work well in this case. The average concentration for each of these constituents was compared to the average concentrations of like constituents from other well groups.

The Regional Upgradient well group was compared to all other groups as a matter of reference. The Site Downgradient and Regional Downgradient groups were likewise compared to all other

Table 12 Summary Statistics for the NRF Groundwater Monitoring Well Groups

Constituents	MCL	Regional Upgradient				System Monitoring				Site Downgradient				Regional Downgradient			
		Mean	Std. Deviation	Normally Distributed ^b	Outliers	Mean	Std. Deviation	Normally Distributed ^b	Outliers	Mean	Std. Deviation	Normally Distributed ^b	Outliers	Mean	Std. Deviation	Normally Distributed ^b	Outliers
Aluminum (ppb)	200 ppb	75	48	Y/Y	3	936	1383	N/N	2	76	46	N/N	5	55	44	N/N	1
Calcium (ppb)	NA	46000	19000	N/Y	0	95000	32000	Y/Y	0	74000	43000	Y/Y	0	62000	11000	Y/Y	0
Chloride (ppb)	250,000 ^a ppb	19000	15000	N/N	0	17100	78000	N/Y	0	42000	9000	Y/Y	0	24000	8700	Y/Y	0
Chromium (ppb)	100 ppb	9	4	N/N	0	44	56	N/N	0	15	33	N/N	0	6	2	N/N	0
Iron (ppb)	300 ^a ppb	389	699	N/N	0	1310	1318	N/N	2	356	1157	N/N	1 ^c	308	678	N/N	**
Nickel (ppb)	100 ppb	4	3	Y/Y	0	20	12	Y/Y	0	9	10	N/N	0	3	3	N/N	0
NO ₂ +NO ₃ (ppb)	10,000 ppb	1184	707	N/Y	0	1458	490	N/N	0	2035	250	N/N	0	1598	429	Y/Y	0
TOC (ppb)	NA	596	424	N/N	2	847	424	N/N	2	751	545	N/N	3	562	403	N/N	4
Gross Beta (pCi/L)	4 mrem/yr	3.79	1.59	N/N	0	6.63	2.67	N/N	2	4.37	2.09	N/N	2	2.71	0.89	N/Y	0
Tritium (pCi/L)	20,000 pCi/L	28.32	32.44	Y/Y	0	65.64	26.71	Y/Y	0	101.54	66.51	N/N	1	37.53	20.68	N/N	0

a Secondary MCL

b Is the constituent data distributed normally at the 95% and 99% Confidence Level Y/N

c Although the test for outliers showed positive indications, results indicate that large variations are typical, thus no data was removed from the set.

Regional Upgradient wells: USGS-12 and NRF-7

Effluent System Monitoring wells: NRF-6 and NRF-13

Site Downgradient wells: NRF-8, NRF-9, NRF-10, NRF-11, NRF-12, and USGS-102

Regional Downgradient wells: USGS-97, USGS-98, and USGS-99

groups as a measure of the effects that NRF operations have had on the SRPA. The same group-wise comparison was made using the non-parametric method. The results of parametric statistical comparisons are shown in Table 13, and the results of non-parametric comparisons are shown in Table 14.

Inspection of Tables 13 and 14 shows very similar results in spite of the fact that normality testing of the data did not favor the use of the ANOVA test method. Both the ANOVA test and the Kruskal-Wallis non-parametric test indicate that widespread contamination of the aquifer may be present. The term "contamination" as used in this context refers to constituents that normally do not occur at the observed level, such that their presence in the aquifer is anomalous. These tests do not indicate the degree of contamination. This is best determined by comparison to constituent background concentrations and maximum contaminant levels set by the EPA.

The statistical results presented in Tables 13 and 14 are consistent with known geologic data as well as NRF contamination history. For example, the Effluent System group of wells is statistically different for most constituents from other well groups. Also, aluminum and iron data are known to occur in widely varying concentrations in most wells, and in fact both these constituents are identified as "no contamination" fewer times than other inorganic constituents in both tables. Regional Upgradient water and Regional Downgradient water possess similar chemical characteristics.

The statistical analyses presented here support the conclusion that activities at NRF have impacted the quality of water in the SRPA. This impact is apparently minor, as no constituent's average concentration exceeds Federal drinking water guidelines and water samples representing upgradient and downgradient background sources are statistically similar.

5.3.2.2 Trend Analysis

The document titled A Review of Hydrogeologic Conditions at NRF and Results of Groundwater Monitoring, 1972 to 1999: Including Analyses, Interpretation, and Recommendations (Appendix A) contains a section that comprehensively examines NRF groundwater data for trends. The examination presented in that report was primarily based on visual data (graphs) and best-fit lines. Several constituents that exhibited strong trends were chosen for additional analysis.

Whereas in the previous section, data were analyzed by grouping wells together, the Appendix A trend analysis is performed using individual wells. This is done since combining data from various wells may mask trends. The results of the trend analysis are summarized as follows. The trends observed in chromium, tritium, and chloride concentrations in the samples collected from the NRF groundwater monitoring wells are consistent with geological principles, known changes in facility operations, and meteorological patterns. The aquifer concentration of chromium and tritium, the origin of which can be traced to NRF operations, has declined in most wells. Chloride concentration has risen in most wells, although several wells display a sharp decline in concentration during the past 6 or 8 quarters. Figures 6 through 8 are graphs displaying trends in chromium data. These graphs were chosen because NRF-6 consistently contains the highest chromium concentrations of all NRF wells, and NRF-13 and NRF-11 are examples of wells where the apparent trend was up and down, respectively. These graphs are exemplary of the behavior of other constituents that have been graphed. These graphs also show that constituent concentrations are highly variable. In those instances where trends are increasing, special attention must be given. In the case of chromium in NRF-13, concentrations are approaching the regulatory level of 100 ppb. Recognizing this trend now will aid NRF in setting the direction of future Five-Year Reviews.

Table 13 Comparison of Well Groups Using the Parametric ANOVA Method

Groups	Al	Ca	Cl	Cr	Fe	Ni	NO ₂ +NO ₃	TOC	Gross Beta	Tritium
RDG to SDG	PC	PC	PC	PC	NC	PC	PC	PC	PC	PC
RUG to SDG	NC	PC	PC	NC	NC	NC	PC	PC	NC	PC
RUG to RDG	PC	PC	PC	PC	NC	PC	PC	PC	PC	NC
RUG to SYS	PC	PC	PC	PC						
SYS to RDG	PC	PC	PC	PC	PC	PC	NC	PC	PC	PC
SYS to SDG	PC	NC	PC	PC						

Table 14 Comparison of Well Groups Using the Kruskal-Wallis Non-parametric Method

Groups	Al	Ca	Cl	Cr	Fe	Ni	NO ₂ +NO ₃	TOC	Gross Beta	Tritium
RDG to SDG	PC	PC	PC	PC	NC	PC	PC	PC	PC	PC
RUG to SDG	NC	PC	PC	PC	NC	PC	PC	PC	NC	PC
RUG to RDG	NC	PC	PC	PC	NC	NC	PC	NC	NC	NC
RUG to SYS	PC	PC	PC	NC						
SYS to RDG	NC	PC	PC	PC	PC	PC	NC	PC	PC	NC
SYS to SDG	NC	PC	PC	PC	PC	PC	PC	NC	PC	PC

RUG = Regional Upgradient Group
 SYS = Effluent System Monitoring Group
 SDG = Site Downgradient Group
 RDG = Regional Downgradient Group
 PC = Possible contamination may be present as evidenced by this comparison.

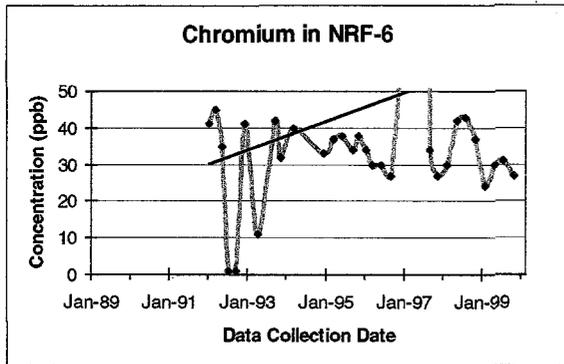


Figure 6 Chromium Trend in NRF-6

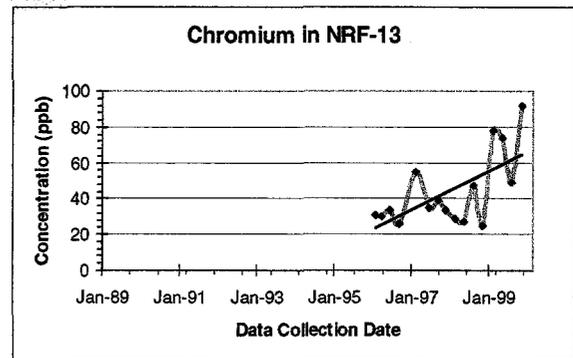


Figure 7 Chromium Trend in NRF-13

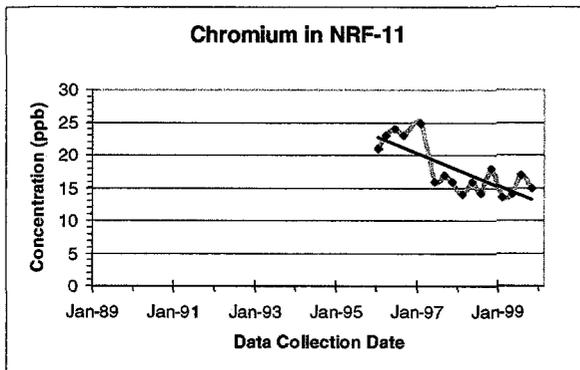


Figure 8 Chromium Trend in NRF-11

5.3.3 Soil Gas Monitoring Results

The soil gas data for the initial baseline data set obtained in October 1996 and the next 12 quarters obtained in 1997 through 1999 are presented in Appendix F. A summary of basic and baseline data are presented in Tables 15, 16, and 17.

