NM2 - ____21____

MONITORING REPORTS YEAR(S):

__2010__

RECEIVED OCD
2011 JAN -4 P 12: 38

TRIDENT ENVIRONMENTAL

CERTIFIED MAIL
RETURN RECIEPT NO. 7010 0290 0003 1264 9093

December 29, 2010

Mr. Brad Jones
New Mexico Energy, Minerals, & Natural Resources
Oil Conservation Division, Environmental Bureau
1220 S. St. Francis Drive
Santa Fe, New Mexico 87504

Re: Centralized Surface Waste Management Facility NM-02-0021
2010 Operations and Monitoring Report
John H. Hendrix Corporation
Section 15, Township 24 South, Range 36 East, Lea County, New Mexico

Dear Mr. Jones:

Trident Environmental, as agent for John H. Hendrix Corporation (JHHC), submits this report to the New Mexico Oil Conservation Division (OCD) for centralized surface waste management facility NM-02-0021 (facility). This report presents the operations, maintenance and monitoring results for soil and groundwater samples collected during calendar year 2010, and includes historical background information. The facility occupies approximately 200 acres in Section 15, Township 24 South, Range 36 East, Lea County, New Mexico as shown in Figure 1.

Operation Background

OCD issued permit number NM-02-0021 to JHHC on November 29, 2004 to construct and operate a centralized surface waste management facility for treating non-hazardous petroleum hydrocarbon-impacted soil resulting from spills, releases and pits from JHHC oil and gas operations.

The facility consists of twelve main cells, numbered 1 through 12. Each 12 acre cell measures approximately 400 ft (north-south) by 1450 ft (east-west) as depicted in Figure 2. The main cells are subdivided into three sub-cells, lettered A, B, and C, each measuring approximately 400 ft x 480 ft (4.40 acres). Cells 10B and 10C are currently are in use for hydrocarbon-impacted soil and tilled once every two weeks (biweekly) to enhance the biodegradation of petroleum hydrocarbons. Cells 1A, 1B, and 1C are closed, and cells 11 and 12 have reached capacity and discontinued accepting imported soil.

No soils were transported during the 2010 reporting period. Transport dates and total volumes for referenced cells since landfarm operations began are summarized below.

Transport Dates and Volumes

Cell	Transportation of Soils		Total Volume (yd^3)
	Began	Ended	
12	03/01/2005	12/12/2006	14,887
1	06/13/2006	02/20/2007	11,116
11	09/17/2007	05/30/2008	26,047
10	06/02/2008	10/22/2009	8,981
		Total	61,391

Sampling Procedures

Soil samples are collected from the active cells according to a semi-annual (twice yearly) schedule approved by the OCD in the permit modification on January 4, 2006. During each event of the 2010 reporting period, soil samples were collected using a decontaminated hand auger, placed in pre-cleaned 4-ounce jars, properly labeled, and placed in an ice-filled cooler. During the second sampling event, a backhoe was utilized to clear the first 12-18 inches of treatment zone soils to minimize chances of cross-contamination prior to advancing the hand auger. Sample locations were recorded using a handheld global positioning device (Garmin *eTrex*™ GPS) as shown in Figures 2 and 3. The auger holes were backfilled with bentonite and hydrated with potable water. Samples were hand-delivered under chain of custody to Cardinal Laboratories (Hobbs, NM) for analysis.

During the first 2010 semi-annual event on April 7, 2010, and the annual sampling event on November 3, 2010, samples were randomly collected at cells 1A, 1B, 1C, 10B, 10C, 11A, 11B, 11C, 12A, 12B, and 12C within the treatment zone (approximately 1 ft below the surface) and the vadose zone (approximately 3 ft below the surface). The treatment zone samples were analyzed for BTEX, TPH, and chloride, while the vadose zone samples were analyzed for BTEX, TPH, metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver, iron, copper, manganese, and zinc) and major ions (total alkalinity, bicarbonate, calcium, magnesium, potassium, sodium, chloride and sulfate).

Soil Analytical Results

The complete historical summary of analytical results for the background, treatment zone, and vadose zone samples are listed in Tables 1 (BTEX, TPH, and chloride), Table 2 (metals), and Table 3 (major ions). Laboratory analytical reports, chains of custody, and sample locations are included in Appendix A.

At the request of NMOCD after the first sampling event in April 2010, Trident Environmental performed an assessment of the potential occurrence of downward migration (exceedence of background conditions) of constituents of concern (COCs) into the vadose zone at the JHHC landfarm. The *Vadose Zone Monitoring Report* was submitted to NMOCD on October 11, 2010, and provided detailed explanations of the comparisons, analyses, and conclusions made. Based on the findings of the vadose zone monitoring assessment and subsequent analytical results, there is no indication of COCs migrating downward to the vadose zone. Activities and operations conducted at the JHHC landfarm are protective of public health, safety and the environment.

Treatment (Tilled) Zone Samples

The treatment zone sample results are compared to target remediation levels established in the permit (10 mg/kg for benzene, 50 mg/kg for BTEX, 100 mg/kg for TPH, and 1,000 mg/kg for chloride).

As summarized in Table 1, benzene and BTEX concentrations in the treatment zone were below the method detection limits (0.05 mg/kg and 0.300 mg/kg, respectively) for all cells during each sampling event. As of the most recent sampling event, the 100 mg/kg target remediation level for TPH in the treatment zone has been met for cells 1A, 1B, 1C, 10C, 11A, 11C, 12A, 12B, and 12C.

Vadose Zone Samples

The vadose zone sample results are compared to the background soil concentrations to evaluate potential infiltration of anthropogenic constituents of concern into the underlying native soils.

For both sampling events during 2010, benzene, BTEX and TPH concentrations in the vadose zone samples in each sampled cell are comparable to background levels and were less than the method detection limits (0.050 mg/kg, 0.300 mg/kg, and 20 mg/kg, respectively) for these constituents, which supports the conclusion that there is no migration of these constituents to underlying soils.

Chloride concentrations within the vadose zone ranged from less than 4 mg/kg to 224 mg/kg, well below the 1,000 mg/kg permitted level, and with no evidence of downward migration. These levels are well below concentrations considered protective of groundwater which is greater than 145 ft below ground surface, particularly when considering that the average chloride concentrations in the treatment and vadose zones for all cells sampled on November 3, 2010, were less than 20.5 mg/kg and 16.3 mg/kg, respectively. In addition, chloride concentrations in the treatment zone have always been well below concentrations considered protective of groundwater.

Metal and major ion constituents within the vadose zone are consistent with background concentrations and normal variations, and there are no distinguishable trends of increasing concentrations over time. Some variability in metal and major ion concentrations is expected

due to differences in soil mineralogy. None of the trace metal COCs exceeded the higher of the PQL or background screening values as established in the *Vadose Zone Monitoring Report.* In addition, statistical analysis and geochemical correlation plots show no indications that trace metal COCs have migrated into the vadose zone. Thus, there is no evidence of anthropogenic sources for these constituents within the vadose zone

Groundwater Conditions

The intended purpose for the groundwater monitoring well network was to establish baseline (background) conditions in 2005 prior to initiating use of the landfarm. That purpose has long since been achieved. A groundwater monitoring well network for a centralized surface waste management facility is not a requirement under past Rule 711, or under current rule 19.15.36 regulations, particularly for a site where depth to groundwater is greater than 100 ft below the bottom of the treatment cells. For reasons cited above, OCD granted administrative approval to suspend groundwater sampling via email on February 22, 2010.

Recommendations

It is recommended that further sampling and tilling of cells 1A, 1B, 1C, 11A, 11B, 11C, 12A, 12B, and 12C be discontinued since laboratory results have consistently shown that benzene, BTEX, TPH, and chloride are below the permitted remediation target levels of 10 mg/kg, 50 mg/kg, 100 mg/kg, and 1,000 mg/kg, respectively. In fact, with the exception of TPH in active cells 10B and 10C, all other treatment zone soils at the JHHC landfarm have been remediated such that they meet the closure performance standards specified in NMAC 19.15.36.15(F) as follows:

(1) Benzene, as determined by EPA SW-846 method 8021B, does not exceed 0.2 mg/kg.

(2) Total BTEX, as determined by EPA SW-846 method 8021B, does not exceed 50 mg/kg.

(3) The GRO and DRO combined fractions (TPH), as determined by EPA SW-846 method 8015M, does not exceed 500 mg/kg.

(4) Chloride, as determined by EPA method 4500-Cl B, does not exceed 1,000 mg/kg (the landfarm is located where ground water is more than 100 feet below the lowest elevation at which the JHHC has placed the treatment zone soils).

Soil samples will continue to be collected from the treatment and vadose zones in cells 10B and 10C until it is confirmed that target remediation levels have been met. Tilling of the treatment zone will continue in cells 10B and 10C to further degrade the petroleum hydrocarbons until remediation target levels are achieved.

JHHC will continue reporting analytical results to the OCD within 45 days after receipt of the laboratory reports.

We appreciate the opportunity to work with you on this project. Please feel free to call me at 432-638-8740 or Carolyn Haynes at 575-390-9689, if you have any questions.

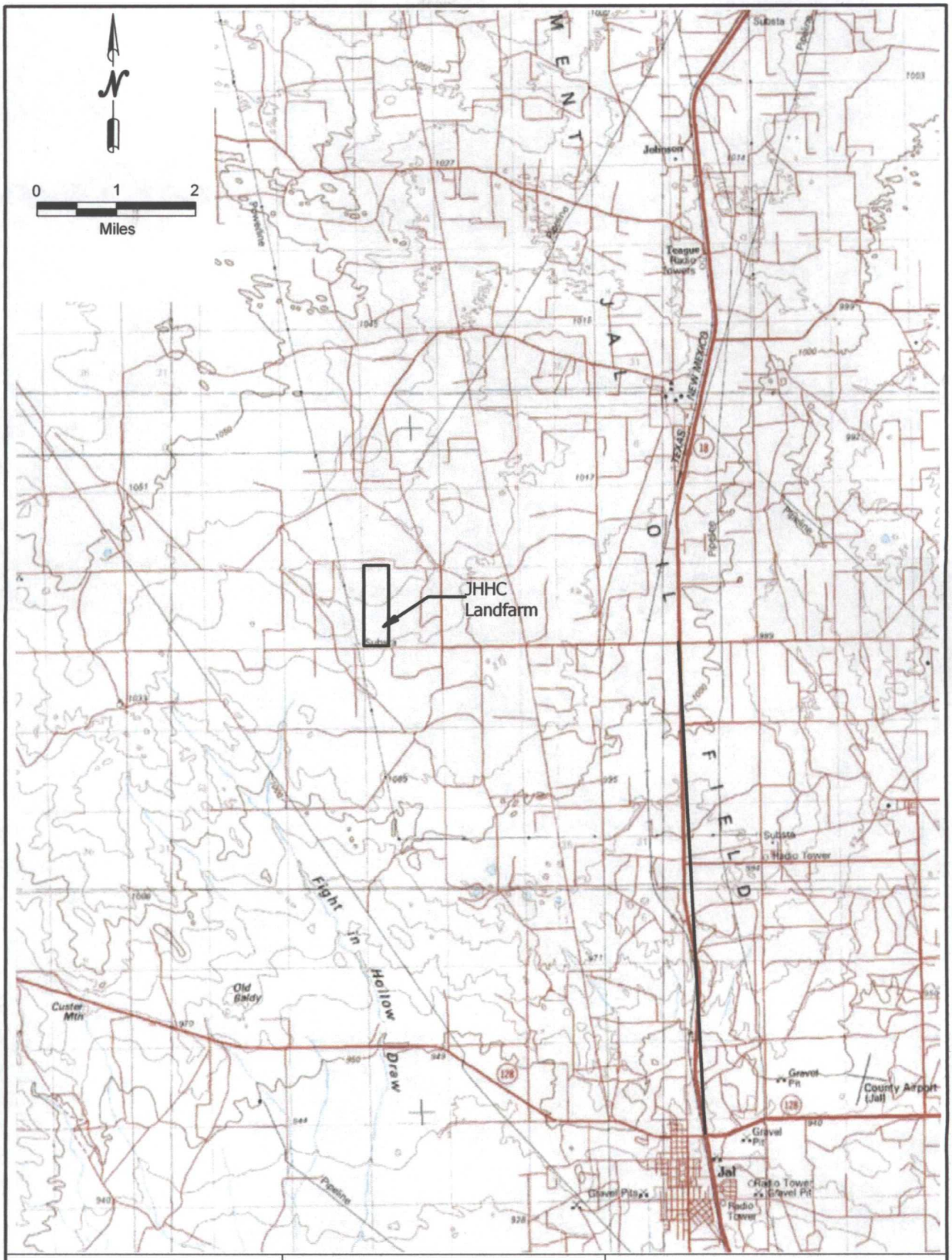
Sincerely,

Gilbert J. Van Deventer, REM, PG
Trident Environmental - Project Manager

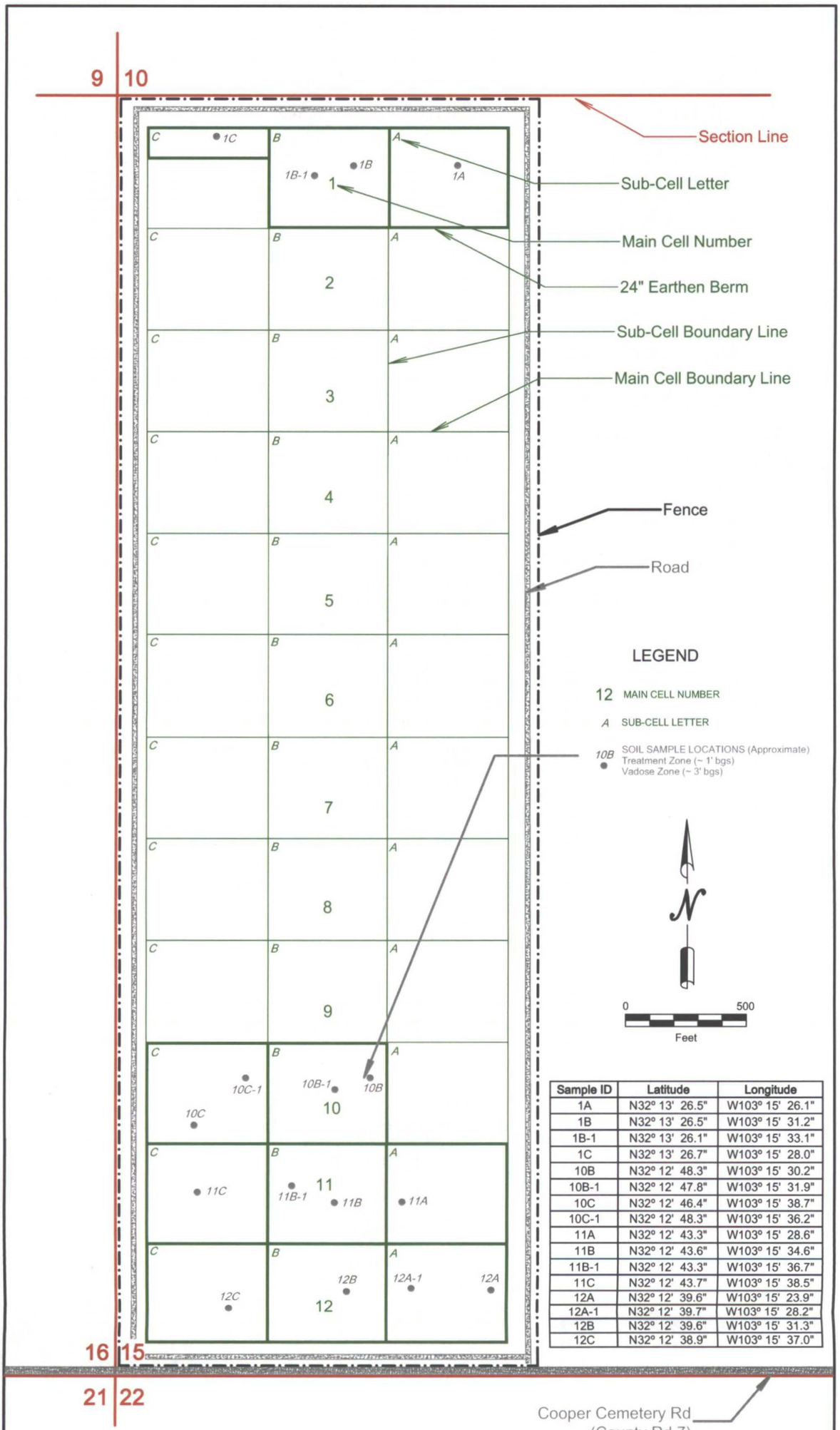
Enclosures

cc: Carolyn Haynes (JHHC)
Larry Hill (OCD-District 1)