5.3.4 Analysis of Soil Gas Data

The following are the Volatile Organic Compounds that were consistently detected above the reporting limit (or sample quantitation limit) during 1997 through 1999: dichlorodifluoromethane (Freon 12), trichlorofluoromethane (Freon-11), 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113), 1,1,1-trichloroethane, chloroform, trichloroethylene, and tetrachloroethylene. Freon 11 and tetrachloroethylene were the two most frequently detected constituents at all of the sites. Details of the constituents detected are discussed below.

The statistical review presented in this section centers on comparison of monitoring results to several different benchmarks. These benchmarks will be baseline concentrations obtained from the October 1996 initial sampling event and maximum concentrations obtained during the Track 2 Investigations for these three landfill areas. Such a comparison also presents a relative risk picture associated with NRF landfills. Ultimately the results of these comparisons will be used to re-evaluate risk associated with the selected remedies and to determine the overall effectiveness of the remedies.

Table 15 Soil Gas Data Summary for Site 8-05-1

Site	Sample Location	Statistical Parameter	Freon 12		Freon 11		Chloroform		ICA		PCE		ICE	
			(ppbv)	ug/m3	(ppbv)	ug/m3	(ppbv)	ug/m3	(ppbv)	ug/m3	(ppbv)	ug/m3	(ppbv)	ug/m3
8-05-1	MW1-1	Baseline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		Sample Mean	ND	ND	ND	ND	ND	ND	ND	ND	11.3	76.2	ND	ND
		Standard Deviation	ND	ND	ND	ND	ND	ND	ND	ND	4.9	33.1	ND	ND
		Maximum	ND	ND	ND	ND	ND	ND	ND	ND	20.0	135.4	ND	ND
		Minimum	ND	ND	ND	ND	ND	ND	ND	ND	3.8	25.7	ND	ND
		Confidence	ND	ND	ND	ND	ND	ND	ND	ND	2.7	18.0	ND	ND
8-05-1	MW1-3	Baseline	ND	8.5	47.7	ND	4.0	19.5	ND	580.0	3926.2	29.0	155.5	
		Sample Mean	ND	5.0	27.8	ND	2.7	13.4	2.6	14.4	458.1	3100.9	21.8	117.1
		Standard Deviation	ND	1.4	8.1	ND	0.8	4.1	1.0	5.5	105.1	711.7	4.0	21.6
		Maximum	ND	8.5	47.7	ND	4.0	19.5	3.9	21.2	616.0	4169.9	29.0	155.5
		Minimum	ND	2.9	16.3	ND	1.8	8.8	ND	ND	333.0	2254.2	14.0	75.1
		Confidence	ND	0.8	4.4	ND	0.5	2.2	0.6	3.0	57.2	386.9	2.2	11.7
8-05-1	MW1-4	Baseline	5.3	26.2	1.7	9.53	2.2	16.8	ND	ND	120.0	812.3	2.9	15.6
		Sample Mean	5.9	29.2	2.4	13.2	2.5	18.8	ND	ND	155.8	1054.7	3.4	18.0
		Standard Deviation	2.5	12.5	1.1	6.2	1.2	8.9	ND	ND	57.2	387.4	1.1	6.0
		Maximum	9.1	44.9	3.8	21.3	3.9	29.8	ND	ND	247.0	1672.0	5.1	27.4
		Minimum	ND	ND	ND	ND	ND	ND	ND	ND	72.0	487.4	1.9	10.2
		Confidence	1.4	6.8	0.6	3.4	0.6	4.8	ND	ND	31.1	210.6	0.6	3.3

Numbers in green represent estimated quantities
 ND = Not Detected

Table 16 Soil Gas Data Summary for Site 8-08-51

Site	Sample Location	Statistical Parameter	Freon 11			Chloroform			TCA			PCE			TCE		
			(ppbv)	ug/m3	(ppbv)	ug/m3	(ppbv)	ug/m3	(ppbv)	ug/m3	(ppbv)	ug/m3	(ppbv)	ug/m3	(ppbv)	ug/m3	
8-05-51	MW51-1	Baseline	15.0	84.1	2.7	13.2	6.3	34.3	22.0	148.9	ND	ND	ND	ND	ND		
		Sample Mean	10.3	57.5	1.7	8.4	4.6	25.0	17.1	115.8	ND	ND	ND	ND	ND		
		Standard Deviation	2.5	14.3	0.6	2.7	1.3	7.0	5.7	38.4	ND	ND	ND	ND	ND		
		Maximum	15.0	84.1	2.7	13.2	7.8	42.5	29.0	196.3	ND	ND	ND	ND	ND		
		Minimum	5.8	32.5	1.0	4.9	3.1	16.9	10.0	67.7	ND	ND	ND	ND	ND		
		Confidence	1.4	7.8	0.3	1.5	0.7	3.8	3.1	20.9	ND	ND	ND	ND	ND		
8-05-51	MW51-2	Baseline	16.0	89.7	2.3	11.2	6.6	35.9	23.0	155.7	ND	ND	ND	ND	ND		
		Sample Mean	10.8	60.7	2.3	11.1	5.2	28.3	17.3	116.9	ND	ND	ND	ND	ND		
		Standard Deviation	2.8	15.6	0.3	1.7	1.2	6.8	4.7	31.9	ND	ND	ND	ND	ND		
		Maximum	16.0	89.7	2.9	14.1	8.4	45.7	23.0	155.7	ND	ND	ND	ND	ND		
		Minimum	6.4	35.9	1.6	7.8	3.0	16.3	4.1	27.8	ND	ND	ND	ND	ND		
		Confidence	1.5	8.5	0.2	0.9	0.7	3.7	2.6	17.4	ND	ND	ND	ND	ND		
8-05-51	MW51-3	Baseline	13.0	72.9	ND	ND	4.8	26.1	19.0	128.6	ND	ND	ND	ND	ND		
		Sample Mean	6.6	36.9	ND	ND	2.8	15.2	17.4	117.5	ND	ND	ND	ND	ND		
		Standard Deviation	3.3	18.5	ND	ND	1.5	8.0	20.4	138.3	ND	ND	ND	ND	ND		
		Maximum	13.0	72.9	ND	ND	5.7	31.0	83.0	561.9	ND	ND	ND	ND	ND		
		Minimum	1.5	8.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
		Confidence	1.8	10.1	ND	ND	0.8	4.3	11.1	75.2	ND	ND	ND	ND	ND		
8-05-51	MW51-4	Baseline	16.0	89.7	2.6	12.7	6.0	32.7	26.0	176.0	ND	ND	ND	ND	ND		
		Sample Mean	8.5	47.6	1.6	7.7	3.6	19.8	15.8	106.7	ND	ND	ND	ND	ND		
		Standard Deviation	3.7	20.9	0.6	3.1	1.6	8.9	5.5	36.9	ND	ND	ND	ND	ND		
		Maximum	16.0	89.7	2.6	12.7	7.0	38.1	26.0	176.0	ND	ND	ND	ND	ND		
		Minimum	1.7	9.5	ND	ND	ND	1.6	3.1	21.0	ND	ND	ND	ND	ND		
		Confidence	2.0	11.4	0.3	1.7	0.9	4.8	3.0	20.1	ND	ND	ND	ND	ND		

Numbers in green represent estimated quantities
 ND = Not Detected

Table 17 Soil Gas Data Summary for Site 8-06-53

Site	Sample Location	Statistical Parameter	Freon 11		PCE	
			(ppbv)	µg/m3	(ppbv)	µg/m3
8-06-53	MW53-1	Baseline	ND	ND	5.2	35.2
		Sample Mean	ND	ND	2.1	14.2
		Standard Deviation	ND	ND	1.1	7.5
		Maximum	ND	ND	5.2	35.2
		Minimum	ND	ND	0.5	3.4
		Confidence	ND	ND	0.6	4.1
8-06-53	MW53-2	Baseline	6.7	37.6	24.0	162.5
		Sample Mean	2.5	14.2	18.0	121.6
		Standard Deviation	1.4	8.0	5.2	35.0
		Maximum	6.7	37.6	25.0	169.2
		Minimum	0.9	5.0	8.5	57.5
		Confidence	0.8	4.3	2.8	19.0
8-06-53	MW53-3	Baseline	ND	ND	ND	ND
		Sample Mean	ND	ND	ND	ND
		Standard Deviation	ND	ND	ND	ND
		Maximum	ND	ND	ND	ND
		Minimum	ND	ND	ND	ND
		Confidence	ND	ND	ND	ND
8-06-53	MW53-4	Baseline	2.1	11.8	3.6	24.4
		Sample Mean	2.2	12.5	3.6	24.3
		Standard Deviation	2.9	16.4	4.6	30.8
		Maximum	11.9	66.7	18.3	123.9
		Minimum	0.9	5.0	1.4	9.5
		Confidence	1.6	8.9	2.5	16.8
8-06-53	MW53-5	Baseline	ND	ND	6.0	40.6
		Sample Mean	ND	ND	2.9	19.7
		Standard Deviation	ND	ND	1.5	10.3
		Maximum	ND	ND	6.0	40.6
		Minimum	ND	ND	1.2	8.1
		Confidence	ND	ND	0.8	5.6
8-06-53	MW53-6	Baseline	ND	ND	9.9	67.0
		Sample Mean	ND	ND	6.6	44.4
		Standard Deviation	ND	ND	2.3	15.5
		Maximum	ND	ND	11.0	74.5
		Minimum	ND	ND	4.2	28.4
		Confidence	ND	ND	1.2	8.4

Numbers in green represent estimated quantities
 ND = Not Detected

5.3.4.1 Statistical Review

5.3.4.1.1 Dichlorodifluoromethane (Freon 12)

Freon 12 was detected at only one site (Site 8-05-1) and at only one sample location (MW1-4) above the reporting limit. Freon 12 was detected at an overall maximum concentration of 9.1 ppbv ($44.9 \mu\text{g}/\text{m}^3$) during the 1997-1999 sampling period at Site 8-05-1. The maximum concentration detected in March 1998 exceeds the baseline concentration of 5.3 ppbv ($26.2 \mu\text{g}/\text{m}^3$); however, the levels detected since March 1998 are less than the maximum level. From the sample mean and the 95% confidence level, the average Freon 12 concentration is within the interval 5.9 ± 1.4 ppbv ($29.2 \pm 6.8 \mu\text{g}/\text{m}^3$) for this set of data.

Freon 12 was not detected at any of the three landfill areas during the Track 2 Investigations. However, the concentrations obtained are relatively low levels in comparison with other halogenated organic compounds detected at these three landfill areas.

5.3.4.1.2 Trichlorofluoromethane (Freon 11)

Freon 11 was detected at all three sites. At Site 8-06-53, Freon 11 was only detected occasionally above the reporting limit, at locations MW53-2 and MW53-4, and typically at less than the reporting limit at the other four sample locations. Most of the concentrations at sample locations MW53-2 and MW53-4 are below the reporting limit but above the method detection limit and are listed in Appendix F as estimated values for the purpose of tracking trends and for obtaining statistical information. The overall Freon 11 maximum concentration detected at Site 8-06-53 during the 1997-1999 sampling period was 11.9 ppbv ($66.5 \mu\text{g}/\text{m}^3$) at sample location MW53-4, greater than the baseline concentration of 2.1 ppbv ($11.8 \mu\text{g}/\text{m}^3$). From the sample mean and the 95% confidence level, the average Freon 11 concentration is within the interval 2.2 ± 1.6 ppbv ($12.5 \pm 8.9 \mu\text{g}/\text{m}^3$) for this set of data. Because of the large confidence interval (± 1.6 ppbv) in comparison with the mean value, the maximum concentration for MW53-4 is suspect. Therefore, the second highest maximum, along with the sample mean and confidence interval, for Site 8-06-53 was evaluated, which occurred at sample location MW53-2. The maximum concentration detected at MW53-2 is 3.5 ppbv ($19.6 \mu\text{g}/\text{m}^3$), which is less than the baseline concentration of 6.7 ppbv ($35.6 \mu\text{g}/\text{m}^3$). From the sample mean and the 95% confidence level, the average Freon 11 concentration is within the interval 2.5 ± 0.8 ppbv ($14.2 \pm 4.3 \mu\text{g}/\text{m}^3$) for this set of data. The sample means for both sample locations are nearly identical but the confidence interval for MW53-2 is much lower than for MW53-4. A further evaluation of the suspect maximum concentration for MW53-4 is discussed in Section 5.3.4.2.

Freon 11 was consistently detected above the reporting limit at two sample locations, MW1-3 and MW1-4, at Site 8-05-1. The overall maximum concentration detected at Site 8-05-1, during the 1997-1999 sampling period was 6.5 ($36.5 \mu\text{g}/\text{m}^3$) at sample location MW1-3. This level is less than the baseline concentration of 8.5 ppbv ($47.7 \mu\text{g}/\text{m}^3$). From the sample mean and the 95% confidence level, the average Freon 11 concentration is within the interval 5.0 ± 0.8 ppbv ($27.8 \pm 4.4 \mu\text{g}/\text{m}^3$) for this set of data.

Freon 11 was detected at all four sample locations at Site 8-05-51 consistently above the reporting limit. Freon 11 was detected at an overall maximum concentration of 15 ppbv ($84 \mu\text{g}/\text{m}^3$) at sample location MW51-2 at Site 8-05-51 during the 1997-1999 sampling period. This level is slightly less than the baseline concentration of 16 ppbv ($89.7 \mu\text{g}/\text{m}^3$). From the

sample mean and the 95% confidence level, the average Freon 11 concentration is within the interval 10.8 ± 1.5 ppbv ($12.5 \pm 8.9 \mu\text{g}/\text{m}^3$) for this set of data.

The overall maximum concentration detected at all three sites during this sampling period was 15 ppbv ($84 \mu\text{g}/\text{m}^3$), which is greater than the maximum concentration of 8.1 ppbv ($45.4 \mu\text{g}/\text{m}^3$) detected during the Track 2 Investigation. However, these concentrations are considered low in comparison with other halogenated organic compounds detected at these three landfill areas.

5.3.4.1.3 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)

Freon 113 was only detected at Site 8-05-1 and at only one sample location, MW1-4, at a maximum concentration of 3.9 ppbv ($29.8 \mu\text{g}/\text{m}^3$) during the 1997-1999 sampling period. This level was greater than the baseline concentration of 2.2 ppbv ($16.8 \mu\text{g}/\text{m}^3$). From the sample mean and the 95% confidence level, the average Freon 113 concentration is within the interval 2.5 ± 0.6 ppbv ($18.8 \pm 4.8 \mu\text{g}/\text{m}^3$) for this set of data.

The overall maximum Freon 113 concentration detected during this sampling period was 3.9 ppbv ($29.8 \mu\text{g}/\text{m}^3$) which is less than the overall maximum concentration of 5.3 ppbv ($40.5 \mu\text{g}/\text{m}^3$) detected during the Track 2 Investigation.

5.3.4.1.4 1,1,1-Trichloroethane

1,1,1-Trichloroethane was detected consistently at Sites 8-05-51 and 8-05-1. 1,1,1-Trichloroethane was detected only twice (just above the reporting limit) at Site 8-06-53, at sample locations MW53-2 and MW53-4. The overall maximum concentration detected at Site OU 8-05-51 during the 1997-1999 sampling period, was 8.4 ppbv ($45.7 \mu\text{g}/\text{m}^3$) at sample location MW51-2. This level was greater than the baseline concentration of 6.6 ppbv ($35.9 \mu\text{g}/\text{m}^3$). From the sample mean and the 95% confidence level, the average concentration is within the interval 5.2 ± 0.7 ppbv ($28.3 \pm 3.7 \mu\text{g}/\text{m}^3$) for this set of data. 1,1,1-Trichloroethane was also detected at Site 8-05-1 but only consistently at one sample location, MW1-3. The maximum concentration at this location was 3.9 ppbv ($21.2 \mu\text{g}/\text{m}^3$). 1,1,1-Trichloroethane was not detected during the baseline sampling evolution for this location. From the sample mean and the 95% confidence level, the average concentration is within the interval 2.6 ± 0.6 ppbv ($14.4 \pm 3.0 \mu\text{g}/\text{m}^3$) for this set of data.

The overall maximum 1,1,1-trichloroethane concentration detected during this sampling period was 8.4 ppbv ($45.7 \mu\text{g}/\text{m}^3$) which is less than the overall maximum concentration of 424 ppbv ($2300 \mu\text{g}/\text{m}^3$) detected during the Track 2 Investigation.