FIGURES



TRIDENT ENVIRONMENTAL	John H. Hendrix Corp. Centralized Landfarm (NM-02-021) T24S - R36E - Section 15 (W/2) Lea County, New Mexico	FIGURE 1 SITE LOCATION MAP (USGS - Jal NM 100K Quadrangle



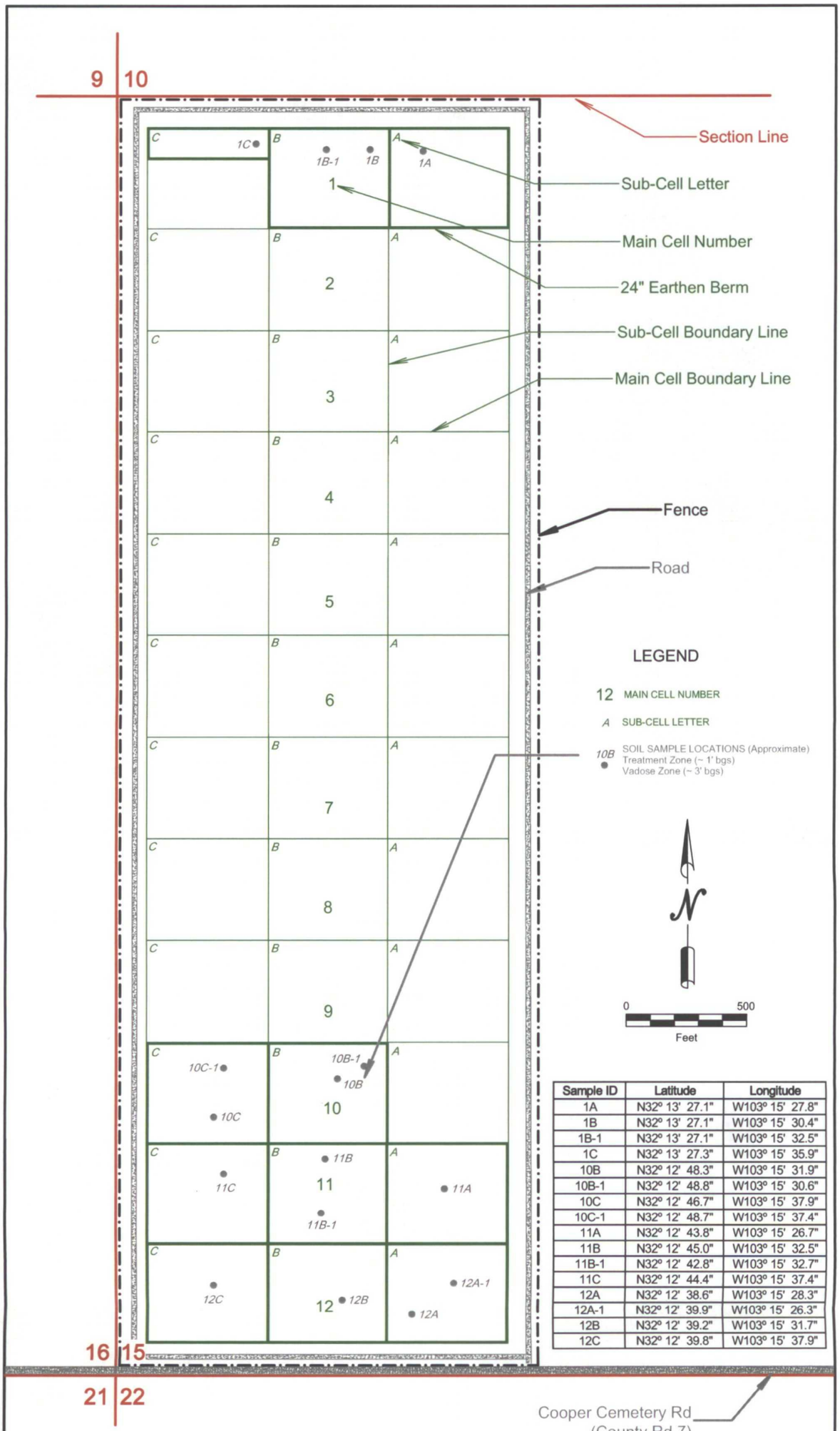
Sample ID	Latitude	Longitude
1A	N32° 13' 26.5"	W103° 15' 26.1"
1B	N32° 13' 26.5"	W103° 15' 31.2"
1B-1	N32° 13' 26.1"	W103° 15' 33.1"
1C	N32° 13' 26.7"	W103° 15' 28.0"
10B	N32° 12' 48.3"	W103° 15' 30.2"
10B-1	N32° 12' 47.8"	W103° 15' 31.9"
10C	N32° 12' 46.4"	W103° 15' 38.7"
10C-1	N32° 12' 48.3"	W103° 15' 36.2"
11A	N32° 12' 43.3"	W103° 15' 28.6"
11B	N32° 12' 43.6"	W103° 15' 34.6"
11B-1	N32° 12' 43.3"	W103° 15' 36.7"
11C	N32° 12' 43.7"	W103° 15' 38.5"
12A	N32° 12' 39.6"	W103° 15' 23.9"
12A-1	N32° 12' 39.7"	W103° 15' 28.2"
12B	N32° 12' 39.6"	W103° 15' 31.3"
12C	N32° 12' 38.9"	W103° 15' 37.0"

TRIDENT ENVIRONMENTAL

John H. Hendrix Corp.
Centralized Landfarm (NM-02-021)
T24S - R36E - Section 15 (W/2)
Lea County, New Mexico

FIGURE 2

Sample Location Map
April 7, 2010



Sample ID	Latitude	Longitude
1A	N32° 13' 27.1"	W103° 15' 27.8"
1B	N32° 13' 27.1"	W103° 15' 30.4"
1B-1	N32° 13' 27.1"	W103° 15' 32.5"
1C	N32° 13' 27.3"	W103° 15' 35.9"
10B	N32° 12' 48.3"	W103° 15' 31.9"
10B-1	N32° 12' 48.8"	W103° 15' 30.6"
10C	N32° 12' 46.7"	W103° 15' 37.9"
10C-1	N32° 12' 48.7"	W103° 15' 37.4"
11A	N32° 12' 43.8"	W103° 15' 26.7"
11B	N32° 12' 45.0"	W103° 15' 32.5"
11B-1	N32° 12' 42.8"	W103° 15' 32.7"
11C	N32° 12' 44.4"	W103° 15' 37.4"
12A	N32° 12' 38.6"	W103° 15' 28.3"
12A-1	N32° 12' 39.9"	W103° 15' 26.3"
12B	N32° 12' 39.2"	W103° 15' 31.7"
12C	N32° 12' 39.8"	W103° 15' 37.9"

TRIDENT ENVIRONMENTAL

John H. Hendrix Corp.
Centralized Landfarm (NM-02-021)
T24S - R36E - Section 15 (W/2)
Lea County, New Mexico

FIGURE 3

Sample Location Map
November 3, 2010

TABLES

Table 1
Summary of BTEX, TPH, and Chloride Concentrations - Soil Analytical Results

Cell No. Ltr.	Sample Date	Sample Zone	Sample ID (Depth)	Benzene (mg/kg)	BTEX (mg/kg)	GRO C6-C10 (mg/kg)	DRO C10-C28 (mg/kg)	TPH C6-C28 (mg/kg)	Chloride (mg/kg)
7B	11/29/04	Background	Facility (2' -3')	<0.025	<0.1	<10	<10	<20	<20
1A	03/02/06	Background	SS-1A (2' -3')	<0.025	<0.1	<10	<10	<20	5.01
	10/24/06	Vadose	1-A-1 (3' - 4')	<0.025	<0.125	<10	<10	<10	211
	10/24/06		1-A-2 (3' - 4')	<0.025	<0.125	<10	<10	<10	38.1
	04/10/07		1A (2' -3')	<0.003	<0.016	<0.065	<2.87	<2.93	<4.92
	04/10/07		1A-1 (2' -3')	<0.003	<0.016	<0.060	<2.72	<2.78	320
	10/15/07		1A (2' -3')	<0.003	<0.018	<0.058	4.06	4.06	<5.33
	10/15/07		1A-1 (2' -3')	<0.003	<0.020	<0.063	<3.20	<3.26	<5.57
	03/20/08		1A (2' -3')	<0.003	<0.018	<0.058	<3.25	<3.31	<5.59
	03/20/08		1A-1 (2' -3')	<0.003	<0.018	<0.055	<2.92	<2.98	<5.13
	04/07/10		1A (2' -3')	<0.050	<0.300	<10	<10	<20	<16
	11/03/10		1A (3')	<0.050	<0.300	<10	<10	<20	4
	10/24/06	Treatment	1-A-1 (0' -1')	<0.025	<0.125	<10	5.69	5.69	12.1
	10/24/06		1-A-2 (0' -1')	<0.025	<0.125	<10	<10	<10	15.0
	04/10/07		1A (0' -1')	<0.003	<0.016	<0.065	<2.76	<2.82	6.2
	04/10/07		1A-1 (0' -1')	<0.003	<0.016	<0.059	<2.87	<2.93	29
	10/09/07		1A (0' -1')	<0.003	<0.016	<0.058	<3.04	<3.10	<5.11
	10/09/07		1A-1 (0' -1')	<0.003	<0.017	<0.056	3.80	3.86	6.7
	03/13/08		1A (0' -1')	<0.003	<0.018	<0.056	<1.50	<1.56	90.1
	03/13/08		1A-1 (0' -1')	<0.003	<0.017	<0.057	<1.54	<1.60	12.8
	04/07/10		1A (0' -1')	<0.050	<0.300	<10	<10	<20	<16
	11/03/10		1A (1')	<0.050	<0.300	<10	<10	<20	24
1B	04/12/07	Background	SS-1B (2' -3')	<0.003	<0.016	<0.067	<2.83	<2.90	<4.96
	10/24/06	Vadose	1-B-1 (3' -4')	<0.025	<0.125	<10	11.3	**11.3**	140
	10/24/06		1-B-2 (3' -4')	<0.025	<0.125	<10	6.8	**6.8**	18.3
	04/12/07		1B (2' -3')	<0.003	<0.016	<0.063	<2.64	<2.70	21.0
	04/12/07		1B-1 (2' -3')	<0.003	<0.017	<0.059	<2.75	<2.81	<4.98
	10/15/07		1B (2' -3')	<0.003	<0.016	<0.063	4.88	**4.88**	<5.34
	03/20/08		1B (2' -3')	<0.003	<0.018	<0.055	<2.92	<2.97	<5.17
	03/20/08		1B-1 (2' -3')	<0.003	<0.016	<0.059	<3.21	<3.27	<5.53
	04/07/10		1B (2' -3')	<0.050	<0.300	<10	<10	<20	<16
	04/07/10		1B-1 (1.5')	<0.050	<0.300	<10	<10	<20	48
	11/03/10		1B (3')	<0.050	<0.300	<10	<10	<20	<4
	11/03/10		1B-1 (3')	<0.050	<0.300	<10	<10	<20	100
	10/24/06	Treatment	1-B-1 (0' -1')	<0.025	<0.125	<10	16.5	16.5	53.3
	10/24/06		1-B-2 (0' -1')	<0.025	<0.125	<10	9.79	9.79	87.0
	04/10/07		1B (0' -1')	<0.003	<0.016	<0.063	<2.79	<2.85	226
	04/10/07		1B-1 (0' -1')	<0.003	<0.015	<0.069	<2.83	<2.90	213
	10/09/07		1B (0' -1')	<0.003	<0.018	<0.061	5.65	5.65	74.7
	10/09/07		1B-1 (0' -1')	<0.003	<0.017	<0.055	6.53	6.53	92.0
	03/13/08		1B (0' -1')	<0.003	<0.016	<0.054	<1.44	<1.49	11.7
	03/13/08		1B-1 (0' -1')	<0.003	<0.017	<0.057	146	146	12.9
	04/07/10		1B (0' -1')	<0.050	<0.300	<10	<10	<20	<16
	04/07/10		1B-1 (0' -1')	<0.050	<0.300	<10	73.4	73.4	128
	11/03/10		1B (1')	<0.050	<0.300	<10	<10	<20	8
	11/03/10		1B-1 (1')	<0.050	<0.300	<10	<10	<20	100

Table 1
Summary of BTEX, TPH, and Chloride Concentrations - Soil Analytical Results

Cell No. Ltr.	Sample Date	Sample Zone	Sample ID (Depth)	Benzene (mg/kg)	BTEX (mg/kg)	GRO C6-C10 (mg/kg)	DRO C10-C28 (mg/kg)	TPH C6-C28 (mg/kg)	Chloride (mg/kg)
	04/12/07	Background	SS-1C (0' -1')	<0.003	<0.016	<0.0625	<2.88	<2.94	<4.93
	03/25/09		SS-1C (2' -3')	<0.050	<0.300	<10	<10	<20	---
	10/01/09	Vadose	1C (2' -3')	<0.050	<0.300	<10	<10	<20	180
	04/07/10		1C (2' -3')	<0.050	<0.300	<10	<10	<20	96
1C	11/03/10		1C (3')	<0.050	<0.300	<10	<10	<20	<4
	03/25/09		1C (0' -1')	<0.050	<0.300	<10	45.3	45.3	---
	10/01/09	Treatment	1C (0' -1')	<0.050	<0.300	<10	213	213	16
	04/07/10		1C (0' -1')	<0.050	<0.300	<10	206	206	<16
	11/03/10		1C (1')	<0.050	<0.300	<10	<10	<20	<4
2A	01/07/08	Background	2A (2' -3')	<0.003	<0.016	<0.061	<5.67	<5.73	<5.01
2B	01/07/08	Background	2B (2' -3')	<0.003	<0.019	<0.071	<6.83	<6.90	<5.95
2C	01/07/08	Background	2C (2' -3')	<0.003	<0.018	<0.066	<6.20	<6.27	<5.43
10A	01/07/08	Background	10A (2' -3')	<0.003	<0.017	<0.061	<6.25	<6.31	<5.24
	01/07/08	Background	10B (2' -3')	<0.005	<0.046	<0.19	<6.2	<6.2	<5.21
	10/01/09		10B (2' -3')	<0.050	<0.300	<10	<10	<20	<80
	10/01/09		10B-1 (2' -3')	<0.050	<0.300	<10	<10	<20	<80
	04/07/10	Vadose	10B (2' -3')	<0.050	<0.300	<10	<10	<20	16
	04/07/10		10B-1 (2' -3')	<0.050	<0.300	<10	<10	<20	16
	11/03/10		10B (3')	<0.050	<0.300	<10	<10	<20	<4
10B	11/03/10		10B-1 (3')	<0.050	<0.300	<10	<10	<20	<4
	10/01/09		10B (0' -1')	<0.050	<0.300	<50	11,000	11,000	400
	10/01/09		10B-1 (0' -1')	<0.050	<0.300	<50	11,100	11,100	448
	04/07/10	Treatment	10B (0' -1')	<0.050	<0.300	<50	19,700	19,700	416
	04/07/10		10B-1 (0' -1')	<0.050	<0.300	<50	17,300	17,300	320
	11/03/10		10B (1')	<0.050	<0.300	<10	2,090	2,090	48
	11/03/10		10B-1 (1')	<0.050	<0.300	<10	143	143	84
	01/07/08	Background	10C (2' -3')	<0.005	<0.045	<0.19	<10	<10	<5.13
	10/07/08		10C (2' -3')	<0.001	<0.008	<16.5	<16.5	<33	---
	03/25/09		10C (2' -3')	<0.050	<0.300	<10	<10	<20	---
	03/25/09		10C-1 (2' -3')	<0.050	<0.300	<10	<10	<20	---
	10/01/09		10C (2' -3')	<0.050	<0.300	<10	<10	<20	<80
	10/01/09	Vadose	10C-1 (2' -3')	<0.050	<0.300	<10	<10	<20	<80
	04/07/10		10C (2' -3')	<0.050	<0.300	<10	<10	<20	16
	04/07/10		10C-1 (2' -3')	<0.050	<0.300	<10	<10	<20	32
	11/03/10		10C (3')	<0.050	<0.300	<10	<10	<20	<4
10C	11/03/10		10C-1 (3')	<0.050	<0.300	<10	<10	<20	<4
	10/07/08		10C (0' -1')	<0.001	<0.007	<75.7	1,290	1,290	---
	03/25/09		10C (0' -1')	<0.050	<0.300	<10	2,340	2,340	---
	03/25/09		10C-1 (0' -1')	<0.050	<0.300	<10	152	152	---
	10/01/09		10C (0' -1')	<0.050	<0.300	<10	454	454	<16
	10/01/09	Treatment	10C-1 (0' -1')	<0.050	<0.300	<10	3,640	3,640	<16
	04/07/10		10C (0' -1')	<0.050	<0.300	<50	274	274	16
	04/07/10		10C-1 (0' -1')	<0.050	<0.300	<50	10,000	10,000	96
	11/03/10		10C (1')	<0.050	<0.300	<10	<10	<20	<4
	11/03/10		10C-1 (1')	<0.050	<0.300	<10	<10	<20	4