5.3.4.1.5 Chloroform

Chloroform was consistently detected at Sites 8-05-1 and 8-05-51. Chloroform was not detected at Site 8-06-53. During the 1997 to 1999 sampling period, chloroform was mainly detected at one sample location (MW1-3) at Site 8-05-1. Chloroform was detected at a maximum concentration of 3.9 ppbv (or $19.0 \mu\text{g}/\text{m}^3$) at sample location MW1-3. This value was nearly equal to the baseline concentration value of 4 ppbv ($19.5 \mu\text{g}/\text{m}^3$). From the sample mean and the 95% confidence level, the average concentration is within the interval 2.7 ± 0.5 ppbv ($13.4 \pm 2.2 \mu\text{g}/\text{m}^3$) for this set of data. Chloroform was only recently detected once above the reporting limit at MW1-4 at a concentration of 4.7 ppbv ($22.9 \mu\text{g}/\text{m}^3$).

Chloroform was detected above the reporting limit at Site 8-05-51 at three out of four sample locations. Chloroform was detected above the reporting limit only twice at both MW51-1 and MW51-4 during the 1997-1999 sampling period. During the other sampling quarters, chloroform was typically detected at levels below the reporting limit but above the method detection limit. Chloroform was detected fairly consistently at sample location MW51-2 above the reporting limit. The overall maximum concentration detected at Site 8-05-51 was 2.9 ppbv (or 14.1 $\mu\text{g}/\text{m}^3$) at sample location MW51-2. This level was slightly greater than the baseline concentration of 2.3 ppbv (11.2 $\mu\text{g}/\text{m}^3$) for this location. From the sample mean and the 95% confidence level, the average concentration is within the interval 2.3 ± 0.2 ppbv (11.1 ± 0.9 $\mu\text{g}/\text{m}^3$) for this set of data.

The overall maximum chloroform concentration detected during this sampling period was 4.7 ppbv (22.9 $\mu\text{g}/\text{m}^3$) which is less than the overall maximum concentration of 19 ppbv (92.6 $\mu\text{g}/\text{m}^3$) detected during the Track 2 Investigation.

5.3.4.1.6 Trichloroethylene

Trichloroethylene was detected predominately at Site 8-05-1 and only twice at Site OU 8-05-51. Trichloroethylene was detected at an overall maximum concentration of 26.7 ppbv (143.2 $\mu\text{g}/\text{m}^3$) at sample location MW1-3 at Site OU 8-05-1 during the 1997-1999 sampling period. This level was slightly less than the baseline concentration of 29 ppbv (155.5 $\mu\text{g}/\text{m}^3$) detected at MW1-3. From the sample mean and the 95% confidence level, the average concentration is within the interval 21.8 ± 2.2 ppbv (117.1 ± 11.7 $\mu\text{g}/\text{m}^3$) for this set of data. Trichloroethylene was also detected at sample location MW1-4 at a maximum concentration of 5.1 ppbv (27.4 $\mu\text{g}/\text{m}^3$).

The overall maximum trichloroethylene concentration detected during this sampling period was 26.7 ppbv (143.2 $\mu\text{g}/\text{m}^3$) which is greater than the overall maximum concentration of 16 ppbv (86 $\mu\text{g}/\text{m}^3$) detected during the Track 2 Investigation. However, these concentrations are considered low in comparison with other halogenated organic compounds detected at these three landfill areas.

5.3.4.1.7 Tetrachloroethylene

Tetrachloroethylene was the most predominately detected constituent above the reportable limit at all three sites. It is also the constituent that was detected at the highest concentration at all three sites. The overall maximum concentration detected during the 1997-1999 sampling period was 616 ppbv (4170 $\mu\text{g}/\text{m}^3$), which occurred at Site 8-05-1 at sample location MW1-3. This level was slightly greater than the baseline concentration of 580 ppbv (3926 $\mu\text{g}/\text{m}^3$) detected at MW1-3. From the sample mean and the 95% confidence level, the average concentration is within the interval 458.1 ± 57.2 ppbv (3100.9 ± 386.9 $\mu\text{g}/\text{m}^3$) for this set of data. At sample location MW1-4, tetrachloroethylene was detected at a maximum concentration of 247 ppbv (1672 $\mu\text{g}/\text{m}^3$). At sample location MW1-1, tetrachloroethylene was detected at a maximum concentration of 20 ppbv (135.4 $\mu\text{g}/\text{m}^3$).

Tetrachloroethylene was consistently detected above the reporting limit at Site 8-06-53 at five out of six sample locations. The overall maximum concentration detected at Site 8-06-53 during this sampling period was 25 ppbv (169 $\mu\text{g}/\text{m}^3$) at sample location MW53-2. This level was only slightly greater than the baseline concentration of 24 ppbv (169 $\mu\text{g}/\text{m}^3$) for this sample location. From the sample mean and the 95% confidence level, the average concentration is within the interval 18.0 ± 2.8 ppbv (121.6 ± 19.0 $\mu\text{g}/\text{m}^3$) for this set of data. Sample location MW53-1 had

only four detectable samples above the reporting limit, with a maximum concentration of 2.8 ppbv ($19 \mu\text{g}/\text{m}^3$). Sample location MW53-4 had six detectable samples above the reporting limit, with a maximum concentration of 18.3 ppbv ($123.9 \mu\text{g}/\text{m}^3$). From the sample mean and the 95% confidence level, the average concentration is within the interval 3.6 ± 2.5 ppbv ($24.3 \pm 16.8 \mu\text{g}/\text{m}^3$) for this set of data. Because of the large confidence interval (± 2.5 ppbv) in comparison with the mean value, the maximum concentration for MW53-4 is suspect. A further evaluation of the suspect maximum concentration for MW53-4 is discussed in Section 5.3.4.2. The maximum concentration detected at sample location MW53-5 was 5.9 ppbv ($39.9 \mu\text{g}/\text{m}^3$). The maximum concentration detected at sample location MW53-6 was 9.3 ppbv ($63 \mu\text{g}/\text{m}^3$). Tetrachloroethylene was consistently detected above the reporting limit at all four sample locations at Site 8-05-51. The overall maximum concentration detected at Site 8-05-51 was 83 ppbv ($562 \mu\text{g}/\text{m}^3$) at sample location MW51-3. This level was above the baseline concentration of 19.0 ppbv ($128.6 \mu\text{g}/\text{m}^3$) for this sample location. From the sample mean and the 95% confidence level, the average concentration is within the interval 17.4 ± 11.1 ppbv ($117.5 \pm 75.2 \mu\text{g}/\text{m}^3$) for this set of data. Because of the large confidence interval (± 11.1 ppbv) in comparison with the mean value, the maximum concentration for MW51-3 is suspect. Therefore, the second highest maximum for Site 8-05-51, which occurred at sample location MW51-1, along with the sample mean and confidence interval, were evaluated. The maximum concentration detected at sample location MW51-1 was 29 ppbv ($196.3 \mu\text{g}/\text{m}^3$) which was slightly greater than the baseline concentration of 22 ppbv ($148.9 \mu\text{g}/\text{m}^3$). From the sample mean and the 95% confidence level, the average concentration is within the interval 17.1 ± 3.1 ppbv ($115.8 \pm 20.9 \mu\text{g}/\text{m}^3$) for this set of data. The sample means for both sample locations are almost identical but the confidence interval for MW51-1 is much lower than for MW51-3. Additional evaluation of the suspect maximum concentration for MW51-3 is provided in Section 5.3.4.2. The maximum concentration detected at sample location MW51-2 was 23 ppbv ($155.7 \mu\text{g}/\text{m}^3$); and at sample location MW51-4 it was 24 ppbv ($162.5 \mu\text{g}/\text{m}^3$).

The overall maximum tetrachloroethylene concentration detected during this sampling period was 616 ppbv ($4170 \mu\text{g}/\text{m}^3$) which is less than the overall maximum concentration of 1400 ppbv ($9477 \mu\text{g}/\text{m}^3$) detected during the Track 2 Investigation.

5.3.4.2 Trend Analysis

The baseline and 1997-1999 analytical data were plotted as concentration versus sample collection date to evaluate any specific patterns, trends, or anomalies. A trend line has been plotted to indicate a decreasing or increasing trend in the data except where a curvilinear type analysis appeared more appropriate. These charts are presented in Appendix H.

With reference to specific patterns in the graphical presentation of the soil gas data, coincident peaks or dips may be attributed to one or more of the following factors: seasonal events (i.e., changes in precipitation or increased infiltration of water from snowmelt), effects of water infiltration within the periphery of the cover on contaminant migration, significant variations in barometric pressure, chemical-specific characteristics affecting migration patterns, or attainment of a new equilibrium within the contaminant/containment system caused by the introduction of the landfill covers. In order to determine whether these factors are causal in the appearance of peaks and dips in the graphical presentation of the soil gas data, additional data (i.e., meteorological data and soil gas monitoring data for additional quarters) will be needed. Some of the factors that will be explored in this section, specific to Site 8-05-1, are the attainment of a new equilibrium and infiltration of water within the periphery of the cover, in

order to explain the dissimilarity between the graphical presentation of the 8-05-1 soil gas data and data from the other two sites.

A common likely anomaly associated, in general, with the fourth quarter data for 1997 is based on a sample collection problem. An inadequate seal in the sampling equipment likely caused the dilution of many of the samples, resulting in lower than expected concentrations. All diluted samples would tend to show a departure from the normal trend of the data before and after the affected data point. This appears to be the case for the affected sample locations, since the data show an obvious dip for all of the constituents. The occurrence of sample dilution can be supported by comparing the duplicate sample analytical results with the original sample results for sample location MW1-4 at Site 8-05-1 for the 1997 fourth quarter data set. The duplicate sample was collected just after the regular sample. The data for the duplicate analytical results are significantly higher than the original. This anomaly is discussed for each of the affected sites below.

With reference to the charts in Appendix H for Site 8-05-1, the graphical presentation of the data for all of the constituents detected exhibited similar patterns (i.e., coincident peaks and dips) in concentration over time for each of the soil gas locations. In addition, with reference to the chart for sample location MW1-3, the data exhibits first a decreasing trend during 1997 and then an increasing trend during the first half of 1998 and a general leveling off in concentration from the second half of 1998 through all of 1999 for all constituents in general. This trend is not quite as pronounced for TCA. For the baseline data, TCA was not detected; therefore the overall trend is increasing. Of all the sites, Site OU 8-05-1 is the only site that experienced an overall increasing trend for the three year sampling period. However, the trend for 1999 indicated an overall decrease in the levels for the constituents detected at sample location MW1-4. It also appears that the trend for sample location MW1-3 has stabilized and appears to exhibit a flat trend in the levels of all the constituents detected from the second half of 1998 through all of 1999.

It appears that perhaps a new equilibrium is being established at 8-05-1 with the placement of the soil cover, since the combination of the landfill cover and the F/L layer underneath the 8-05-1 Site and extending beyond the sample locations may act more efficiently at limiting contaminant migration than at the other two sites. This is possible since the F/L layer (which is not completely continuous below NRF) at this site appears to have a lower permeability and is thicker and more extensive than at the other two sites. The landfill cover's low permeable layer is also thicker than at the other two sites. These two bounding physical barriers would tend to limit both the upward and downward migration of contaminants and potentially enhance their lateral movement. One would eventually expect a decreasing trend in contaminant concentrations over a period of time. A perched water zone that appeared briefly in the region of sample location MW1-4 may have had an impact on the data. Also, water may have entered the waste layer (or contaminants bounded in the soil) laterally from the periphery of the cover and caused a new release of the buried contaminants. Percolating water from natural precipitation will acquire soluble organic components that have been immobilized by adsorption in the soil or that were contained by the waste, by processes of desorption and/or dissolution. These organic compounds can be transported a certain distance away from the original source and then become immobilized again (L. G. Everett, et. al.); the organic compounds can then evaporate and become a new source for soil gases or supplement an existing source.

With reference to the charts in Appendix H for Site 8-05-51, the graphical presentation of the data for all of the constituents detected exhibit similar patterns. The similarities are in the general shape of the curves and the occurrences of the peaks and valleys for each constituent

at each sample location. The data also exhibits a decreasing trend in concentration over time, in general, with the exception of chloroform at sample location MW51-2 at 8-05-51, which exhibits a slightly increasing trend.

Some of the differences in the general pattern exhibited by the graphs may be attributed to additional anomalies in the data, beyond the sample dilution discussed above. An apparent anomaly may be associated with the PCE data obtained from soil gas monitoring sample location MW51-3 during the second quarter of 1998 (depicted as a high concentration spike in the graph where this maximum concentration was determined to be suspect as discussed in Section 5.3.4.1). Based on the discussion in Section 5.3.4.1 and the overall general trend of data for this sample collection period, it appears like this second quarter data point for 1998 is one order of magnitude higher than what is expected. If the suspect data point for PCE is adjusted by one order of magnitude lower than the reported value, then all other data points before and after, fall in line within the anticipated range of values. The data in the modified graph do not appear to be suppressed as in the original graph with the suspect maximum concentration (typically, an anomalous data point tends to obscure patterns in the data). Another anomaly that may be attributed to the sample dilution problem is apparent in the data (manifested as a dip in concentration) for sample locations MW51-2 and MW51-3 (4th quarter, 1997), and MW51-4 (3rd quarter, 1998).

With reference to the charts in Appendix H for Site 8-06-53, the graphical presentation of the data for the two constituents detected (Freon 11 and PCE) exhibit a pattern of change in concentration over time for each of the individual soil gas locations similar to that observed at Site 8-05-51. The similarities, as above, are in the general shape of the curves and the occurrences of the peaks and dips for each constituent at each sample location. The data exhibit an overall decreasing trend with the exception of sample locations MW53-2 and MW53-4. Sample location MW53-2 exhibits an overall increasing trend for PCE but a decreasing trend for Freon 11. There is a significant increase in concentration for both constituents detected during the 1998 third quarter at sample location MW53-4, but this appears to be a data anomaly (apparent as a high concentration spike in the graphs where these maximum concentrations were determined to be suspect as discussed in Section 5.3.4.1). Based on the discussion in Section 5.3.4.1 and the overall general trend of data for this sample collection period, it appears that the third quarter data point for 1998 may be in error by one order of magnitude. If the suspect 1998 third quarter data points for both PCE and Freon 11 are adjusted to fall more in line with the overall data, the resulting graphs appear to be more representative of the overall data when compared to the other graphs of the other sample locations at Site 8-06-53 (see modified charts in Appendix H for PCE and Freon 11). The data in the modified graphs do not appear to be suppressed as in the original graphs with the suspect maximum concentration (typically, an anomalous data point tends to obscure patterns in the data). The patterns in the data presented in the modified graph are more pronounced which is more conducive for comparison with the other graphs from the other sample locations at Site 8-06-53. The trend lines for both chemicals presented in the modified charts are essentially flat. The sample dilution problem that is associated with the fourth quarter data for 1997 as discussed previously, is somewhat apparent only for sample location MW 53-2.

In summary, all areas exhibit either stable, slowly decreasing, or on occasion, slightly increasing trends, perhaps tending towards new post-cover equilibrium values. This will be tracked by the continuing monitoring program.

5.3.4.3 Comparison to Groundwater Data

Of the volatile organic compounds detected under the current soil gas and groundwater monitoring programs, only chloroform, 1,1,1-trichloroethane, and tetrachloroethylene were detected under both monitoring programs. Organic compounds detected in groundwater samples at some of the groundwater monitoring well locations occurred at trace levels, significantly less the levels detected in the soil gas samples. This indicates that organic compounds are not significantly migrating from the landfill sites at this time.

5.3.5 Risk Information Review

5.3.5.1 Review Constituents of Concern

The Chemicals of Potential Concern identified as a result of the data collection and evaluation process during the Track 2 Investigation included several volatile organics and metals. Xylenes, ethylbenzene, 1,1,1,-trichloroethane, and tetrachloroethylene were the only organic compounds initially identified as Chemicals of Potential Concern in the Track 2 Investigation. However, Freon 11, Freon 113, chloroform, and trichloroethylene were detected during the Track 2 Investigations of the three landfill areas 8-05-1, 8-05-51, and 8-06-53. Of the organic chemicals detected under the Track 2 Investigation, only one additional volatile organic compound was detected under the current soil gas monitoring evolution. The additional VOC is Freon 12, which was detected at low levels at Site 8-05-1.

5.3.5.2 Review ARARs

The selected remedy of containment with a vegetative soil cover for the three landfill areas was designed to meet substantive aspects of the ARARs identified in the ROD. There were no chemical-specific ARARs identified for the selected remedy.

The selected remedy triggered action-specific ARARs under specific state (Idaho Administration Procedures Act-IDAPA) and Federal (RCRA Subtitle C) regulations that relate to the closure and post-closure care of the inactive landfill areas as well as regulations concerning the control of fugitive dust.

The following are the pertinent action-specific ARARs that were defined for the selected remedy and were reviewed for changes that could affect protectiveness:

- 40 CFR 264.310 (RCRA Subtitle C), Closure and Post-Closure Care, (Relevant and Appropriate)
- IDAPA 16.01.05.008, Closure and Post-Closure Care, (Relevant and Appropriate)
- IDAPA 16.01.01.650-01651, Rules for Control of Fugitive Dust and General Rules, (Applicable)

The following are the pertinent location-specific ARARs defined for the selected remedy:

- 36 CFR 800, Protection of Historic and Cultural Properties, (Applicable)
- 43 CFR 7, Protection of Archeological Resources, (Applicable)

These ARARs have not become more stringent since the signing of the ROD. However, the State of Idaho promulgates standards for groundwater contaminant concentrations, and has revised existing groundwater quality standards. These new standards have been reviewed and were determined to be relevant and appropriate. Based on this review, NRF is currently monitoring for the specific constituents of concern (pertinent to NRF as identified in risk assessments for NRF CERCLA sites) listed in the new standard, and thus monitoring activities at NRF were determined to remain protective of human health and the environment, and no additions to NRF's monitored constituents are required at this time.