Table 1
Summary of BTEX, TPH, and Chloride Concentrations - Soil Analytical Results

Cell No. Ltr.	Sample Date	Sample Zone	Sample ID (Depth)	Benzene (mg/kg)	BTEX (mg/kg)	GRO C6-C10 (mg/kg)	DRO C10-C28 (mg/kg)	TPH C6-C28 (mg/kg)	Chloride (mg/kg)
11A	03/02/06	Background	11A (2' -3')	<0.025	<0.1	<10	<10	<20	4.67
	10/06/08	Vadose	11A (2' -3')	<0.001	<0.007	<15.7	<15.7	<31.4	<5.00
	03/25/09		11A (2' -3')	<0.050	<0.300	<10	<10	<20	---
	10/01/09		11A (2' -3')	<0.050	<0.300	<10	<10	<20	60
	04/07/10		11A (2' -3')	<0.050	<0.300	<10	<10	<20	224
	11/03/10		11A (3')	<0.050	<0.300	<10	<10	<20	16
	10/06/08	Treatment	11A (0' -1')	<0.001	<0.007	<15.5	621	621	<5.00
	03/25/09		11A (0' -1')	<0.050	<0.300	<10	<10	<20	---
	10/01/09		11A (0' -1')	<0.050	<0.300	<10	27.0	27.0	<16
	04/07/10		11A (0' -1')	<0.050	<0.300	<10	161	161	16
	11/03/10		11A (1')	<0.050	<0.300	<10	<10	<20	8
11B	01/07/08	Background	11B (2' -3')	<0.005	<0.051	<0.19	<10	<10	<5.13
	03/20/08	Vadose	11B (2' -3')	<0.003	<0.017	<0.060	<3.18	<3.24	<5.39
	03/20/08		11B-1 (2' -3')	<0.003	<0.019	<0.061	<3.11	<3.17	<5.35
	10/06/08		11B (2' -3')	<0.001	<0.007	<15.6	<15.6	<31.2	52.1
	10/06/08		11B-1 (2' -3')	<0.001	<0.008	<16.2	<16.2	<32.4	473
	03/25/09		11B (2' -3')	<0.050	<0.300	<10	<10	<20	---
	10/01/09		11B (2' -3')	<0.050	<0.300	<10	<10	<20	40
	10/01/09		11B-1 (2' -3')	<0.050	<0.300	<10	<10	<20	260
	04/07/10		11B (2' -3')	<0.050	<0.300	<10	<10	<20	32
	04/07/10		11B-1 (2' -3')	<0.050	<0.300	<10	<10	<20	192
	11/03/10		11B (3')	<0.050	<0.300	<10	<10	<20	<4
	11/03/10		11B-1 (3')	<0.050	<0.300	<10	<10	<20	76
	03/13/08	Treatment	11B (0' -1')	<0.001	<0.007	2.78	5910	5913	931
	03/13/08		11B-1 (0' -1')	<0.001	<0.007	2.91	6170	6173	1170
	10/06/08		11B (0' -1')	<0.003	0.0533	<15.5	2230	2230	495
	10/06/08		11B-1 (0' -1')	<0.003	0.066	<15.6	1080	1080	451
	03/25/09		11B (0' -1')	<0.050	<0.300	<10	298	298	---
	10/01/09		11B-1 (0' -1')	<0.050	<0.300	<10	38.1	38.1	<16
	10/01/09		11B (0' -1')	<0.050	0.286	<10	1,140	1,140	160
	04/07/10		11B (0' -1')	<0.050	<0.300	<10	71.8	71.8	96
	04/07/10		11B-1 (0' -1')	<0.050	<0.300	<50	468	468	64
	11/03/10		11B (1')	<0.050	<0.300	<10	<10	<20	<4
	11/03/10		11B-1 (1')	<0.050	<0.300	<10	284	284	8
11C	10/15/07	Background	11C (2' -3')	<0.005	<0.045	<0.19	<10	<10	<5.13
	10/15/07	Vadose	11C (2' -3')	<0.003	<0.018	<0.059	4.49	4.49	<5.47
	03/20/08		11C (2' -3')	<0.003	<0.021	<0.069	<3.44	<3.51	<6.05
	03/20/08		11C-1 (2' -3')	<0.003	<0.019	<0.066	<3.28	<3.35	<5.65
	10/06/08		11C (2' -3')	<0.001	<0.008	<16.3	<16.3	<32.6	<10.0
	03/25/09		11C (2' -3')	<0.050	<0.300	<10	<10	<20	---
	03/25/09		11C-1 (2' -3')	<0.050	<0.300	<10	<10	<20	---
	10/01/09		11C (2' -3')	<0.050	<0.300	<10	<10	<20	<80
	04/07/10		11C (2' -3')	<0.050	<0.300	<10	<10	<20	<16
	11/03/10		11C (3')	<0.050	<0.300	<10	<10	<20	8
	03/13/08	Treatment	11C (0' -1')	<0.003	<0.016	0.081	635	635	42.9
	03/13/08		11C-1 (0' -1')	<0.003	<0.017	<0.054	1300	1300	30.1
	10/06/08		11C (0' -1')	<0.001	<0.008	<15.8	519	519	<10.0
	03/25/09		11C (0' -1')	<0.050	<0.300	<10	34.3	34.3	---
	03/25/09		11C-1 (0' -1')	<0.050	<0.300	<10	78.1	78.1	---
	10/01/09		11C (0' -1')	<0.050	<0.300	<10	15.4	15.4	<16
	04/07/10		11C (0' -1')	<0.050	<0.300	<10	253	253	32
	11/03/10		11C (1')	<0.050	<0.300	<10	<10	<20	<4

Table 1
Summary of BTEX, TPH, and Chloride Concentrations - Soil Analytical Results

Cell No. Ltr.	Sample Date	Sample Zone	Sample ID (Depth)	Benzene (mg/kg)	BTEX (mg/kg)	GRO C6-C10 (mg/kg)	DRO C10-C28 (mg/kg)	TPH C6-C28 (mg/kg)	Chloride (mg/kg)
12A	03/02/06	Background	12A (2' -3')	<0.050	<0.300	<10	<10	<20	8.86
	03/20/08	Vadose	12A (2' -3')	<0.003	<0.018	<0.057	<3.07	<3.13	<5.40
	10/06/08		12A (2' -3')	<0.001	<0.008	<16.0	<16.0	<32.0	<10.0
	03/25/09		12A (2' -3')	<0.050	<0.300	<10	<10	<20	---
	10/01/09		12A (2' -3')	<0.050	<0.300	<10	<10	<20	60
	10/01/09		12A-1 (2' -3')	<0.050	<0.300	<10	<10	<20	60
	04/07/10		12A (2' -3')	<0.050	<0.300	<10	<10	<20	<16
	04/07/10		12A-1 (2' -3')	<0.050	<0.300	<10	<10	<20	16
	11/03/10		12A (3')	<0.050	<0.300	<10	<10	<20	4
	11/03/10		12A-1 (3')	<0.050	<0.300	<10	<10	<20	<4
	03/20/08	Treatment	12A (0' -1')	<0.003	<0.019	<0.066	518	518	<5.72
	10/06/08		12A (0' -1')	<0.001	<0.008	<15.7	198	198	<5.00
	03/25/09		12A (0' -1')	<0.050	<0.300	<10	118	118	---
	10/01/09		12A (0' -1')	<0.050	<0.300	<10	37.2	37.2	<16
	10/01/09		12A-1 (0' -1')	<0.050	<0.300	<10	21.4	21.4	<16
	04/07/10		12A (0' -1')	<0.050	<0.300	<10	332	332	<16
	04/07/10		12A-1 (0' -1')	<0.050	<0.300	<10	82.0	82.0	<16
	11/03/10		12A (1')	<0.050	<0.300	<10	79	79	<4
	11/03/10		12A-1 (1')	<0.050	<0.300	<10	<10	<20	<4
12B	04/12/07	Background	12B (2' -3')	<0.004	<0.044	<0.18	<10	<10	<4.88
	03/02/06	Vadose	SS-B (2' -3')	<0.025	<0.1	<10	<10	<20	4.98
	03/02/06		SS-E (2' -3')	<0.025	<0.125	<10	<10	<20	15.2
	10/25/06		12B-1 (3' - 4')	<0.025	<0.125	<10	<10	<10	60
	10/25/06		12B-2 (3' - 4')	<0.025	<0.125	<10	<10	<10	151
	04/12/07		12B (2' -3')	<0.003	<0.017	<0.061	<2.81	<2.81	21.2
	10/16/07		12B (2' -3')	<0.003	<0.018	<0.065	5.46	5.53	<5.65
	03/20/08		12B (2' -3')	<0.003	<0.019	<0.058	<3.26	<3.32	171
	10/06/08		12B (2' -3')	<0.001	<0.008	<16.0	<16.0	<32.0	30.7
	03/25/09		12B (2' -3')	<0.050	<0.300	<10	<10	<20	---
	10/01/09		12B (2' -3')	<0.050	<0.300	<10	<10	<20	60
	04/07/10		12B (2' -3')	<0.050	<0.300	<10	<10	<20	96
	11/03/10		12B (3')	<0.050	<0.300	<10	<10	<20	20
	03/02/06	Treatment	SS-B (0' -1')	<0.025	<0.1	<10	707	707	---
	03/02/06		SS-E (0' -1')	<0.025	<0.1	<10	79.1	79.1	---
	10/25/06		12B-1 (0' -1')	<0.025	<0.125	<10	397	397	151
	10/25/06		12B-2 (0' -1')	<0.025	<0.125	<10	98.1	98.1	18.0
	04/12/07		12B (0' -1')	<0.003	<0.016	<0.061	285	285	23.6
	10/09/07		12B (0' -1')	<0.003	<0.017	<0.055	886	886	6.54
	03/13/08		12B (0' -1')	<0.003	<0.020	<0.068	569	569	36.6
	10/06/08		12B (0' -1')	<0.001	<0.008	<15.8	243	243	<5.00
	03/25/09		12B (0' -1')	<0.050	<0.300	<10	67.8	67.8	---
	10/01/09		12B (0' -1')	<0.050	<0.300	<10	<10	<20	<16
	04/07/10		12B (0' -1')	<0.050	<0.300	<10	<10	<20	<16
	11/03/10		12B (1')	<0.050	<0.300	<10	<10	<20	16

Table 1
Summary of BTEX, TPH, and Chloride Concentrations - Soil Analytical Results

Cell No. Ltr.	Sample Date	Sample Zone	Sample ID (Depth)	Benzene (mg/kg)	BTEX (mg/kg)	GRO C6-C10 (mg/kg)	DRO C10-C28 (mg/kg)	TPH C6-C28 (mg/kg)	Chloride (mg/kg)
12C	04/17/07	Background	12C (2' -3')	<0.003	<0.017	<0.053	<2.90	<2.90	<4.97
	03/02/06	Vadose	SS-C (2' -3')	<0.025	<0.1	<10	<10	<20	42.8
	03/02/06		SS-D (2' -3')	<0.025	<0.125	<10	<10	<20	4.92
	10/25/06		12C-1 (3' - 4')	<0.025	<0.125	<10	<10	<10	15.0
	10/25/06		12C-2 (3' - 4')	<0.025	<0.125	<10	<10	<10	27.6
	04/12/07		12C (2' -3')	<0.003	<0.018	<0.056	<2.73	<2.79	<4.56
	04/12/07		12C-1 (2' -3')	<0.003	<0.017	<0.062	10.1	10.1	<4.98
	10/16/07		12C (2' -3')	<0.003	<0.018	<0.055	<2.68	<2.73	<5.57
	03/20/08		12C (2' -3')	<0.003	<0.017	<0.060	<3.08	<3.14	<5.22
	03/20/08		12C-1 (2' -3')	<0.003	<0.018	<0.057	<3.25	<3.31	<5.42
	10/06/08		12C (2' -3')	<0.001	<0.008	<15.7	16.6	16.6	<5.00
	10/06/08		12C-1 (2' -3')	<0.001	<0.008	<15.9	67.1	67.1	<5.00
	03/25/09		12C (2' -3')	<0.050	<0.300	<10	<10	<20	---
	03/25/09		12C-1 (2' -3')	<0.050	<0.300	<10	<10	<20	---
	10/01/09		12C (2' -3')	<0.050	<0.300	<10	<10	<20	<80
	04/07/10		12C (2' -3')	<0.050	<0.300	<10	<10	<20	<16
	11/03/10		12C (3')	<0.050	<0.300	<10	<10	<20	<4
	04/10/07	Treatment	12C (0' -1')	<0.003	<0.016	<0.063	175	175	<4.99
	04/10/07		12C-1 (0' -1')	<0.003	<0.016	<0.061	218	218	<4.90
	10/09/07		12C (0' -1')	<0.003	<0.017	<0.053	3.80	3.80	<5.00
	10/09/07		12C-1 (0' -1')	<0.003	<0.018	<0.060	9.95	9.95	<5.07
	03/13/08		12C (0' -1')	<0.003	<0.019	<0.069	236	236	<5.67
	03/13/08		12C-1 (0' -1')	<0.003	<0.018	<0.057	681	681	<5.22
	10/06/08		12C (0' -1')	<0.001	<0.007	<15.4	729	729	<5.00
	10/06/08		12C-1 (0' -1')	<0.001	<0.007	<15.3	36.7	36.7	<5.00
	03/25/09		12C (0' -1')	<0.050	<0.300	<10	<10	<20	---
	03/25/09		12C-1 (0' -1')	<0.050	<0.300	<10	66.6	66.6	---
	10/01/09		12C (0' -1')	<0.050	<0.300	<10	26.4	26.4	<16
	04/07/10		12C (0' -1')	<0.050	<0.300	<10	108	108	16
	11/03/10		12C (1')	<0.050	<0.300	<10	<10	<20	<4
Closure performance standards for treatment zone as specified in NMAC 19.15.36.15(F)				0.2	50	NA	NA	500	1,000