5.3.6 Risk Recalculation/Assessment

The only new constituent that was detected during the current soil gas monitoring program and not during the Track 2 Investigations is Freon 12. However, Freon 12 was detected at low levels in comparison with other halogenated organic compounds (i.e., tetrachloroethylene) that were detected during both the Track 2 Investigations and under the current soil gas monitoring program. The levels of Freon 12 are about two orders of magnitude lower than for tetrachloroethylene. Exposure data for Freon 12 from soil gas sampling is only available for evaluating the inhalation pathway. However, the inhalation pathway could not be evaluated since the toxicity of this compound has not been determined (the inhalation reference dose has not been established for Freon 12); therefore, the associated risk may be underestimated for Site 8-05-1. No significant risk was associated with the other halogenated organic compounds evaluated under the risk assessments (where toxicity values were available) conducted during the Track 2 Investigations. Furthermore, the levels of Freon 12 are significantly lower than tetrachloroethylene (evaluated in the Track 2 risk assessment) and Freon 12 currently displays a decreasing trend. In addition, the levels of all other chemicals detected during the report period have not exceeded the maximum levels detected under the Track 2 Investigations. Therefore, there is no need for recalculating risk at this time.

6.0 Assessment

6.1 Conditions External to the Remedy

Certain conditions external to the selected remedy can have a far-reaching influence on the applicability and the ultimate success of a chosen remedy.

6.1.1 Changes in Land Use or Projected Land Use

Prior to 1989, NRF had two primary missions. The first mission was to test equipment and train U. S. Navy personnel to operate nuclear propulsion plants aboard Fleet vessels. The second mission was to receive and examine cores from Fleet vessels at the Expended Core Facility (ECF). At the time of the ROD signing, two of NRF's three prototype plants were closed. Since the ROD signing, the last of the NRF prototypes was inactivated (May 1995), but the fundamental operation of the ECF has not changed.

Presently, expended cores are examined by ECF and then sent to INTEC, a facility located approximately 5 miles south of NRF, for temporary storage. At about the time of the ROD, a decision was made to place all of the Navy's spent fuel into dry storage. Facilities for the interim dry storage of the Navy's expended nuclear fuel are under construction adjacent to Site 8-05-1 at NRF. The facility is expected to begin receiving fuel by 2001.

The new facility's eastern boundary at Site 8-05-1 was delineated by placing a temporary fence prior to the commencement of construction, to ensure that construction activities would not encroach into the landfill cover. During construction near the east boundary at Site 8-05-1, the excavation activities were closely monitored to further ensure that the integrity of the landfill cover was maintained and that the landfill contents were not exposed. Photographs of the excavation activities that took place near the east boundary of Site 8-05-1 were taken to demonstrate that the landfill cover integrity was maintained (see Appendix C).

6.1.2 New Contaminants, Sources, or Pathway

New contaminants have not been observed in groundwater since the signing of the ROD. One new contaminant, dichlorodifluoromethane or Freon 12, has been detected in the soil gas monitoring wells, as discussed in Section 5.3.6. Freon 12 has only been detected at Site 8-05-1 at low concentrations. In addition, the numbers of constituents detected at the other sites, as well as their concentrations, have varied between the Track 2 Investigations and the current soil gas sampling evolution. This is probably due to the difference in the sample locations. For instance, at Site 8-06-53 under the Track 2 Investigation, tetrachloroethylene was detected at a higher level than at the other two sites. Under the current soil gas monitoring program, tetrachloroethylene has been detected at Site 8-05-1 at a higher level than currently detected at Site 8-06-53, yet the level detected at Site 8-05-1 is less than the highest level detected at Site 8-06-53 during the Track 2 Investigation.

Evidence collected during past Remedial Investigations indicated that the likely source for chromium in groundwater near NRF is the IWD; contaminant migration is accomplished through the leaching of existing contaminants from the soil. The same investigation supports the conclusion that the source for elevated tritium in NRF groundwater is most likely a perched water zone that formed while the S1W leaching beds were active. The dynamic nature of the aquifer beneath NRF contributes to constantly changing groundwater flow paths beneath NRF.

For example, reduced flow to the IWD is causing a local reversal of flow near NRF-13, and a reduction in elevation of the groundwater high east of NRF. These changing flow patterns affect the way contaminants are transported.

The effects on NRF due to these changes are measurable and important; however, they will not have any direct effect on the landfill covers or soil gas wells. Potential impacts due to these changes on groundwater monitoring do exist; however, localized changes in discharge patterns are not expected to create new contaminant sources or pathways that cannot be detected by the current groundwater monitoring network.

6.1.3 Changes in Hydrologic/Hydrogeologic Site Conditions

Recent changes in NRF site operations have resulted in a substantial reduction in water usage. Reduced water usage results in smaller quantities of water being pumped from the aquifer and discharged to the IWD. This has caused the IWD to shrink in size along with a corresponding decrease in infiltration. Since NRF sits atop a portion of the SRPA that is relatively flat (approximately a 6 inch drop in water table elevation per mile), small changes in both pattern and proportion of surface recharge can cause a disproportionately large change in the local groundwater flow direction. Transport patterns of potential aquifer contaminants would change correspondingly.

Past hydrological evidence suggests that contaminants released from the IWD and the NRF sewage lagoons, both located north of the facility, pass east of NRF due to a localized groundwater high formed from the effluent discharged to the aquifer north of the facility. With decreased flow to both the IWD and the sewage lagoons and with decreased pumping from NRF wells, the localized groundwater high becomes less pronounced. This flow configuration favors contaminant flow paths that take a more south to north path. Such a change in hydrogeologic condition was anticipated during the design phase of the NRF groundwater monitoring network. Any change in contaminant flow path will be detected by the monitoring array, and will not affect the well groupings as described previously. In particular, NRF-7 will most likely remain an upgradient well for NRF.

During the construction of the 8-05-1 soil gas monitoring probes, moist soil was discovered near the top of a clay unit believed to be stratigraphically equivalent with clay deposits found during the hydrogeologic investigation associated with the IWD RI/FS. This clay layer was described as a thick fluvial lacustrine (F/L) deposit. This clay is semi-impermeable to water and readily promotes the formation of perched water. After the construction of the soil gas probes, during routine sampling, standing water was discovered once in one probe and twice in another; however, no water was found during the December 1999 sampling event. The origin of the water is not believed to be related to infiltration through the landfill cover. Both probes are located near topographic depressions at the surface near the edge of the landfill covers. Precipitation that collects in surface depressions, ponding in sufficient quantities, typically infiltrates into the subsurface where it encounters the F/L deposit discussed above. The landfill covers are designed to allow the precipitation to drain away from the covers to the outer perimeter of the landfill areas. At two of the landfill areas, Sites 8-05-1 and 8-06-53, two intersecting roads bound the southwest corner of each site. Also, located at the southwest corner at each of these sites are the two soil gas probes where standing water has been detected. This physical layout may cause storm water runoff to saturate the soils in these areas and cause water to infiltrate down to the surface of the F/L layer. The slope of the surface of the F/L layer directs water toward the probe locations. Standing water in these probes has been observed typically after large precipitation events.

6.2 Remedy Implementation and System Operations/(O&M)

6.2.1 Health and Safety Plan/Contingency Plan (HASP/CP)

All sample collection activities are conducted per local Health and Safety procedures. These procedures are reviewed and updated as needed by the local Industrial Hygienist.

6.2.2 Access and Institutional Controls

Access controls include the fact that these landfill areas are under DOE-NR control, where access to the general public is prohibited. Both NRF and INEEL security monitor access to these sites by indigenous personnel.

Institutional controls include internal administrative restrictions on the use of the land. At the time the properties are transferred to another agency or released for residential or commercial ownership, deed restrictions and fencing will be placed on the landfill areas as appropriate.

6.2.3 Remedy Performance

6.2.3.1 Landfill Covers

The performance of the landfill covers is directly measured in several ways. First, a visual inspection confirms the physical integrity of the covers. This inspection is intended to identify the following problems: occurrence of soil erosion, establishment of adequate vegetative cover, penetration of the cover by various burrowing animals, or formation of cracks in the cover due to temperature extremes or subsidence. The results of these inspections show that the landfill, with several minor exceptions, are performing as designed. The exceptions relate to inadequate vegetative cover at Site 8-05-1. This problem is addressed in more detail in Section 7.2.

The second measure of performance is gauged by results of surface soil gas monitoring. If the landfill covers are working as designed, then little or no organic vapors will be detected at the surface of the landfill covers. Three soil gas surface emissions surveys have been performed since the construction of the landfill covers. No significant concentrations of volatile organic constituents have been detected, thereby indicating the landfill covers are performing as designed.

Several indirect indicators are used to assess the performance of landfill covers. The soil gas monitoring probes measure the concentration of soil gas adjacent to the covers. The concentrations of soil gas constituents are essentially stable in all soil gas monitoring probes, with some small decreasing trends and few slight increasing trends. A significant increase in soil gas concentrations would indicate possible seepage of water through the covers. Infiltrating water would facilitate the migration of contaminants away from the landfills toward the groundwater monitoring wells and potentially the aquifer. Groundwater monitoring wells placed downgradient of the landfills are designed to detect organic compounds in the groundwater. To date, no unusual levels of organic compounds have been detected in soil gas probes, and no appreciable concentrations of organic compounds have been detected in groundwater samples. In summary, NRF concludes that the landfill covers are functioning as designed.

6.2.3.2 Groundwater Monitoring System

This section of the Five-Year Review document assesses four aspects of the groundwater monitoring system to determine its overall performance. The topics covered in the section includes fitness of the wells, monitoring network fitness, constituents monitored, and sampling frequency.

6.2.3.2.1 Well Fitness

The fundamental element of the NRF groundwater monitoring system is the individual wells. As previously discussed, the NRF groundwater monitoring network has evolved over the past decade; however, no changes have occurred since the ROD. It is comprised of a combination of old and new wells.

Information used to assess the fitness of a well includes construction guidelines provided by RCRA, the State of Idaho, and industry. NRF has 13 wells in its groundwater monitoring network. Nine of these wells have been constructed within the past 12 years, with the remaining wells being constructed between 1950 and 1980. Installation of the new wells incorporated modern drilling and construction techniques. They were built with environmentally inert materials and were designed to target the upper 50 feet of the aquifer. The other wells are older, and are not optimally constructed for specifically monitoring the upper 50 feet of the aquifer (wells USGS-12, USGS-97, USGS-98, and USGS-99). Additionally, these wells may possess problems such as inadequate grouting, and carbon steel in contact with aquifer water. In spite of these potential problems, these wells provide useable information.

6.2.3.2.2 Network Fitness

The Site Downgradient wells, NRF-8, 9, 10, 11, and 12, and USGS-102, the core of the NRF groundwater monitoring network, were designed using computer based modeling. Groundwater as well as hydrogeologic evidence collected over the past several years indicate that these wells adequately and effectively monitor potential groundwater contaminants. For example, these wells have detected contamination in locations where it was anticipated, and in expected concentrations. Also, the results from the regional downgradient wells (USGS-97, 98, and 99) confirm the results from the local downgradient wells.

6.2.3.2.3 Adequacy of Monitored Constituents

The NRF groundwater monitoring system is designed to search for constituents that potentially could be released to the environment because of operations at NRF. This monitoring network also searches for constituents that are characteristic groundwater indicators such as calcium and chloride. All constituents that are believed to be potential contaminants to the environment are currently monitored by NRF. Several constituents currently monitored by NRF appear benign to the environment or occur at consistently low levels. With the risk posed by such constituents being very low, they become candidates for removal from the list of monitored constituents. Included in the list of low risk constituents are antimony, arsenic, beryllium, cadmium, mercury, selenium, silver, thallium, NO₃, TKN, TOX and phosphorus. Caution must be used before these constituents are removed from the monitoring program. Two reasons not to remove a constituent is because it was released in quantity at NRF in the past, and there is no monetary incentive to do so. Some of the listed constituents, although they are seldom detected in NRF groundwater, have potentially been released in quantity in the past. Removing these constituents from the list may increase the risk of unmonitored releases in the future.

Alternatively, some constituents may be analytically tied in with other constituents, and removal from the list of analytes may not result in any cost savings because the analytical method used identifies a suite of constituents. As a result, NRF proposes to remove TKN, TOC, and phosphorus from the analyte list at this time.

NRF also analyzes groundwater for several radiological parameters. These include gross alpha, gross beta, tritium, strontium-90, and isotopic gamma. These radiological parameters were originally monitored because of the uncertainty associated with past radiological releases at NRF. After the results of the comprehensive RI/FS were analyzed, NRF concluded that alpha and beta emitters were either not released in quantity at NRF, or they did not migrate appreciably from the point of discharge. The low levels of these parameters in NRF groundwater over the past four years confirms that constituents that emit alpha and beta radioactivity are not major problems. In addition, strontium-90 was known to have been released in quantity at NRF, yet most strontium-90 results are below minimum detectable activity (MDA). Based on these observations, the radiological parameters currently monitored by NRF appear to be very conservative, with respect to protecting groundwater. Although the remedies associated with the findings of the NRF Comprehensive RI/FS have not yet been fully implemented, adjustments in the NRF radiological monitoring program appear to be warranted; i. e., deletion of gross alpha and gross beta in quarterly groundwater samples.

6.2.3.2.4 Adequacy of Sampling Frequency

The NRF groundwater monitoring well sampling frequency was originally designed to gather groundwater constituent data in an environment where little or no data existed. Factors such as random variations in aquifer parameters, the affects of seasons, and flow in the Big Lost River were all unknowns. Since the majority of the NRF groundwater monitoring wells were first sampled during the fall of 1995, approximately four years of data have been collected through 1999. During this time, analysis of the data has led to a better understanding of the factors that affect contaminant transport and fate in the aquifer near NRF.

From a hydrogeologic perspective, it is now known that the water table at NRF is relatively flat compared to the surrounding water table. Furthermore, flow in the Big Lost River, or the absence thereof, effects on NRF hydrology. This situation causes several important consequences relative to groundwater flow patterns and contaminant transport and fate. Sampling frequency is influenced by these hydrogeologic factors. The Appendix A 1999 Hydrogeologic Report presents evidence that changes in flow in the Big Lost River are transmitted to NRF much more quickly that previously expected. Additionally, small changes in local aquifer recharge cause a large change in groundwater flow paths. These conditions require that samples be collected regularly and frequently so that changes caused by short-term fluctuations can be recognized.

From what is known now, it appears that NRF operations have a minimal impact on the extended groundwater quality of the SRPA. The extended groundwater quality is the quality of the groundwater downgradient of NRF measured at a distance that is outside the immediate influence of the facility. For NRF, this distance appears to be approximately one mile. Beyond this distance, natural processes cause potential contaminant levels to fall near background.

The current quarterly sampling frequency appears to account for short-term fluctuations in groundwater flow direction, short-term variations in local recharge, and longer-term trends due to known or unknown factors. Based on these observations, the current sampling frequency appears appropriate for NRF groundwater monitoring for the present. No increase or decrease

in sampling frequency is warranted at this time. A decrease in sampling frequency to three times annually appears possible beginning in 2003, following completion of ongoing CERCLA remedial actions.

6.2.3.3 Soil Gas Monitoring System

The current analytical method being employed for the soil gas monitoring program incorporates all of the potential organic chemicals of concern, with adequate detection levels (MDLs). Since some of the soil gas sampling locations exhibit a slight increasing trend, it is recommended that the current sampling frequency be maintained at this time.

6.2.4 System Operations

The current O&M requirements appear adequate for detecting potential problems with the selected remedies. Section 7 discusses minor deficiencies that have been addressed. The site inspections have been able to detect problems with erosion and the vegetative cover. None of the minor problems encountered have been detrimental, and have been detected early enough to take the appropriate action.

Internal audits are conducted at least annually to ensure compliance with sample collection procedures. Sample collection data sheets are filled out to ensure all sample collection steps have been followed.

6.3 ARARs

No changes to the ROD-identified ARARs are required at this time. A new Idaho Groundwater Quality Rule that potentially affected at least one chemical of concern was reviewed for applicability, but no changes to the current monitoring programs appear warranted because of this Rule.

6.4 Risk Information

As stated previously, the only new constituent that was detected during the current soil gas monitoring program (i.e., not during the Track 2 Investigations) is Freon 12. As discussed in Section 5.3, there are no significant changes in the level of risk.

7.0 Deficiencies

7.1 Overview

This section of the Five-Year Review Report discusses deficiencies observed in the construction and operation of the selected remedies for the Landfill Areas.

7.2 Landfill Covers

Inspection of the landfill covers revealed the following deficiencies:

- 1) Some minor signs of erosion along the west side slope of the cover at Site 8-05-1 were observed over the past several years, as described in Section 6.2.3.2. No repairs were warranted and no significant advancement in erosion has been observed since 1999.
- 2) With regard to vegetative covers, Site 8-06-53 had the best density, most mature growth, and the healthiest plants of the preferred vegetation. Site 8-05-51 has the next best density of preferred vegetation, but with some bare spots and some weeds. Overall, the plants were not fully matured. Site 8-05-1 has an elevated density of weeds compared with the preferred vegetation. However, an increase in the density of desired vegetation has been observed from one year to the next. The majority of the plants are still immature.