Table 2

Summary of Metal Concentrations - Soil Analytical Results

Cell No.	Sample Date	Sample Zone	Sample ID (Depth in Ft)	Metals (mg/kg)											
				As	Ag	Ba	Cd	Cr	Pb	Hg	Se	Cu	Fe	Mn	Zn
7B	11/29/04	Background	Facility (2' -3')	3.65	<0.25	507	0.341	3.01	0.5	<0.25	<0.2	---	---	---	---
1A	04/12/07	Background	SS-1A (2' -3')	3.23	<0.094	55.4	0.196	13.4	6.84	<0.016	1.70	---	---	---	---
	04/10/07	Treatment	1A (0' -1')	1.94	<0.090	62.9	0.111	5.92	3.57	<0.015	0.98	---	---	---	---
	04/10/07		1A-1 (0' -1')	2.34	1.14	96.2	0.120	5.86	3.37	<0.014	1.14	---	---	---	---
	10/09/07		1A (0' -1')	1.95	<0.096	73.6	<0.096	5.90	3.37	<0.016	0.313	---	---	---	---
	10/09/07		1A-1 (0' -1')	2.21	0.150	91.3	0.173	5.76	3.65	<0.015	0.356	---	---	---	---
	03/13/08		1A (0' -1')	2.29	<0.096	75.0	0.114	5.75	3.27	<0.016	0.730	---	---	---	---
	03/13/08		1A-1 (0' -1')	1.96	<0.100	64.0	0.105	5.88	3.31	<0.014	0.798	---	---	---	---
	10/24/06	Vadose	1-A-1 (3' -4')	1.79	0.543	22.0	<0.173	6.83	3.56	0.013	<0.751	---	---	---	---
	10/24/06		1-A-2 (3' -4')	1.09	0.435	13.7	<0.173	4.86	2.54	0.012	<0.751	---	---	---	---
	04/10/07		1A (2' -3')	2.99	<0.089	49.4	0.231	12.4	5.70	<0.014	1.43	---	---	---	---
	04/12/07		1A-1 (2' -3')	1.79	<0.099	27.0	<0.099	7.22	3.51	<0.015	0.987	---	---	---	---
	10/15/07		1A (2' -3')	1.27	<0.094	18.2	<0.094	5.68	2.80	<0.015	0.491	---	---	---	---
	10/15/07		1A-1 (2' -3')	2.82	<0.088	46.8	<0.107	11.5	6.09	<0.015	0.871	---	---	---	---
	03/20/08		1A (2' -3')	4.18	<0.112	53.5	0.258	14.1	7.64	<0.083	1.55	---	---	---	---
	03/20/08		1A-1 (2' -3')	1.61	<0.097	25.3	<0.097	6.83	3.57	<0.076	1.01	---	---	---	---
	04/07/10		1A (2' -3')	0.877	<0.25	19.5	0.151	3.79	2.88	<0.1	<0.5	1.34	3,890	28.6	4.50
	11/03/10		1A (3')	2.21	0.052	35.7	0.04	5.51	4.76	0.007	0.331	2.11	8,320	51.7	18.0
1B	04/12/07	Background	SS-1B (2' -3')	3.05	<0.086	48.4	0.178	12.5	6.30	<0.014	1.46	---	---	---	---
	04/10/07	Treatment	1-B (0' -1')	1.82	<0.088	51.5	0.103	6.04	3.63	<0.015	0.943	---	---	---	---
	04/10/07		1-B-1 (0' -1')	2.05	<0.086	82.2	0.121	5.61	3.58	<0.014	0.850	---	---	---	---
	10/09/07		1B (0' -1')	1.97	<0.091	85.5	<0.091	6.70	3.91	<0.036	0.350	---	---	---	---
	10/09/07		1B-1 (0' -1')	1.82	<0.087	70.0	<0.087	6.35	3.72	<0.015	0.292	---	---	---	---
	03/13/08		1B (0' -1')	1.73	<0.100	44.5	<0.100	6.41	3.56	<0.016	0.758	---	---	---	---
	03/13/08		1B-1 (0' -1')	2.09	<0.102	126	0.116	6.68	3.97	<0.017	1.04	---	---	---	---
	10/24/06	Vadose	1-B-1 (3' -4')	2.31	0.210	35.8	<0.173	10.2	5.25	0.009	<0.751	---	---	---	---
	10/24/06		1-B-2 (3' -4')	0.981	0.099	21.1	<0.173	5.80	3.02	0.007	<0.751	---	---	---	---
	04/10/07		1B (2' -3')	2.14	<0.087	31.8	0.134	8.30	4.36	<0.015	1.12	---	---	---	---
	04/12/07		1B-1 (2' -3')	1.73	<0.094	29.3	0.103	7.46	3.75	<0.015	0.950	---	---	---	---
	10/15/07		1B (2' -3')	1.97	<0.095	39.2	0.101	8.34	4.57	<0.015	0.843	---	---	---	---
	03/20/08		1B (2' -3')	1.38	<0.094	25.6	0.115	5.90	3.44	<0.015	0.798	---	---	---	---
	03/20/08		1B-1 (2' -3')	1.88	<0.105	31.3	0.127	7.49	4.01	<0.018	0.889	---	---	---	---
	04/07/10		1B (2' -3')	0.845	<0.25	19.5	0.180	3.95	2.77	<0.1	<0.5	1.45	3,870	34.0	4.81
	04/07/10		1B-1 (1.5')	1.57	<0.25	17.6	0.247	4.25	3.86	<0.1	<0.5	1.74	4,000	37.5	9.93
	11/03/10		1B (3')	3.03	0.043	42.3	0.04	6.01	5.79	0.008	0.385	2.47	10,500	55.3	21.9
	11/03/10		1B-1 (3')	2.39	0.051	44.6	0.04	5.85	5.13	0.005	0.384	<2.00	8,850	56.2	20.1

Table 2

Summary of Metal Concentrations - Soil Analytical Results

Cell No.	Sample Date	Sample Zone	Sample ID (Depth in Ft)	Metals (mg/kg)											
				As	Ag	Ba	Cd	Cr	Pb	Hg	Se	Cu	Fe	Mn	Zn
1C	04/12/07	Background	SS-1C (2' -3')	2.24	<0.175	46.8	0.142	9.14	5.13	<0.04	1.35	---	---	---	---
	10/01/09	Vadose	1C (2' -3')	3.15	<1.0	68.6	0.422	11.3	6.20	<0.1	0.464	3.9	10,700	63.4	23.9
	04/07/10		1C (2' -3')	2.00	<0.25	53.1	0.320	7.73	6.78	<0.1	<0.5	2.10	9,190	40.9	15.1
	11/03/10		1C (3')	1.75	0.047	29.5	0.08	3.61	3.95	0.006	0.250	<2.00	5,870	53.2	11.9
2A	01/07/08	Background	2A (2' -3')	0.839	<0.092	15.4	<0.092	3.77	2.39	<0.016	0.589	---	---	---	---
2B	01/07/08	Background	2B (2' -3')	1.72	<0.109	26.0	<0.109	5.89	3.67	<0.018	0.990	---	---	---	---
2C	01/07/08	Background	2C (2' -3')	2.84	<0.100	51.4	0.130	9.64	5.77	<0.016	1.49	---	---	---	---
10A	01/07/08	Background	10A (2' -3')	1.63	<0.100	34.1	<0.100	6.55	4.09	<0.015	1.19	---	---	---	---
10B	01/07/08	Background	10B (2' -3')	1.24	<0.2	23.0	<0.3	5.24	3.05	<0.04	1.01	---	---	---	---
	10/01/09	Vadose	10B (2' -3')	0.862	<1.0	21.8	0.180	4.90	2.33	<0.1	0.155	2.3	4,050	36.8	8.9
	10/01/09		10B-1 (2' -3')	1.08	<1.0	22.2	0.209	5.20	2.97	<0.1	0.295	2.2	4,550	48.7	10.0
	04/07/10		10B (2' -3')	0.988	<0.25	24.9	0.238	4.78	3.63	<0.1	<0.5	2.12	4,650	44.6	8.35
	04/07/10		10B-1 (2' -3')	1.03	<0.25	29.5	0.222	4.87	4.07	<0.1	<0.5	2.13	5,490	48.1	8.95
	11/03/10		10B (3')	1.80	0.034	28.3	0.08	4.61	3.77	0.009	0.345	<2.00	6,390	63.1	15.6
	11/03/10		10B-1 (3')	1.69	0.049	36.9	0.05	4.84	3.97	0.007	0.280	2.19	5,630	54.9	13.8
10C	01/07/08	Background	10C (2' -3')	1.43	<0.2	23.5	<0.3	5.31	3.36	<0.04	1.08	---	---	---	---
	10/07/08	Vadose	10-C (2' -3')	<5.00	<2.00	12.9	<2.50	12.7	<6.00	0.019	<5.00	---	---	---	---
	10/01/09		10C (2' -3')	1.70	<1.0	26.2	0.261	6.40	3.90	<0.1	0.485	<2.0	6,070	46.9	12.7
	10/01/09		10C-1 (2' -3')	1.86	<1.0	32.4	0.245	9.10	3.74	<0.1	0.401	2.5	6,770	53.4	15.4
	04/07/10		10C (2' -3')	1.72	<0.25	42.7	0.292	6.93	5.62	<0.1	<0.5	1.67	8,250	41.5	11.7
	04/07/10		10C-1 (2' -3')	1.51	<0.25	36.1	0.256	5.39	4.70	<0.1	<0.5	1.93	6,690	41.1	9.91
	11/03/10		10C (3')	2.01	0.036	35.2	0.04	5.69	4.64	0.007	0.290	2.01	7,100	60.8	15.8
	11/03/10		10C-1 (3')	1.47	0.039	20.5	0.03	3.16	3.59	0.005	0.237	<2.00	4,270	35.6	9.3
11A	01/07/08	Background	11A (2' -3')	1.53	<0.2	27.1	<0.3	5.93	3.46	<0.04	0.938	---	---	---	---
	10/06/08	Vadose	11A (2' -3')	<5.00	14.8	112	<2.50	14.9	<6.00	<0.013	<5.00	---	---	---	---
	10/01/09		11A (2' -3')	2.42	<1.0	40.9	0.272	10.2	4.79	<0.1	0.480	3.4	9,360	63.3	20.3
	04/07/10		11A (2' -3')	2.07	<0.25	60.8	0.391	7.56	6.39	<0.1	<0.5	13.6	9,520	45.0	15.0
	11/03/10		11A (3')	2.47	0.044	39.5	0.04	6.00	4.91	0.008	0.339	2.00	8,790	56.3	20.0

Table 2

Summary of Metal Concentrations - Soil Analytical Results

Cell No.	Sample Date	Sample Zone	Sample ID (Depth in Ft)	Metals (mg/kg)											
				As	Ag	Ba	Cd	Cr	Pb	Hg	Se	Cu	Fe	Mn	Zn
11B	01/07/08	Background	11B (2' -3')	1.23	<0.2	21.8	<0.3	4.98	3.53	<0.04	0.735	---	---	---	---
	03/13/08	Treatment	11B (0' -1')	4.66	<0.095	131	0.172	7.57	4.31	<0.014	1.05	---	---	---	---
	03/13/08		11B-1 (0' -1')	4.47	<0.098	130	0.157	7.09	3.91	<0.015	0.702	---	---	---	---
	03/20/08	Vadose	11B (2' -3')	2.52	<0.099	47.6	0.168	9.58	5.31	<0.015	1.25	---	---	---	---
	03/20/08		11B-1 (2' -3')	2.21	<0.100	37.2	0.152	8.91	5.04	<0.017	1.26	---	---	---	---
	10/06/08		11B (2' -3')	5.75	4.65	18.1	<2.50	12.9	14.9	<0.013	<5.00	---	---	---	---
	10/06/08		11B-1 (2' -3')	<5.00	<2.00	25.0	<2.50	15.8	<6.00	<0.013	<5.00	---	---	---	---
	10/01/09		11B (2' -3')	2.44	<1.0	48.5	0.260	10.2	4.67	<0.1	0.378	2.6	9,470	55.0	21.1
	10/01/09		11B-1 (2' -3')	1.74	<1.0	29.2	0.288	7.60	4.31	<0.1	0.189	2.3	6,980	57.4	16.5
	04/07/10		11B (2' -3')	0.90	<0.25	18.9	0.181	4.09	3.21	<0.1	<0.5	1.46	4,230	31.9	5.25
	04/07/10		11B-1 (2' -3')	1.55	<0.25	60.5	0.292	6.91	5.86	<0.1	<0.5	2.45	9,210	57.7	11.3
	11/03/10		11B (3')	2.97	0.062	46.9	0.05	6.77	5.97	0.008	0.401	2.54	10,600	66.6	25.7
	11/03/10		11B-1 (3')	1.42	0.045	20.4	0.04	3.22	3.39	0.006	0.206	<2.00	4,920	39.3	9.8
11C	10/15/07	Background	SS-11C (2' -3')	2.67	<0.2	300	0.113	5.47	2.62	<0.04	0.490	---	---	---	---
	10/09/07	Treatment	11C (0' -1')	1.97	<0.090	143	0.102	7.50	4.10	<0.014	0.316	---	---	---	---
	03/13/08		11C (0' -1')	1.97	<0.100	109	0.109	7.35	3.87	<0.015	0.930	---	---	---	---
	03/13/08		11C-1 (0' -1')	1.88	<0.101	70.6	0.132	7.49	4.16	<0.014	0.646	---	---	---	---
	10/15/07	Vadose	11C (2' -3')	2.05	<0.095	50	<0.095	8.49	4.26	<0.015	0.766	---	---	---	---
	03/20/08		11C-1 (2' -3')	3.01	<0.099	57.7	0.206	11.7	6.19	<0.016	1.16	---	---	---	---
	03/20/08		11C (2' -3')	2.13	<0.104	231	0.132	1.94	1.09	<0.016	0.367	---	---	---	---
	10/06/08		11C (2' -3')	8.95	<2.00	25.4	<2.50	19.7	13.8	<0.014	<5.00	---	---	---	---
	10/01/09		11C (2' -3')	1.07	<1.0	25.2	0.213	5.70	2.86	<0.1	<0.100	2.0	4,910	47.0	10.5
	04/07/10		11C (2' -3')	1.30	<0.25	38.4	0.271	6.02	5.00	<0.1	<0.5	2.06	6,680	52.8	11.0
	11/03/10		11C (3')	2.16	0.329	40.0	0.02	5.24	4.60	0.008	0.329	<2.00	7,890	54.5	19.1
12A	04/12/07	Background	SS-12A (2' -3')	2.90	<0.2	50.8	0.176	11.4	5.61	<0.04	1.40	---	---	---	---
	04/10/07	Treatment	12A (0' - 1')	3.44	<0.94	73.6	0.218	9.55	7.39	<0.014	1.10	---	---	---	---
	10/09/07		12A (0' - 1')	7.09	<0.096	72.4	<0.096	6.30	5.23	<0.016	0.264	---	---	---	---
	03/13/08		12A (0' - 1')	3.81	<0.103	96.3	0.146	7.52	5.62	<0.017	0.841	---	---	---	---
	04/12/07	Vadose	12A (2' -3')	2.13	<0.98	191	0.130	2.85	1.42	<0.015	0.489	---	---	---	---
	10/16/07		12A (2' -3')	2.08	<0.108	38.7	<0.108	8.81	4.41	<0.016	0.654	---	---	---	---
	10/16/07		12A-1 (2' -3')	2.14	<0.100	39.4	<0.100	8.56	4.54	<0.017	0.806	---	---	---	---
	03/20/08		12A (2' -3')	2.51	<0.102	45.0	0.172	9.80	5.35	<0.015	1.21	---	---	---	---
	10/06/08		12A (2' -3')	<5.00	10.7	27.6	<2.50	18.7	<6.00	<0.015	<5.00	---	---	---	---
	10/01/09		12A (2' -3')	2.76	<1.0	66.7	0.309	12.2	6.16	<0.1	0.284	2.8	11,600	62.1	25.2
	10/01/09		12A-1 (2' -3')	1.67	<1.0	35.7	0.228	8.50	3.94	<0.1	<0.100	2.2	7,920	64.9	17.9
	04/07/10		12A (2' -3')	1.82	<0.25	63.3	0.328	7.89	7.27	<0.1	<0.5	1.87	10,400	39.9	12.9
	04/07/10		12A-1 (2' -3')	1.92	<0.25	55.1	0.375	8.78	7.45	<0.1	<0.5	2.29	11,900	57.6	15.7
	11/03/10		12A (3')	2.90	0.035	64.4	0.06	7.36	6.56	0.008	0.352	2.31	11,600	67.4	26.4
	11/03/10		12A-1 (3')	2.24	0.048	36.2	0.04	5.93	4.79	0.016	0.318	2.69	8,270	80.4	20.0