7.3 Groundwater Monitoring Network

Deficiencies related the groundwater monitoring network are listed below:

- 1) The upgradient groundwater quality relative to NRF is not well defined. This condition is unchanged since the ROD. At NRF, upgradient water samples are collected primarily from one well, with additional data coming from NRF-7, a well not physically upgradient of the facility that has a geochemical signature consistent with upgradient water. USGS-12 is located approximately three miles north of NRF (i.e., undesirably far away), was constructed in 1950, and is cased with carbon steel to a depth of 563 feet. The total depth of the USGS-12 borehole was recorded at 692 feet; however geophysical logging information is only recorded to 564 feet. It is not clear whether the borehole was partially or completely back-filled 130 feet, or if logging was prematurely terminated. Information that was gathered during an INEEL site-wide well fitness survey indicated that the well was open from 585 to 692 feet or over a 107 foot interval. The submersible pump is located at 358 feet below land surface (bls). Hydrographs from the well indicate water level has varied from approximately 313 feet to 326 feet bls. Water samples from this well may be collected from depths that are not reflective of background conditions at NRF. The likely effect of not having adequate upgradient groundwater information is to potentially overstate the impact that NRF operations may have had on the aquifer.
- 2) Although the NRF wells constructed since 1988 were specifically designed to have a 50 foot screened interval (approximately 40 feet are exposed to the aquifer under typical water conditions), this design may inadvertently underestimate the impact that NRF operations have on the aquifer. It is now known that the vertical flow component in the aquifer near NRF is very small. Potential contaminants released to the aquifer will stay close to the surface of the aquifer. Because of the length of the screened interval and

the placement of the submersible pump, much of the water being sampled will be below the zone of potential contamination. Clean water will be mixed with potentially contaminated water, causing a dilution of the potential contaminants. The resulting analytical concentration will be artificially lower than if the sample had been collected nearer the surface. Conversely, though, the results would tend to overestimate NRF's impact on the aquifer as a whole. Since the detectable results are all far below risk-based levels of concern, well data appears to remain useful and applicable to assessing NRF's impact on the aquifer. This conservative tendency reaffirms that the selected remedies remain protective of human health and the environment.

- 3) Water samples from two wells, NRF-10 and NRF-13, consistently contain higher than desired levels of suspended solids. The source of the suspended soils is sedimentary interbeds that intersect the screened interval of the wells. The suspended solids in the wells contain metals that in turn raise the level of these metals in the water analyses. Groundwater sample results that are biased high for metal content in downgradient wells could exaggerate any conclusion that activities at NRF have adversely affected groundwater quality. Filtering the samples prior to analysis may reduce the reported metal concentrations in the samples. Comparison of these results with the results of an unfiltered split sample may indicate the portion of metals attributable to the suspended solids.
- 4) The scarcity of wells within the NRF fenced area increases the chance of near-site undetected releases.

7.4 Soil Gas Probes

Inspection of the soil gas probes revealed the following deficiencies:

- 1) All but two soil gas monitoring probes have been functioning properly. Probe location MW1-2, northeast of 8-05-01, is plugged. Sampling of this location has not been attempted since 1997. Probe location MW1-1, northwest of 8-05-01, is partially plugged; however, sampling of this location is possible. The plugging problem associated with these two monitoring probes may be due to defective construction.
- 2) Several probe locations have had standing water in them. The source of water is believed to be related to seasonal precipitation. Data collection from these locations have been unaffected by the water.

8.0 Recommendations and Required Actions

8.1 Overview

The purpose of this section of the Five-Year Review is to evaluate the deficiencies discussed in Section 7.0 and make recommendations regarding what actions, if any, may be appropriate to correct a deficiency.

8.2 Landfill Covers

With regard to the covers, no immediate actions are recommended. Site 8-05-51 appears to have an adequate concentration of preferred vegetation; however, much of this vegetation is still immature. If this problem persists with little or no improvement over the next two years, NRF plans fertilization of the landfill area with re-seeding of any bare spots. With regard to the vegetation problem at Site 8-05-1, the site will be re-seeded and fertilized during the fall of 2001. If re-seeding and the application of fertilizer are required at Site 8-05-51 after an inspection is conducted during June 2001, then both Sites 8-05-1 and 8-05-51 will be considered for action at the same time. In addition, if adverse weather conditions interfere with natural germination and propagation of the vegetative cover at any of the landfill areas, NRF will take action as appropriate. This would be normal O&M action for such deficiencies.

Although current security measures and administrative controls make accidental incursion onto the landfill areas unlikely, NRF plans to further post the landfills with appropriate signs to warn employees, subcontractors, or potential trespassers of the nature of the operable unit. The signs are planned for installation during the summer of 2001.

8.3 Groundwater Monitoring Network

The nature and extent of the groundwater monitoring network at NRF was designed to minimize risk to human health and the environment while at the same time being cost effective. Because of the predominantly unpredictable nature of hydrogeologic systems, any effort to quantify groundwater quality and infer impact to the aquifer is hypothetically based. Computer modeling of well locations and other parameters can improve accuracy, but only to a limited extent.

Several choices are available for modifying the current groundwater monitoring network. The number of wells could be increased or decreased; constituents on the monitored list could be added or deleted; sampling could be targeted (such as in micropurging); or the sampling frequency could be adjusted. Applying these choices could impact the effectiveness of the current groundwater monitoring network, raising or lowering the risk of not detecting potential releases from NRF or correctly interpreting the impact that NRF is having on the SRPA, as well as raising or lowering the cost of the monitoring program. Based on the data presented in this review, and the discussion of Section 6.2.3.2, NRF proposes no changes in the number or locations of monitoring wells, or in sampling methodology, at this time. NRF proposes maintaining the quarterly sampling frequency through 2002, after which NRF proposes that sampling frequency be changed to three times per year. NRF proposes deletion of the chemical parameters TKN, TOC, and phosphorus. These data are no longer needed. NRF also proposes no change for the radiological parameters cesium-137, strontium-90, tritium, and gamma spectroscopy, since tritium is detectable and gamma analyses provide a cost effective screening tool for potential future contaminants. However, NRF recommends deletion of the radiological parameters gross alpha and gross beta, since these no longer appear warranted

and are not cost-effective ways to monitor for potential future releases. NRF will consider proposing deletion of strontium-90 at a future time if results warrant.

DOE, EPA, and IDEQ will develop a list of criteria for re-evaluating groundwater chromium and for considering possible responses in the event that apparent trends in chromium concentrations observed in NRF-13 continue, and Federal MCLs are exceeded for an average of four quarters.

8.4 Soil gas Monitoring Probes

With regard to the soil gas monitoring probes at Site 8-05-1, one was found to be partially plugged and another was found to be completely plugged. The partially plugged monitoring probe supplies useable data; the completely plugged monitoring probe does not. All soil gas probes at Site 8-05-1 are completed on top of a clay layer that severely retards the downward movement of soil gases present at the site. The surface of the clay layer dips away from the plugged probe towards the other probes. Any contaminants migrating away from the landfill tend to flow down the sloped clay surface and away from the plugged monitoring probe. Hence, NRF expects that little or no contamination would be detected in the plugged monitoring probe even if it were functioning correctly. However, NRF will attempt to rectify the monitoring probe plugging problem at 8-05-01 by clearing the restrictions within the probes. Attempts to unplug the probes will be conducted during calendar year 2001. If unsuccessful, two options will be considered: 1) seek regulatory agreement that the plugged probe is in a non-critical area and no further action is required; or 2) construct a new monitoring probe to replace the plugged probe.

With regard to the soil gas monitoring sampling frequency, since some of the soil gas sampling locations exhibits a slight increasing trend, it is recommended that the current sampling frequency be maintained at this time.

9.0 Conclusions

9.1 Overview

The protectiveness of the remedies selected for the NRF Inactive Landfill Areas are discussed individually below. Because the individual remedies are each protective of human health and the environment, the remedies for the NRF Inactive Landfill Areas as a whole are protective.

9.2 Landfill Covers

From the visual information and analytical data obtained thus far, the landfill covers appear to be effective at containing contaminants by inhibiting infiltration of precipitation and by preventing direct contact with contaminated soils and landfill wastes.

9.3 Soil Gas Monitoring Probes

The soil gas monitoring probes have adequately monitored the content of VOCs in the subsurface near the inactive landfills. Based on the pattern of constituents detected, geologic conditions, and the concentration trends of VOCs, the landfill covers appear to limit the migration of VOCs away from the landfill areas. Although one soil gas monitoring probe near Site 8-05-1 does not operate, the other monitoring probes provide sufficient information.

9.4 Groundwater Monitoring Program

The NRF Groundwater Monitoring Well Network adequately monitors the SRPA near NRF. Both local downgradient groundwater water quality and regional downgradient groundwater quality indicate no significant impact from the landfill areas. Although the design or location of some monitoring wells is not optimal, these deficiencies are minor and do not belie the conclusion that the landfill covers are working effectively and are protective of human health and the environment. Several minor modifications to the groundwater monitoring program have been proposed.

10.0 Next Review

NRF is a statutory site that requires ongoing Five-Year Reviews. The next review will be conducted within five years of the completion of this Five-Year Review. The next Five-Year Review is currently scheduled for February 2006; however, to reduce effort, the next Inactive Landfill Areas Five-Year Review may be consolidated with the OU 8-08 Five-Year Review, which is to be issued in 2004. If so, both the Landfill Areas and OU 8-08 Five-Year Reviews would be completed as a single document on a recurring five-year schedule thereafter.