Table 2

Summary of Metal Concentrations - Soil Analytical Results

Cell No.	Sample Date	Sample Zone	Sample ID (Depth in Ft)	Metals (mg/kg)											
				As	Ag	Ba	Cd	Cr	Pb	Hg	Se	Cu	Fe	Mn	Zn
12B	01/07/08	Background	SS-12B (2' -3')	2.58	<0.2	236	0.202	5.76	3.08	<0.04	1.07	---	---	---	---
	04/10/07	Treatment	12B (0' -1')	4.09	<0.088	214	0.148	9.92	5.05	<0.014	1.18	---	---	---	---
	10/09/07		12B (0' -1')	2.38	<0.095	140	<0.095	7.19	5.11	<0.015	0.406	---	---	---	---
	03/13/08		12B (0' -1')	2.31	<0.117	84.2	0.153	8.43	4.76	<0.017	1.23	---	---	---	---
	03/02/06	Vadose	SS-B (2' -3')	0.89	0.778	19.8	<0.148	5.21	2.34	0.008	<1.29	---	---	---	---
	03/02/06		SS-C (2' -3')	1.29	<0.377	25.8	<0.148	6.85	2.79	0.017	<1.29	---	---	---	---
	10/25/06		12B-1 (3' -4')	2.08	0.189	259	<0.346	1.10	0.405	0.010	<1.50	---	---	---	---
	10/25/06		12B-2 (3' -4')	<0.852	0.208	157	<0.346	<0.488	1.05	0.008	<1.50	---	---	---	---
	04/12/07		12B (2' -3')	1.98	<0.050	112	0.141	4.92	2.57	<0.008	0.939	---	---	---	---
	10/16/07		12B (2' -3')	2.19	0.103	175	0.125	7.58	3.51	<0.016	0.690	---	---	---	---
	03/20/08		12B (2' -3')	2.70	<0.093	59.0	0.188	10.5	6.12	<0.016	1.340	---	---	---	---
	10/06/08		12B (2' -3')	<5.00	<2.00	24.9	<2.50	21.4	8.25	<0.013	<5.00	---	---	---	---
	10/01/09		12B (2' -3')	1.51	<1.0	37.7	0.276	7.10	3.66	<0.1	<0.100	<2.0	6,380	55.5	14.6
	04/07/10		12B (2' -3')	1.68	<0.25	39.5	0.289	6.38	5.27	<0.1	<0.5	1.67	7,670	37.4	10.8
	11/03/10		12B (3')	1.69	0.059	54.6	0.07	3.35	4.12	0.008	0.309	2.28	6,460	63.0	16.9
12C	04/12/07	Background	SS-12C (2' -3')	1.89	<0.2	62.6	0.152	6.43	3.60	<0.04	1.34	---	---	---	---
	04/10/07	Treatment	12C (0' -1')	1.90	<0.097	36.7	0.128	6.73	4.48	<0.016	0.89	---	---	---	---
	04/10/07		12C-1 (0' -1')	2.01	<0.093	50.1	0.126	6.89	3.66	<0.014	0.99	---	---	---	---
	10/09/07		12C (0' -1')	1.18	<0.085	31.2	<0.085	5.03	3.55	<0.037	0.271	---	---	---	---
	10/09/07		12C-1 (0' -1')	1.61	<0.091	52.5	0.099	6.05	4.01	<0.015	0.263	---	---	---	---
	03/13/08		12C (0' -1')	1.84	<0.114	117	0.140	6.41	4.16	<0.017	0.981	---	---	---	---
	03/13/08		12C-1 (0' -1')	2.17	<0.104	89.5	0.149	7.28	5.00	<0.016	0.551	---	---	---	---
	03/02/06	Vadose	SS-D (2' -3')	1.30	0.092	27.2	<0.148	7.21	3.00	0.021	<1.29	---	---	---	---
	03/02/06		SS-E (2' -3')	1.05	<0.377	26.4	<0.148	6.90	2.95	0.012	<1.29	---	---	---	---
	10/25/06		12C-1 (3' -4')	3.34	3.92	834	<0.346	2.20	1.21	0.006	<1.50	---	---	---	---
	10/25/06		12C-2 (3' -4')	3.57	0.332	833	<0.346	2.06	0.837	0.007	<1.50	---	---	---	---
	04/17/07		12C (2' -3')	2.04	<0.099	33.8	0.180	7.93	4.47	<0.015	1.72	---	---	---	---
	04/17/07		12C-1 (2' -3')	2.34	<0.099	38.5	0.205	8.98	4.74	<0.014	1.61	---	---	---	---
	10/16/07		12C (2' -3')	1.87	<0.099	86.4	0.101	6.77	3.28	<0.016	0.634	---	---	---	---
	03/20/08		12C (2' -3')	1.39	<0.105	36.6	<0.105	6.06	3.32	<0.016	0.83	---	---	---	---
	03/20/08		12C-1 (2' -3')	1.88	<0.099	102	0.154	5.84	3.26	<0.016	0.74	---	---	---	---
	10/06/08		12C (2' -3')	<5.00	<2.00	21.8	<2.50	7.25	<6.00	<0.013	<5.00	---	---	---	---
	10/06/08		12C-1 (2' -3')	9.95	17.5	24.9	<2.50	15.7	9.20	<0.013	<5.00	---	---	---	---
	10/01/09		12C (2' -3')	1.21	<1.0	44.4	0.257	5.10	2.07	<0.1	0.240	2.4	4,160	47.2	15.7
	04/07/10		12C (2' -3')	0.87	<0.25	27.8	0.195	4.23	3.32	<0.1	<0.5	1.97	3,980	48.7	6.61
	11/03/10		12C (3')	1.17	0.049	30.0	0.22	3.45	3.38	0.007	0.230	2.14	5,090	56.5	11.4
Background Screening Values				3.84	0.273	507	0.341	13.4	7.20	0.156	1.81	---	---	---	---

Table 3
Summary of Major Ion Concentrations - Soil Analytical Results

Cell No.	Sample Date	Sample Zone	Sample ID (Depth)	Cations (mg/kg)					Anions (mg/kg)		
				T-Alk	Ca	Mg	K	Na	Cl	SO_4	HCO_3
7B	11/29/04	Background	Facility (2' -3')	1,340	220,000	2,240	274	2,060	<20	<2.5	---
1A	04/12/07	Background	SS-1A (2' -3')	76.1	1,650	2,300	2,980	30.5	<4.98	<9.96	---
	10/24/06	Vadose	1-A-1 (3' -4')	50	135	29.8	6.12	11.3	211	17.1	---
	10/24/06		1-A-2 (3' -4')	160	66.1	59.2	119	8.05	38.1	30.8	---
	04/10/07		1A (2' -3')	72.5	2,070	2,200	2,690	163	<4.92	42.4	---
	04/12/07		1A-1 (2' -3')	165	2,200	1,250	1,270	256	320	51.3	---
	10/15/07		1A (2' -3')	237	593	617	937	120	<5.33	<10.7	<53.7
	10/15/07		1A-1 (2' -3')	119	1,170	1,840	2,380	106	<5.57	153	<55.5
	03/20/08		1A (2' -3')	170	1,430	2,120	3,670	212	<5.59	<11.2	<56.9
	03/20/08		1A-1 (2' -3')	74.9	530	789	1,140	132	<5.13	27.3	<52.4
	04/07/10		1A (2' -3')	144	390	443	660	155	<16	<40	176
	11/03/10		1A (3')	208	895	1,220	1,620	460	24	1,160	254
1B	04/12/07	Background	SS-1B (2' -3')	89.1	1,570	2,140	2,950	30.2	<4.96	<9.92	---
	10/24/06	Vadose	1-B-1 (3' -4')	80	72.9	16.9	3.57	3.75	140	16.8	---
	10/24/06		1-B-2 (3' -4')	60	59.7	102	171	5.88	18.3	16.5	---
	04/10/07		1B (2' -3')	140	1,160	1,270	1,720	36.6	21.0	26.5	---
	04/12/07		1B-1 (2' -3')	122	1,500	784	1,220	19.6	<4.98	<9.96	---
	10/15/07		1B (2' -3')	57	824	1,120	1,660	17.0	<5.34	13.7	<53.1
	03/20/08		1B (2' -3')	55.4	552	612	1,080	58	<5.17	13.7	<52.8
	03/20/08		1B-1 (2' -3')	85.8	581	913	1,520	212	<5.53	11.5	<55.7
	04/07/10		1B (2' -3')	80	500	433	700	54.3	<16	<40	97.6
	04/07/10		1B-1 (1.5')	416	32500	1590	939	157	48	307	508
	11/03/10		1B (3')	20	1,920	1,870	2,060	<50	<4	38.8	24.4
	11/03/10		1B-1 (3')	104	3,190	1,540	1,780	<50	100	72.6	127
1C	04/12/07	Background	SS-1C (2' -3')	166	2,290	1,720	1,740	19.2	<4.93	<9.86	<49.8
	10/01/09	Vadose	1C (2' -3')	40.0	96.2	24.3	19.2	<5	180	<50	48.8
	04/07/10		1C (2' -3')	160	<50	1,560	1,880	<50	96	<40	195
	11/03/10		1C (3')	48	761	745	1,210	<50.0	<4	51.3	58.6
2A	01/07/08	Background	2A (2' -3')	70.0	486	389	643	<11.5	<5.01	10.1	<50.4
2B	01/07/08	Background	2B (2' -3')	<58.9	562	6,536	1,090	<13.6	<5.95	<11.9	<58.9
2C	01/07/08	Background	2C (2' -3')	63.0	1,080	1,460	2,110	16.0	<5.43	<10.9	<54.8
10A	01/07/08	Background	10A (2' -3')	53.9	827	932	1380	<12.5	<5.24	<140.5	<52.4
10B	01/07/08	Background	10B (2' -3')	<52.1	533	602	968	<12.5	<5.21	<10.4	<52.1
	10/01/09	Vadose	10B (2' -3')	24	40.1	24.3	17.3	<5	<80	129	29.3
	10/01/09		10B-1 (2' -3')	44	60.1	24.3	20.8	<5	<80	<125	53.7
	04/07/10		10B (2' -3')	80	870	691	962	<50	16	<40	97.6
	04/07/10		10B-1 (2' -3')	144	1,060	832	1,050	<50	16	<40	176
	11/03/10		10B (3')	112	1,860	1,010	1,210	<50	<4	<10	137
	11/03/10		10B-1 (3')	107	4,600	875	1,100	<50	<4	<10	88.0

Table 3
Summary of Major Ion Concentrations - Soil Analytical Results

Cell No.	Sample Date	Sample Zone	Sample ID (Depth)	Cations (mg/kg)					Anions (mg/kg)		
				T-Alk	Ca	Mg	K	Na	Cl	SO_4	HCO_3
10C	01/07/08	Background	10C (2' -3')	<51.0	513	554	898	<12.6	<5.13	<10.3	<51.0
	10/07/08	Vadose	10-C (2' -3')	600	322	440	839	16.9	60.4	31.0	---
	10/01/09		10C (2' -3')	112	60.1	24.3	7.7	<5	<80	<125	137
	10/01/09		10C-1 (2' -3')	250	64.1	19.4	6.5	20	<80	<50	305
	04/07/10		10C (2' -3')	64	1,370	1,220	1,440	<50	16	46	78.0
	04/07/10		10C-1 (2' -3')	256	2,250	1,030	1,230	<50	32	156	312
	11/03/10		10C (3')	32	987	1,030	1,360	<50	<4	26	39.0
	11/03/10		10C-1 (3')	64	574	597	868	<25	<4	<10	78.1
11A	01/07/08	Background	11A (2' -3')	56.0	642	658	1,030	<12.7	<5.17	<10.3	56.0
	10/06/08	Vadose	11A (2' -3')	60.0	129	197	350	3.13	<5.00	<5.00	---
	10/01/09		11A (2' -3')	140	64.1	14.6	15.6	122	60	270	171
	04/07/10		11A (2' -3')	240	9,830	1,710	2,070	256	224	464	293
	11/03/10		11A (3')	12	1,420	1,290	1,760	102	16	177	12.0
11B	01/07/08	Background	11B (2' -3')	<51.6	482	494	809	<12.6	<5.14	<10.3	<51.6
	03/20/08	Vadose	11B (2' -3')	152	1,380	1,390	1,940	<12.1	<5.39	<10.8	<54.1
	03/20/08		11B-1 (2' -3')	67.8	1,090	1,300	1,630	<12.5	<5.35	<10.7	<53.4
	10/06/08		11B (2' -3')	800	56.2	43.8	79.9	12.7	52.1	24.3	---
	10/06/08		11B-1 (2' -3')	80.0	185	27.3	22.6	62.0	473	121	---
	10/01/09		11B (2' -3')	200	60.1	24.3	13.8	<5	40	<125	244
	10/01/09		11B-1 (2' -3')	60	96.2	24.3	15.3	55	260	51.3	73.5
	04/07/10		11B (2' -3')	176	831	515	796	<50	32	<40	215
	04/07/10		11B-1 (2' -3')	224	1,880	1,470	1,780	<50	192	<40	273
	11/03/10		11B (3')	52	1,810	1,690	2,260	79.8	<4	34.5	63.4
	11/03/10		11B-1 (3')	16	637	596	928	90.6	76	101	19.5
11C	10/15/07	Background	SS-11C (2' -3')	318	170,000	2,160	1,090	73	<5.64	41.4	<56.6
	10/15/07	Vadose	11C (2' -3')	363	12,400	1,200	1,520	24.8	<5.47	25.5	<54.7
	03/20/08		11C (2' -3')	1,430	283,000	1,510	376	52.4	<6.05	30.8	<61.0
	03/20/08		11C-1 (2' -3')	82.4	1,390	1,600	3,030	12.9	<5.65	<11.3	<56.8
	10/06/08		11C (2' -3')	280	428	31.6	32.0	1.54	<10.0	30.3	---
	10/01/09		11C (2' -3')	36	60.1	48.6	57.0	<5	<80	<125	43.9
	04/07/10		11C (2' -3')	128	1,330	1,000	1,380	<50	<16	<40	156
	11/03/10		11C (3')	80	5,810	1,240	1,460	<50	8	82.2	97.6

Table 3
Summary of Major Ion Concentrations - Soil Analytical Results

Cell No.	Sample Date	Sample Zone	Sample ID (Depth)	Cations (mg/kg)					Anions (mg/kg)		
				T-Alk	Ca	Mg	K	Na	Cl	SO_4	HCO_3
12A	04/12/07	Background	SS-12A (2' -3')	163	1,980	2,030	2,210	23	<4.97	<9.94	<50
	04/12/07	Vadose	12A (2' -3')	884	314,000	2560	629	89.7	<4.97	<9.94	---
	10/16/07		12A (2' -3')	94	1,030	1,300	1,810	18.2	<5.38	<10.8	<54.0
	10/16/07		12A-1 (2' -3')	124	898	1,120	1,700	45.3	<5.29	13.30	<53.9
	03/20/08		12A (2' -3')	59.8	1,130	1,410	2,170	40.60	<5.40	127	<53.9
	10/06/08		12A (2' -3')	450	39.7	32.0	38.0	7.52	<10.0	69.0	---
	10/01/09		12A (2' -3')	28	120	97.2	22.5	<5	<80	<250	34.2
	10/01/09		12A-1 (2' -3')	32	120	48.6	35.4	<5	<80	<125	39.0
	04/07/10		12A (2' -3')	80	1,930	1,850	2,040	<50	<16	58.6	97.6
	04/07/10		12A-1 (2' -3')	256	2,650	2,190	2,810	53.4	16	146	312
	11/03/10		12A (3')	64	3,170	2,290	2,910	<50	4	127	78.1
	11/03/10		12A-1 (3')	76	3,110	1,400	1,930	<50	<4	55.4	92.7
12B	01/07/08	Background	SS-12B (2' -3')	700	256,000	3,330	1,320	91	<4.88	23	<49.8
	03/02/06	Vadose	SS-B (2' -3')	112	949	164	186	857	4.98	<0.5	---
	03/02/06		SS-C (2' -3')	112	1,290	210	219	996	42.8	23.3	---
	10/25/06		12B-1 (3' -4')	290	78.7	6.53	2.10	3.13	60.0	59.7	---
	10/25/06		12B-2 (3' -4')	410	154	12.3	3.11	7.68	151	36.4	---
	04/12/07		12B (2' -3')	914	120,000	1,860	1,080	63.0	21.2	46.8	---
	10/16/07		12B (2' -3')	452	125,000	1,760	1,570	67.7	<5.65	49.9	<57.4
	03/20/08		12B (2' -3')	<54.7	1,510	1,620	2,160	61.4	171	19.2	<54.7
	10/06/08		12B (2' -3')	800	165	238	401	38.8	30.7	7.13	---
	10/01/09		12B (2' -3')	40	80.2	36.4	<5	<5	<80	<125	32.0
	04/07/10		12B (2' -3')	464	541	1,430	1,530	547	96	<40	566
	11/03/10		12B (3')	152	10,000	1,100	1,470	157	20	<10	185
12C	04/12/07	Background	SS-12C (2' -3')	506	53,400	1,170	1,280	29.9	<4.97	<9.94	<49.8
	03/02/06	Vadose	SS-D (2' -3')	112	1,250	204	186	844	4.92	12.2	---
	03/02/06		SS-E (2' -3')	112	1,410	187	173	697	15.2	16.7	---
	10/25/06		12C-1 (3' -4')	1,900	126	7.75	1.92	2.97	15.0	81.9	---
	10/25/06		12C-2 (3' -4')	670	105	8.53	1.00	3.17	27.6	58.5	---
	04/17/07		12C (2' -3')	118	1,060	1,200	1,590	35.5	<4.96	<9.92	---
	04/17/07		12C-1 (2' -3')	127	1,460	1,540	1,700	22.4	<4.98	<9.95	---
	10/16/07		12C (2' -3')	2,110	78,100	1,310	1,400	72.8	<5.57	33.5	<56.3
	03/20/08		12C (2' -3')	311	12,500	798	1,150	19.6	<5.22	20.3	<52.5
	03/20/08		12C-1 (2' -3')	900	76.1	113	196	16.3	<5.00	8.77	<55.6
	10/06/08		12C (2' -3')	477	23,000	1,590	1,200	47.0	<5.42	<10.8	---
	10/06/08		12C-1 (2' -3')	900	200	71.5	98.3	3.85	<5.00	<5.00	---
	10/01/09		12C (2' -3')	112	128	43.7	5.7	<5	<80	<50	104
	04/07/10		12C (2' -3')	352	1,650	599	800	<50	<16	<40	366
	11/03/10		12C (2' -3')	72	1,950	708	1,060	<50	<4	13.2	87.8

APPENDIX A

Laboratory Analytical Reports and Chains of Custody

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

April 27, 2010

Carolyn Haynes
John H. Hendrix Corporation
P.O. Box 910
Eunice, NM 88231

Re: JHHC Surface Waste Management Facility (NM-02-0021)

Enclosed are the results of analyses for sample number H19626, received by the laboratory on 04/09/10 at 11:30 am.

Cardinal Laboratories is accredited through Texas NELAP for:

Method SW-846 8021	Benzene, Toluene, Ethyl Benzene, and Total Xylenes
Method SW-846 8260	Benzene, Toluene, Ethyl Benzene, and Total Xylenes
Method TX 1005	Total Petroleum Hydrocarbons

Certificate number T104704398-08-TX. Accreditation applies to solid and chemical materials and non-potable water matrices.

Cardinal Laboratories is accredited though the State of Colorado Department of Public Health and Environment for:

Method EPA 552.2	Haloacetic Acids (HAA-5)
Method EPA 524.2	Total Trihalomethanes (TTHM)
Method EPA 524.2	Regulated VOCs (V2, V3)

Accreditation applies to public drinking water matrices.

Total Number of Pages of Report: 17 (includes Chain of Custody)

Sincerely,

Celey D. Keene
Laboratory Director

This report conforms with NELAP requirements.

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575) 394-2853

Receiving Date: 04/09/10
Reporting Date: 04/26/10
Project Number: JOHN H. HENDRIX CORP.
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2°C
Sample Received By: AB
Analyzed By: JM

TOTAL METALS

LAB NO.	SAMPLE ID	As (mg/kg)	Ag (mg/kg)	Ba (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Pb (mg/kg)	Hg (mg/kg)	Se (mg/kg)
ANALYSIS DATE:		04/22/10	04/22/10	04/22/10	04/22/10	04/22/10	04/22/10	04/20/10	04/22/10
H19626-2	10B (2' - 3')	0.988	<0.25	24.9	0.2383	4.78	3.63	< 0.1	<0.5
H19626-4	10B-1 (2' - 3')	1.03	<0.25	29.5	0.2217	4.87	4.07	<0.1	<0.5
H19626-6	10C (2' - 3')	1.72	<0.25	42.7	0.2924	6.93	5.62	<0.1	<0.5
H19626-8	10C-1 (2' - 3')	1.51	<0.25	36.1	0.2561	5.39	4.70	<0.1	<0.5
H19626-10	11A (2' - 3')	2.07	<0.25	60.8	0.3914	7.56	6.39	<0.1	<0.5
H19626-12	11B (2' - 3')	0.895	<0.25	18.9	0.1809	4.09	3.21	<0.1	<0.5
H19626-14	11B-1 (2' - 3')	1.55	<0.25	60.5	0.2921	6.91	5.86	<0.1	<0.5
H19626-16	11C (2' - 3')	1.30	<0.25	38.4	0.2709	6.02	5.00	<0.1	<0.5
H19626-18	12A (2' - 3')	1.82	<0.25	63.3	0.3282	7.89	7.27	<0.1	<0.5
H19626-20	12A-1 (2' - 3')	1.92	<0.25	55.1	0.3746	8.78	7.45	<0.1	<0.5
H19626-22	12B (2' - 3')	1.68	<0.25	39.5	0.2886	6.38	5.27	<0.1	<0.5
H19626-24	12C (2' - 3')	0.869	<0.25	27.8	0.1948	4.23	3.32	<0.1	<0.5
H19626-26	1A (2'-3')	0.877	<0.25	19.5	0.1510	3.79	2.88	<0.1	<0.5
H19626-28	1B (2'-3')	0.845	<0.25	17.6	0.1797	3.95	2.77	<0.1	<0.5
H19626-30	1B-1 (1.5')	1.57	<0.25	77.2	0.2466	4.25	3.86	<0.1	<0.5
H19626-32	1C (2' - 3')	2.00	<0.25	53.1	0.3198	7.73	6.78	<0.1	<0.5
Quality Control		0.0505	0.0488	0.0496	0.0526	0.051	0.0510	0.0021	0.248
True Value QC		0.050	0.050	0.050	0.050	0.050	0.050	0.0020	0.250
% Recovery		101	97.6	99.2	105	102	102	105	99.2
Relative Standard Deviation		7.4	<0.1	4.1	13.0	9.0	5.4	4.9	<0.1
METHODS: EPA 600/4-91/010,3050		6020	6020	6020	6020	6020	6020	7471	6020

Analyses subcontracted to Green Analytical Laboratories, a subsidiary of Cardinal Laboratories.

Chemist

04/27/10
Date

H19626M J. Hendrix

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575) 394-2653

Receiving Date: 04/09/10
Reporting Date: 04/26/10
Project Number: JOHN H. HENDRIX CORP.
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2°C
Sample Received By: AB
Analyzed By: JM

TOTAL METALS

LAB NO.	SAMPLE ID	Cu (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
ANALYSIS DATE:		04/22/10	04/16/10	04/22/10	04/22/10
H19626-2	10B (2' - 3')	2.12	4,650	44.6	8.35
H19626-4	10B-1 (2' - 3')	2.13	5,490	48.1	8.95
H19626-6	10C (2' - 3')	1.67	8,250	41.5	11.7
H19626-8	10C-1 (2' - 3')	1.93	6,690	41.1	9.91
H19626-10	11A (2' - 3')	13.6	9,520	45.0	15.0
H19626-12	11B (2' - 3')	1.46	4,230	31.9	5.25
H19626-14	11B-1 (2' - 3')	2.45	9,210	57.7	11.3
H19626-16	11C (2' - 3')	2.06	6,680	52.8	11.0
H19626-18	12A (2' - 3')	1.87	10,400	39.9	12.9
H19626-20	12A-1 (2' - 3')	2.29	11,900	57.6	15.7
H19626-22	12B (2' - 3')	1.67	7,670	37.4	10.8
H19626-24	12C (2' - 3')	1.97	3,980	48.7	6.61
H19626-26	1A (2'-3')	1.34	3,890	28.6	4.50
H19626-28	1B (2'-3')	1.45	3,870	34.0	4.81
H19626-30	1B-1 (1.5')	1.74	4,000	37.5	9.93
H19626-32	1C (2' - 3')	2.10	9,190	40.9	15.1
Quality Control		0.0517	5.23	0.0492	0.044
True Value QC		0.050	5.00	0.050	0.050
% Recovery		103	105	98.4	88.0
Relative Standard Deviation		15.8	1.6	5.3	10.6
METHODS: EPA 600/4-91/010,3050		6020	6010	6020	6020

Analyses subcontracted to Green Analytical Laboratories, a subsidiary of Cardinal Laboratories.

Chemist

04/27/10
Date

H19626M J. Hendrix

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575) 394-2653

Receiving Date: 04/09/10
Reporting Date: 04/26/10
Project Number: JOHN H. HENDRIX CORPORATION
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: JM/HM

LAB NUMBER	SAMPLE ID	Na* (mg/kg)	Ca* (mg/kg)	Mg* (mg/kg)	K* (mg/kg)
ANALYSIS DATE:		04/16/10	04/16/10	04/16/10	04/16/10
H19626-2	10B (2' - 3')	< 50	870	691	962
H19626-4	10B-1 (2' - 3')	< 50	1,060	832	1,050
H19626-6	10C (2' - 3')	< 50	1,370	1,220	1,440
H19626-8	10C (2' - 3')	< 50	2,250	1,030	1,230
H19626-10	11A (2' - 3')	256	9,830	1,710	2,070
H19626-12	11B (2' - 3')	< 50	831	515	796
Quality Control		8.31	5.25	4.99	10.4
True Value QC		8.10	5.00	5.00	10.0
% Recovery		102	105	99.8	104
Relative Percent Difference		0.6	1.5	1.3	2.2
METHODS:		3050/6010	3050/6010	3050/6010	3050/6010

LAB NUMBER	SAMPLE ID	Cl (mg/kg)	SO_4 (mg/kg)	CO_3 (mg/kg)	HCO_3 (mg/kg)	T-Alkalinity ($mgCaCO_3/kg$)
ANALYSIS DATE:		04/22/10	04/22/10	04/23/10	04/23/10	04/23/10
H19626-2	10B (2' - 3')	16	< 40	0	97.6	80
H19626-4	10B-1 (2' - 3')	16	< 40	0	176	144
H19626-6	10C (2' - 3')	16	46	0	78.0	64
H19626-8	10C (2' - 3')	32	156	0	312	256
H19626-10	11A (2' - 3')	224	464	0	293	240
H19626-12	11B (2' - 3')	32	<40	0	215	176
Quality Control		490	43.7	NR	988	NR
True Value QC		500	40.0	NR	1000	NR
% Recovery		98.0	109	NR	98.8	NR
Relative Percent Difference		2.0	3.0	NR	4.8	NR
METHODS:		SM4500-Cl-B	375.4	310.1	310.1	310.1

*Analyses subcontracted to Green Analytical a subsidiary of Cardinal Laboratories.

Chemist

04/27/10
Date

H19626-2 thru 12 Hendrix

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575) 394-2853

Receiving Date: 04/09/10
Reporting Date: 04/26/10
Project Number: JOHN H. HENDRIX CORPORATION
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: JM/HM

LAB NUMBER	SAMPLE ID	Na* (mg/kg)	Ca* (mg/kg)	Mg* (mg/kg)	K* (mg/kg)
ANALYSIS DATE:		04/16/10	04/16/10	04/16/10	04/16/10
H19626-14	11B-1 (2' - 3')	< 50	1,880	1,470	1,780
H19626-16	11C (2' - 3')	< 50	1,330	1,000	1,380
H19626-18	12A (2' - 3')	< 50	1,930	1,850	2,040
H19626-20	12A-1 (2' - 3')	53.4	2,650	2,190	2,810
H19626-22	12B (2' - 3')	547	541	1,430	1,530
H19626-24	12C (2' - 3')	< 50	1,650	599	800
Quality Control		8.31	5.25	4.99	10.4
True Value QC		8.10	5.00	5.00	10.0
% Recovery		102	105	99.8	104
Relative Percent Difference		0.6	1.5	1.3	2.2
METHODS:		3050/6010	3050/6010	3050/6010	3050/6010

LAB NUMBER	SAMPLE ID	Cl (mg/kg)	SO_4 (mg/kg)	CO_3 (mg/kg)	HCO_3 (mg/kg)	T-Alkalinity ($mgCaCO_3/kg$)
ANALYSIS DATE:		04/22/10	04/22/10	04/23/10	04/23/10	04/23/10
H19626-14	11B-1 (2' - 3')	192	< 40	0	273	224
H19626-16	11C (2' - 3')	< 16	< 40	0	156	128
H19626-18	12A (2' - 3')	< 16	58.6	0	97.6	80
H19626-20	12A-1 (2' - 3')	16	146	0	312	256
H19626-22	12B (2' - 3')	96	< 40	0	566	464
H19626-24	12C (2' - 3')	< 16	< 40	16	366	352
Quality Control		490	43.5	NR	988	NR
True Value QC		500	40.0	NR	1000	NR
% Recovery		98.0	109	NR	98.8	NR
Relative Percent Difference		2.0	3.0	NR	4.8	NR
METHODS:		SM4500-Cl-B	375.4	310.1	310.1	310.1

*Analyses subcontracted to Green Analytical a subsidiary of Cardinal Laboratories.

Chemist

04/27/10
Date

H19626CA Report.xls

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575) 394-2653

Receiving Date: 04/09/10
Reporting Date: 04/26/10
Project Number: JOHN H. HENDRIX CORPORATION
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: JM/ HM

LAB NUMBER	SAMPLE ID	Na* (mg/kg)	Ca* (mg/kg)	Mg* (mg/kg)	K* (mg/kg)
ANALYSIS DATE:		04/16/10	04/16/10	04/16/10	04/16/10
H19626-26	1A (2' - 3')	155	390	443	660
H19626-28	1B (2' - 3')	54.3	500	433	700
H19626-30	1B-1 (1.5')	157	32,500	1,590	939
H19626-32	1C (2' - 3')	< 50	1,840	1,560	1,880
Quality Control		8.31	49.7	51.5	3.01
True Value QC		8.10	50.0	50.0	3.00
% Recovery		102	99.4	103	100
Relative Percent Difference		0.6	3.2	1.9	2.7
METHODS:		3050/6010	3050/6010	3050/6010	3050/6010

LAB NUMBER	SAMPLE ID	Cl (mg/kg)	SO_4 (mg/kg)	CO_3 (mg/kg)	HCO_3 (mg/kg)	T-Alkalinity ($mgCaCO_3/kg$)
ANALYSIS DATE:		04/22/10	04/22/10	04/23/10	04/23/10	04/23/10
H19626-26	1A (2' - 3')	< 16	< 40	0	176	144
H19626-28	1B (2' - 3')	< 16	307	0	97.6	80
H19626-30	1B-1 (1.5')	48	< 40	0	508	416
H19626-32	1C (2' - 3')	96	< 40	0	195	160
Quality Control		490	44.6	NR	988	NR
True Value QC		500	40.0	NR	1000	NR
% Recovery		98.0	112	NR	98.8	NR
Relative Percent Difference		2.0	2.0	NR	4.8	NR
METHODS:		SM4500-Cl-B	375.4	310.1	310.1	310.1

*Analyses subcontracted to Green Analytical a subsidiary of Cardinal Laboratories.

Chemist

04/27/10
Date

H19626 CHL HM0104

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575) 394-2653

Receiving Date: 04/09/10
Reporting Date: 04/12/10
Project Owner: JOHN H. HENDRIX CORPORATION
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY NM

Analysis Date: 04/12/10
Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2°C
Sample Received By: AB
Analyzed By: HM

LAB NO.	SAMPLE ID	Cl^- (mg/kg)
H19626-1	10B (0' -1')	416
H19626-3	10B-1 (0' -1')	320
H19626-5	10C (0' -1')	16
H19626-7	10C-1 (0' -1')	96
H19626-9	11A (0' -1')	16
H19626-11	11B (0' -1')	96
H19626-13	11B-1 (0' -1')	64
H19626-15	11C (0' - 1')	32
H19626-17	12A (0' -1')	< 16
H19626-19	12A-1 (0' - 1')	< 16
H19626-21	12B (0' - 1')	< 16
H19626-23	12C (0' - 1')	16
H19626-25	1A (0' - 1')	< 16
H19626-27	1B (0' - 1')	< 16
H19626-29	1B-1 (0' -1')	128
H19626-31	1C (0' - 1')	< 16
Quality Control		500
True Value QC		500
% Recovery		100
Relative Percent Difference		4.1

METHOD: Standard Methods	4500-Cl^-B

Note: Analyses performed on 1:4 w:v aqueous extracts.
Not accredited for chloride.

Chemist

04/27/10
Date

H19626 J. Hendrix

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575)394-2853

Receiving Date: 04/09/10
Reporting Date: 04/14/10
Project Owner: JHHC
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: AB

LAB NUMBER	SAMPLE ID	GRO (C_6-C_{10}) (mg/kg)	DRO (>C_{10}-C_{28}) (mg/kg)
ANALYSIS DATE:		04/12/10	04/12/10
H19626-1	10B (0'-1')	<50.0	19,700
H19626-2	10B (2'-3')	<10.0	<10.0
H19626-3	10B-1 (0'-1')	<50.0	17,300
H19626-4	10B-1 (2'-3')	<10.0	<10.0
H19626-5	10C (0'-1')	<10.0	274
H19626-6	10C (2'-3')	<10.0	<10.0
H19626-7	10C-1 (0'-1')	<50.0	10,000
H19626-8	10C-1 (2'-3')	<10.0	<10.0
H19626-9	11A (0'-1')	<10.0	161
H19626-10	11A (2'-3')	<10.0	<10.0
H19626-11*	11B (0'-1')	<10.0	71.8
H19626-12	11B (2'-3')	<10.0	<10.0
Quality Control		517	483
True Value QC		500	500
% Recovery		103	96.6
Relative Percent Difference		1.2	10.7

METHOD: SW-846 8015 M
Not accredited for GRO/DRO. Reported on wet weight.
*One or more TPH surrogates outside historical limits due to matrix interference.

Chemist

04/27/10
Date

H19626 T JHC

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575)394-2653

Receiving Date: 04/09/10
Reporting Date: 04/14/10
Project Owner: JHHC
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: AB

LAB NUMBER	SAMPLE ID	GRO (C_6-C_{10}) (mg/kg)	DRO (>C_{10}-C_{28}) (mg/kg)
ANALYSIS DATE:		04/14/10	04/14/10
H19626-13	11B-1 (0'-1')	<50.0	468
H19626-14	11B-1 (2'-3')	<10.0	<10.0
H19626-15	11C (0'-1')	<10.0	253
H19626-16	11C (2'-3')	<10.0	<10.0
H19626-17	12A (0'-1')	<10.0	332
H19626-18*	12A (2'-3')	<10.0	<10.0
H19626-19	12A-1 (0'-1')	<10.0	82.0
H19626-20*	12A-1 (2'-3')	<10.0	<10.0
H19626-21	12B (0'-1')	<10.0	<10.0
H19626-22	12B (2'-3')	<10.0	<10.0
Quality Control		486	563
True Value QC		500	500
% Recovery		97.2	113
Relative Percent Difference		0.6	10.2

METHOD: SW-846 8015 M
Not accredited for GRO/DRO. Reported on wet weight.
*One or more TPH surrogates outside historical limits due to matrix interference.

Chemist

04/27/10
Date

H19626 T JHC

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575)394-2653

Receiving Date: 04/09/10
Reporting Date: 04/14/10
Project Owner: JHHC
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: AB

LAB NUMBER	SAMPLE ID	GRO (C_6-C_{10}) (mg/kg)	DRO (>C_{10}-C_{28}) (mg/kg)
ANALYSIS DATE:		04/14/10	04/14/10
H19626-23	12C (0'-1')	<10.0	108
H19626-24	12C (2'-3')	<10.0	<10.0
H19626-25	1A (0'-1')	<10.0	<10.0
H19626-26	1A (2'-3')	<10.0	<10.0
H19626-27	1B (0'-1')	<10.0	<10.0
H19626-28	1B (2'-3')	<10.0	<10.0
H19626-29	1B-1 (0'-1')	<10.0	73.4
H19626-30	1B-1 (1.5')	<10.0	<10.0
H19626-31	1C (0'-1')	<10.0	206
Quality Control		486	563
True Value QC		500	500
% Recovery		97.2	113
Relative Percent Difference		0.6	10.2

METHOD: SW-846 8015 M
Not accredited for GRO/DRO. Reported on wet weight.

Chemist

Date 04/27/10

H19626 T JHC

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575)394-2653

Receiving Date: 04/09/10
Reporting Date: 04/14/10
Project Owner: JHHC
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: AB

LAB NUMBER	SAMPLE ID	GRO (C_6-C_{10}) (mg/kg)	DRO (>C_{10}-C_{28}) (mg/kg)
ANALYSIS DATE:		04/15/10	04/15/10
H19626-32	1C (2'-3')	<10.0	<10.0
Quality Control		481	544
True Value QC		500	500
% Recovery		96.2	109
Relative Percent Difference		0.2	11.9

METHOD: SW-846 8015 M
Not accredited for GRO/DRO. Reported on wet weight.

Chemist

04/27/10
Date

H19626 T JHC

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575)394-2653

Receiving Date: 04/09/10
Reporting Date: 04/14/10
Project Owner: JHHC
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: ZL

LAB NO.	SAMPLE ID	BENZENE (mg/kg)	TOLUENE (mg/kg)	ETHYL BENZENE (mg/kg)	TOTAL XYLENES (mg/kg)
ANALYSIS DATE:		04/12/10	04/12/10	04/12/10	04/12/10
H19626-1	10B (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-2	10B (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-3	10B-1 (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-4	10B-1 (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-5	10C (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-6	10C (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-7	10C-1 (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-8	10C-1 (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-9	11A (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-10	11A (2'-3')	<0.050	<0.050	<0.050	<0.300
Quality Control		0.051	0.050	0.052	0.154
True Value QC		0.050	0.050	0.050	0.150
% Recovery		102	100	104	103
Relative Percent Difference		5.6	18.0	9.7	16.7

METHODS: BTEX - SW-846 8021B;

TEXAS NELAP ACCREDITATION T104704398-08-TX FOR BENZENE, TOLUENE, ETHYL BENZENE, AND TOTAL XYLENES. Reported on wet weight.

Lab Director

04/27/10
Date

H19626 BTEX JHHC

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575)394-2653

Receiving Date: 04/09/10
Reporting Date: 04/14/10
Project Owner: JHHC
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: ZL

LAB NO.	SAMPLE ID	BENZENE (mg/kg)	TOLUENE (mg/kg)	ETHYL BENZENE (mg/kg)	TOTAL XYLENES (mg/kg)
ANALYSIS DATE:		04/12/10	04/12/10	04/12/10	04/12/10
H19626-11	11B (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-12	11B (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-13	11B-1 (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-14	11B-1 (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-15	11C (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-16	11C (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-17	12A (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-18	12A (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-19	12A-1 (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-20	12A-1 (2'-3')	<0.050	<0.050	<0.050	<0.300
Quality Control		0.051	0.050	0.052	0.154
True Value QC		0.050	0.050	0.050	0.150
% Recovery		102	100	104	103
Relative Percent Difference		5.6	18.0	9.7	16.7

METHODS: BTEX - SW-846 8021B;

TEXAS NELAP ACCREDITATION T104704398-08-TX FOR BENZENE, TOLUENE, ETHYL BENZENE, AND TOTAL XYLENES. Reported on wet weight.

Lab Director

04/27/10
Date

H19626 BTEX JHHC

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575)394-2653

Receiving Date: 04/09/10
Reporting Date: 04/14/10
Project Owner: JHHC
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: ZL

LAB NO.	SAMPLE ID	BENZENE (mg/kg)	TOLUENE (mg/kg)	ETHYL BENZENE (mg/kg)	TOTAL XYLENES (mg/kg)
ANALYSIS DATE:		04/13/10	04/13/10	04/13/10	04/13/10
H19626-21	12B (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-22	12B (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-23	12C (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-24	12C (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-25	1A (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-26	1A (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-27	1B (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-28	1B (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-29	1B-1 (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-30	1B-1 (1.5')	<0.050	<0.050	<0.050	<0.300
H19626-31	1C (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-32	1C (2'-3')	<0.050	<0.050	<0.050	<0.300
Quality Control		0.046	0.043	0.045	0.130
True Value QC		0.050	0.050	0.050	0.150
% Recovery		92.0	86.0	90.0	86.7
Relative Percent Difference		2.7	<1.0	2.2	3.2

METHODS: BTEX - SW-846 8021B;

TEXAS NELAP ACCREDITATION T104704398-08-TX FOR BENZENE, TOLUENE, ETHYL BENZENE, AND TOTAL XYLENES. Reported on wet weight.

Lab Director

04/27/10
Date

H19626 BTEX JHHC

101 East Marland - Hobbs, New Mexico 88240
Tel (575) 393-2326
Fax (575) 393-2476

Cardinal Laboratories, Inc.

CHAIN-OF-CUSTODY AND ANALYSIS REQUEST

LAB Order ID # _____

Company Name: John H. Hendrix Corporation	BILL TO Company: John H. Hendrix Corporation PO#
Project Manager: Carolyn Haynes	Project Manager: Carolyn Haynes
Address: (Street, City, Zip) PO Box 910, Eunice NM 88231	Address: (Street, City, Zip) PO Box 3040, Midland TX 79702-3040 Fax#
Phone #: (575) 394-2649 Fax#: (575) 394-2653	Phone #: (432) 684-6631 Email: cdoranhaynes@jhhc.org
Project #: John H. Hendrix Corporation	Project Name: JHHC Surface Waste Management Facility (NM-02-0021)
Project Location: T24S, R36E, Sec 15, W/2 NW/4 & W/2 SW/4, Lea County NM	Sampler Name: Gil Van Deventer

LAB # (LAB USE ONLY)	FIELD CODE	(G)rab or (C)omp	# CONTAINERS	MATRIX				PRESERVATIVE METHOD						SAMPLING		MTBE 8021B/602	BTEX 8021 B	TPH 8015M	PAH 8270C	RCRA Metals: Ag As Ba Cd Cr Pb Se Hg	WQCC Metals: Ag As Ba Cd Cr Pb Se Hg Cu Fe Mn Zn	TCLP Volatiles	TCLP Semi Volatiles	TCLP Pesticides	RCI	GC/MS Vol. 8260B/624	GC/MS Semi. Vol. 8270C/625	Moisture Content	Cations (Ca, Mg, K, Na)	Anions (Cl, SO4, CO3, HCO3, T-ALK)	Total Dissolved Solids (SM2540C)	Chlorides (326.3 / SM4500 B)	SPLP Chloride	Turn Around Time - 24 Hours
				WATER	SOIL	AIR	SLUDGE	HCL	HNO_3	$NaHSO_4$	H_2SO_4	ICE	None	DATE	TIME																		
H19626-1	10B (0' - 1')	G	1		X							X		4/7/10	1700		X	X												X		
-2	10B (2' - 3')	G	1		X							X		4/7/10	1705		X	X			X								X	X		
-3	10B-1 (0' - 1')	G	1		X							X		4/7/10	1730		X	X												X		
-4	10B-1 (2' - 3')	G	1		X							X		4/7/10	1735		X	X			X								X	X		
-5	10C (0' - 1')	G	1		X							X		4/7/10	1350		X	X												X		
-6	10C (2' - 3')	G	1		X							X		4/7/10	1355		X	X			X								X	X		
-7	10C-1 (0' - 1')	G	1		X							X		4/7/10	1410		X	X												X		
-8	10C-1 (2' - 3')	G	1		X							X		4/7/10	1415		X	X			X								X	X		
-9	11A (0' - 1')	G	1		X							X		4/7/10	1130		X	X												X		
-10	11A (2' - 3')	G	1		X							X		4/7/10	1135		X	X			X								X	X		

Relinquished by: Gil Van Deventer	Date: 4/9/10	Time: 11:30a	Received by: [signature]
Relinquished by:	Date:	Time:	Received By: (Laboratory Staff)
Delivered By: (Circle One) Sampler - UPS - Bus - Other:	Sample Condition: Cool: Yes [X] No [ ] Intact: Yes [X] No [ ]		CHECKED BY: (Initials) [signature]

#26 2.0°C

Phone Results: [ ] Yes [ ] No
Fax Results: [ ] Yes [ ] No Additional Fax Number:

REMARKS:

Email Results to:
cdoranhaynes@jhhc.org
gil@trident-environmental.com

101 East I. · Hobbs, New Mexico 88240
Tel (575) 393-2326
Fax (575) 393-2476

Cardinal Laboratories, Inc.

CHAIN-OF-CUSTODY AND ANALYSIS REQUEST

LAB Order ID # _____

Company Name: John H. Hendrix Corporation	BILL TO Company: John H. Hendrix Corporation PO#
Project Manager: Carolyn Haynes	Project Manager: Carolyn Haynes
Address: (Street, City, Zip) PO Box 910, Eunice NM 88231	Address: (Street, City, Zip) PO Box 3040, Midland TX 79702-3040 Fax#:
Phone #: (575) 394-2649 Fax#: (575) 394-2653	Phone #: (432) 684-6631 Email: cdoranhaynes@jhhc.org
Project #: John H. Hendrix Corporation	Project Name: JHHC Surface Waste Management Facility (NM-02-0021)
Project Location: T24S, R36E, Sec 15, W/2 NW/4 & W/2 SW/4, Lea County NM	Sampler Name: Gil Van Deventer

LAB # (LAB USE ONLY)	FIELD CODE	(G)rab or (C)omp	# CONTAINERS	MATRIX: WATER	SOIL	AIR	SLUDGE	PRESERVATIVE METHOD: HCL	HNO_3	$NaHSO_4$	H_2SO_4	ICE	None	SAMPLING: DATE	TIME
H19626-11	11B (0' - 1')	G	1		X							X		4/7/10	1200
-12	11B (2' - 3')	G	1		X							X		4/7/10	1205
-13	11B-1 (0' - 1')	G	1		X							X		4/7/10	1220
-14	11B-1 (2' - 3')	G	1		X							X		4/7/10	1225
-15	11C (0' - 1')	G	1		X							X		4/7/10	1300
-16	11C (2' - 3')	G	1		X							X		4/7/10	1305
-17	12A (0' - 1')	G	1		X							X		4/7/10	1030
-18	12A (2' - 3')	G	1		X							X		4/7/10	1035
-19	12A-1 (0' - 1')	G	1		X							X		4/7/10	1100
-20	12A-1 (2' - 3')	G	1		X							X		4/7/10	1105

ANALYSIS REQUEST

(Circle or Specify Method No.)

MTBE 8021B/602	BTEX 8021 B	TPH 8015M	PAH 8270C	RCRA Metals: Ag As Ba Cd Cr Pb Se Hg	WQCC Metals: Ag As Ba Cd Cr Pb Se Hg Cu Fe Mn Zn	TCLP Volatiles	TCLP Semi Volatiles	TCLP Pesticides	RCI	GC/MS Vol. 8260B/624	GC/MS Semi. Vol. 8270C/625	Moisture Content	Cations (Ca, Mg, K, Na)	Anions (Cl, SO4, CO3, HCO3, ALK)	Total Dissolved Solids (SM2540C)	Chlorides (325.3 / SM4500 B)	SPLP Chloride	Turn Around Time ~ 24 Hours
	X	X														X		
	X	X			X								X	X				
	X	X														X		
	X	X			X								X	X				
	X	X														X		
	X	X			X								X	X				
	X	X														X		
	X	X			X								X	X				
	X	X														X		
	X	X			X								X	X				

Relinquished by:	Date:	Time:	Received by:	Date:	Time:
[signature]	4/9/10	11:30	[signature] CBJ	4/9/10	11:30
Relinquished by:	Date:	Time:	Received By: (Laboratory Staff)	Date:	Time:

Phone Results ☐ Yes ☐ No

Fax Results ☐ Yes ☐ No Additional Fax Number:

REMARKS:

Email Results to:
cdoranhaynes@jhhc.org
gil@trident-environmental.com

Delivered By: (Circle One)
Sampler - UPS - Bus - Other:

Sample Condition: Cool: Yes [X] No [ ] Intact: Yes [X] No [ ]

CHECKED BY: (Initials) [signature]

#26 2.0°C

101 East Marland - Hobbs, New Mexico 88240
Tel (575) 393-2326
Fax (575) 393-2476

Cardinal Laboratories, Inc.

CHAIN-OF-CUSTODY AND ANALYSIS REQUEST

LAB Order ID # _____

Company Name: John H. Hendrix Corporation	BILL TO Company: John H. Hendrix Corporation PO#
Project Manager: Carolyn Haynes	Project Manager: Carolyn Haynes
Address: (Street, City, Zip) PO Box 910, Eunice NM 88231	Address: (Street, City, Zip) PO Box 3040, Midland TX 79702-3040 Fax#:
Phone #: (575) 394-2649 Fax#: (575) 394-2653	Phone #: (432) 684-6631 Email: cdoranhaynes@jhhc.org
Project #: John H. Hendrix Corporation	Project Name: JHHC Surface Waste Management Facility (NM-02-0021)
Project Location: T24S, R36E, Sec 15, W/2 NW/4 & W/2 SW/4, Lea County NM	Sampler Name: Gil Van Deventer

LAB # (LAB USE ONLY)	FIELD CODE	(G)rab or (C)omp	# CONTAINERS	MATRIX: WATER	SOIL	AIR	SLUDGE	PRESERVATIVE METHOD: HCL	HNO_3	$NaHSO_4$	H_2SO_4	ICE	None	SAMPLING: DATE	TIME	MTBE 8021B/602	BTEX 8021 B	TPH 8015M	PAH 8270C	RCRA Metals: Ag As Ba Cd Cr Pb Se Hg	WQCC Metals: Ag As Ba Cd Cr Pb Se Hg Cu Fe Mn Zn	TCLP Volatiles	TCLP Semi Volatiles	TCLP Pesticides	RCI	GC/MS Vol. 8260B/624	GC/MS Semi. Vol. 8270C/625	Moisture Content	Cations (Ca, Mg, K, Na)	Anions (Cl, SO4, CO3, HCO3, ALK)	Total Dissolved Solids (SM2540C)	Chlorides (325.3 / SM4500 B)	SPLP Chloride	Turn Around Time - 24 Hours
4196-21	12B (0' - 1')	G	1		X							X		4/7/10	1240		X	X														X		
-22	12B (2' - 3')	G	1		X							X		4/7/10	1245		X	X			X								X	X				
-23	12C (0' - 1')	G	1		X							X		4/7/10	1330		X	X														X		
-24	12C (2' - 3')	G	1		X							X		4/7/10	1335		X	X			X								X	X				
-25	1A (0' - 1')	G	1		X							X		4/7/10	1630		X	X														X		
-26	1A (2' - 3')	G	1		X							X		4/7/10	1635		X	X			X								X	X				
-27	1B (0' - 1')	G	1		X							X		4/7/10	1500		X	X														X		
-28	1B (2' - 3')	G	1		X							X		4/7/10	1505		X	X			X								X	X				
-29	1B-1 (0' - 1')	G	1		X							X		4/7/10	1530		X	X														X		
-30	1B-1 ~~(2' - 3')~~ (1.5')	G	1		X							X		4/7/10	1535		X	X			X								X	X				
-31	1C (0' - 1')	G	1		X							X		4/7/10	1430		X	X														X		
-32	1C (2' - 3')	G	1		X							X		4/7/10	1435		X	X			X								X	X				

ANALYSIS REQUEST

(Circle or Specify Method No.)

Relinquished by:	Date:	Time:	Received by:	Date:	Time:
	4/9/10	11:30am		4/9/10	11:30
Relinquished by:	Date:	Time:	Received By: (Laboratory Staff)	Date:	Time:

Phone Results ☐ Yes ☐ No

Fax Results ☐ Yes ☐ No Additional Fax Number:

REMARKS:

Email Results to:
cdoranhaynes@jhhc.org
gil@trident-environmental.com

Delivered By: (Circle One)
Sampler - UPS - Bus - Other:

Sample Condition: Cool: Yes [X] No [ ] Intact: Yes [X] No [ ]

CHECKED BY: (Initials)

#26 2.0°C

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

November 30, 2010

CAROLYN DORAN HAYNES

JOHN H. HENDRIX CORPORATION

P. O. BOX 3040

MIDLAND, TX 79702

RE: JHHC SWMF NM-02-0021

Enclosed are the results of analyses for samples received by the laboratory on 11/05/10 12:40.

Cardinal Laboratories is accredited through Texas NELAP for:

Method SW-846 8021	Benzene, Toluene, Ethyl Benzene, and Total Xylenes
Method SW-846 8260	Benzene, Toluene, Ethyl Benzene, and Total Xylenes
Method TX 1005	Total Petroleum Hydorcarbons

Certificate number T104704398-08-TX. Accreditation applies to solid and chemical materials and non-potable water matrices.

Cardinal Laboratories is accreditated through the State of Colorado Department of Public Health and Environment for:

Method EPA 552.2	Haloacetic Acids (HAA-5)
Method EPA 524.2	Total Trihalomethanes (TTHM)
Method EPA 524.4	Regulated VOCs (V2, V3)

Accreditation applies to public drinking water matrices.

This report meets NELAP requirements and is made up of a cover page, analytical results, and a copy of the original chain-of-custody. If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Celey D. Keene

Celey D. Keene
Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 A (1') (H021239-01)

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/09/2010	ND	2.01	101	2.00		
Toluene*	<0.050	0.050	11/09/2010	ND	2.33	117	2.00		
Ethylbenzene*	<0.050	0.050	11/09/2010	ND	1.92	95.8	2.00		
Total Xylenes*	<0.150	0.150	11/09/2010	ND	5.74	95.6	6.00		

Surrogate: 4-Bromofluorobenzene (PIL *110 %* *80-120*

Chloride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**4.00**	4.00	11/17/2010	ND	400	100	400	3.92	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/13/2010	ND	151	75.5	200	1.59	
DRO >C10-C28	<10.0	10.0	11/13/2010	ND	158	79.2	200	18.4	

Surrogate: 1-Chlorooctane *94.2 %* *70-130*

Surrogate: 1-Chlorooctadecane *92.6 %* *70-130*

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 A (3') (H021239-02)

Aluminum 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Aluminum	**8620**	10.0	11/12/2010	ND	4.1	102	4.00	0.734	GAL

Arsenic 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Arsenic	**2.21**	0.25	11/16/2010	ND	0.05	96.8	0.0500	7.75	GAL

Barium 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Barium	**35.7**	0.25	11/16/2010	ND	0.05	103	0.0500	0.778	GAL

Bicarbonate 310.1M — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Bicarbonate	**254**	5.00	11/27/2010	ND	988	98.8	1000	4.41	

BTEX 8021B — mg/kg — Analyzed By: cms

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/09/2010	ND	2.01	101	2.00		
Toluene*	<0.050	0.050	11/09/2010	ND	2.33	117	2.00		
Ethylbenzene*	<0.050	0.050	11/09/2010	ND	1.92	95.8	2.00		
Total Xylenes*	<0.150	0.150	11/09/2010	ND	5.74	95.6	6.00		

Surrogate: 4-Bromofluorobenzene (PIL *124 %* *80-120*

Cadmium 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Cadmium	**0.04**	0.02	11/16/2010	ND	0.05	107	0.0500	2.28	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 A (3') (H021239-02)

Calcium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Calcium	**895**	50.0	11/12/2010	ND	4.0	100	4.00	0.249	GAL

Carbonate 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Carbonate	<0.00	0.00	11/27/2010	ND					

Chloride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**24.0**	4.00	11/20/2010	ND	400	100	400	3.92	

Chromium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chromium	**5.51**	0.500	11/16/2010	ND	0.055	110	0.0500	1.27	GAL

Copper, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Copper	**2.11**	2.00	11/12/2010	ND	4.21	105	4.00	0.476	GAL

Iron 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Iron	**8320**	5.0	11/12/2010	ND	4.0	99.2	4.00	0.503	GAL

Lead 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Lead	**4.76**	0.05	11/16/2010	ND	0.05	102	0.0500	1.38	GAL

Magnesium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 A (3') (H021239-02)

Magnesium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Magnesium	**1220**	50.0	11/17/2010	ND	3.9	97.5	4.00	0.00	GAL

Manganese 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Manganese	**51.7**	0.5	11/17/2010	ND	2.0	100	2.00	0.499	GAL

Mercury, 7471A — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Mercury	**0.007**	0.020	11/17/2010	ND	0.002	100	0.00200	0.00	GAL, J

Potassium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Potassium	**1620**	50.0	11/12/2010	ND	10.5	105	10.0	2.90	GAL

Selenium 200.8 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Selenium	**0.331**	0.100	11/15/2010	ND	0.243	97.2	0.250	3.64	GAL

Silver 200.8 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Silver	**0.052**	0.025	11/16/2010	ND	0.054	109	0.0500	4.69	GAL

Sodium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sodium	**460**	50.0	11/12/2010	ND	16.7	103	16.2	0.601	GAL

Sulfate 375.4 — **mg/kg** — **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 A (3') (H021239-02)

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sulfate	**1160**	500	11/29/2010	ND	46.1	115	40.0	2.19	

Total Alkalinity 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Total	**208**	4.00	11/27/2010	ND	810	81.0	1000	4.88	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/13/2010	ND	151	75.5	200	1.59	
DRO >C10-C28	<10.0	10.0	11/13/2010	ND	158	79.2	200	18.4	
Surrogate: 1-Chlorooctane	*107 %*	*70-130*							
Surrogate: 1-Chlorooctadecane	*112 %*	*70-130*							

Zinc 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Zinc	**18.0**	5.0	11/12/2010	ND	2.0	97.5	2.00	0.512	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 B (1') (H021239-03)

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/09/2010	ND	2.01	101	2.00		
Toluene*	<0.050	0.050	11/09/2010	ND	2.33	117	2.00		
Ethylbenzene*	<0.050	0.050	11/09/2010	ND	1.92	95.8	2.00		
Total Xylenes*	<0.150	0.150	11/09/2010	ND	5.74	95.6	6.00		

Surrogate: 4-Bromofluorobenzene (PIL *99.3 %* *80-120*

oride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**8.00**	4.00	11/17/2010	ND	400	100	400	3.92	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/13/2010	ND	151	75.5	200	1.59	
DRO >C10-C28	<10.0	10.0	11/13/2010	ND	158	79.2	200	18.4	

Surrogate: 1-Chlorooctane *88.6 %* *70-130*

Surrogate: 1-Chlorooctadecane *95.1 %* *70-130*

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 B (3') (H021239-04)

Aluminum 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Aluminum	**11500**	10.0	11/12/2010	ND	4.1	102	4.00	0.734	GAL

Arsenic 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Arsenic	**3.03**	0.25	11/16/2010	ND	0.05	96.8	0.0500	7.75	GAL

Barium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Barium	**42.3**	0.25	11/16/2010	ND	0.05	103	0.0500	0.778	GAL

Bicarbonate 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Bicarbonate	**24.4**	5.00	11/27/2010	ND	988	98.8	1000	4.41	

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/09/2010	ND	2.01	101	2.00		
Toluene*	<0.050	0.050	11/09/2010	ND	2.33	117	2.00		
Ethylbenzene*	<0.050	0.050	11/09/2010	ND	1.92	95.8	2.00		
Total Xylenes*	<0.150	0.150	11/09/2010	ND	5.74	95.6	6.00		

Surrogate: 4-Bromofluorobenzene (PIL *98.2 %* *80-120*

Cadmium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Cadmium	**0.04**	0.02	11/16/2010	ND	0.05	107	0.0500	2.28	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 B (3') (H021239-04)

Calcium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Calcium	**1920**	50.0	11/12/2010	ND	4.0	100	4.00	0.249	GAL

Carbonate 310.1M — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Carbonate	<0.00	0.00	11/27/2010	ND					

Chloride, SM4500Cl-B — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	<4.00	4.00	11/20/2010	ND	400	100	400	3.92	

Chromium 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chromium	**6.01**	0.500	11/16/2010	ND	0.055	110	0.0500	1.27	GAL

Copper, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Copper	**2.47**	2.00	11/12/2010	ND	4.21	105	4.00	0.476	GAL

Iron 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Iron	**10500**	5.0	11/12/2010	ND	4.0	99.2	4.00	0.503	GAL

Lead 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Lead	**5.79**	0.05	11/16/2010	ND	0.05	102	0.0500	1.38	GAL

Magnesium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 B (3') (H021239-04)

Magnesium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Magnesium	**1870**	50.0	11/17/2010	ND	3.9	97.5	4.00	0.00	GAL

Manganese 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Manganese	**55.3**	0.5	11/17/2010	ND	2.0	100	2.00	0.499	GAL

Mercury, 7471A mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Mercury	**0.008**	0.020	11/17/2010	ND	0.002	100	0.00200	0.00	GAL, J

Potassium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Potassium	**2060**	50.0	11/12/2010	ND	10.5	105	10.0	2.90	GAL

Selenium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Selenium	**0.385**	0.100	11/15/2010	ND	0.243	97.2	0.250	3.64	GAL

Silver 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Silver	**0.043**	0.025	11/16/2010	ND	0.054	109	0.0500	4.69	GAL

Sodium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sodium	<50.0	50.0	11/12/2010	ND	16.7	103	16.2	0.601	GAL

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 B (3') (H021239-04)

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sulfate	**38.8**	10.0	11/29/2010	ND	46.1	115	40.0	2.19	

Total Alkalinity 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Total	**20.0**	4.00	11/27/2010	ND	810	81.0	1000	4.88	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/13/2010	ND	151	75.5	200	1.59	
DRO >C10-C28	<10.0	10.0	11/13/2010	ND	158	79.2	200	18.4	
Surrogate: 1-Chlorooctane	*104 %*	*70-130*							
Surrogate: 1-Chlorooctadecane	*108 %*	*70-130*							

Zinc 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Zinc	**21.9**	5.0	11/12/2010	ND	2.0	97.5	2.00	0.512	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 B -1 (1') (H021239-05)

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/13/2010	ND	1.84	92.0	2.00	1.50	
Toluene*	<0.050	0.050	11/13/2010	ND	1.80	90.1	2.00	3.59	
Ethylbenzene*	<0.050	0.050	11/13/2010	0.054	1.67	83.6	2.00	5.57	
Total Xylenes*	<0.150	0.150	11/13/2010	ND	5.14	85.7	6.00	6.20	

Surrogate: 4-Bromofluorobenzene (PIL *88.3 %* *80-120*

Chloride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**100**	4.00	11/17/2010	ND	400	100	400	3.92	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/13/2010	ND	151	75.5	200	1.59	
DRO >C10-C28	<10.0	10.0	11/13/2010	ND	158	79.2	200	18.4	

Surrogate: 1-Chlorooctane *105 %* *70-130*

Surrogate: 1-Chlorooctadecane *104 %* *70-130*

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 B - 1 (3') (H021239-06)

Aluminum 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Aluminum	**10100**	10.0	11/12/2010	ND	4.1	102	4.00	0.734	GAL

Arsenic 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Arsenic	**2.39**	0.25	11/16/2010	ND	0.05	96.8	0.0500	7.75	GAL

Barium 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Barium	**44.6**	0.25	11/16/2010	ND	0.05	103	0.0500	0.778	GAL

Bicarbonate 310.1M mg/kg Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Bicarbonate	**127**	5.00	11/27/2010	ND	988	98.8	1000	4.41	

BTEX 8021B mg/kg Analyzed By: cms

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/13/2010	ND	1.84	92.0	2.00	1.50	
Toluene*	<0.050	0.050	11/13/2010	ND	1.80	90.1	2.00	3.59	
Ethylbenzene*	<0.050	0.050	11/13/2010	0.054	1.67	83.6	2.00	5.57	
Total Xylenes*	<0.150	0.150	11/13/2010	ND	5.14	85.7	6.00	6.20	

Surrogate: 4-Bromofluorobenzene (PIL *92.5 %* *80-120*

Cadmium 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Cadmium	**0.04**	0.02	11/16/2010	ND	0.05	107	0.0500	2.28	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 B - 1 (3') (H021239-06)

Calcium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Calcium	**3190**	50.0	11/12/2010	ND	4.0	100	4.00	0.249	GAL

Carbonate 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Carbonate	<0.00	0.00	11/27/2010	ND					

Chloride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**100**	4.00	11/20/2010	ND	400	100	400	3.92	

Chromium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chromium	**5.85**	0.500	11/16/2010	ND	0.055	110	0.0500	1.27	GAL

Copper, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Copper	<2.00	2.00	11/12/2010	ND	4.21	105	4.00	0.476	GAL

Iron 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Iron	**8850**	5.0	11/12/2010	ND	4.0	99.2	4.00	0.503	GAL

Lead 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Lead	**5.13**	0.05	11/16/2010	ND	0.05	102	0.0500	1.38	GAL

Magnesium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 B - 1 (3') (H021239-06)

Magnesium, 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Magnesium	**1540**	50.0	11/17/2010	ND	3.9	97.5	4.00	0.00	GAL

Manganese 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Manganese	**56.2**	0.5	11/17/2010	ND	2.0	100	2.00	0.499	GAL

Mercury, 7471A mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Mercury	**0.005**	0.020	11/17/2010	ND	0.002	100	0.00200	0.00	GAL, J

Potassium, 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Potassium	**1780**	50.0	11/12/2010	ND	10.5	105	10.0	2.90	GAL

Selenium 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Selenium	**0.384**	0.100	11/15/2010	ND	0.243	97.2	0.250	3.64	GAL

Silver 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Silver	**0.051**	0.025	11/16/2010	ND	0.054	109	0.0500	4.69	GAL

Sodium, 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sodium	<50.0	50.0	11/12/2010	ND	16.7	103	16.2	0.601	GAL

Sulfate 375.4 mg/kg Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 B - 1 (3') (H021239-06)

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sulfate	**72.6**	10.0	11/29/2010	ND	46.1	115	40.0	2.19	

Total Alkalinity 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Total	**104**	4.00	11/27/2010	ND	810	81.0	1000	4.88	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/13/2010	ND	151	75.5	200	1.59	
DRO >C10-C28	<10.0	10.0	11/13/2010	ND	158	79.2	200	18.4	
Surrogate: 1-Chlorooctane	*105 %*	*70-130*							
Surrogate: 1-Chlorooctadecane	*109 %*	*70-130*							

Zinc 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Zinc	**20.1**	5.0	11/12/2010	ND	2.0	97.5	2.00	0.512	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 C (1') (H021239-07)

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/13/2010	ND	1.84	92.0	2.00	1.50	
Toluene*	<0.050	0.050	11/13/2010	ND	1.80	90.1	2.00	3.59	
Ethylbenzene*	<0.050	0.050	11/13/2010	0.054	1.67	83.6	2.00	5.57	
Total Xylenes*	<0.150	0.150	11/13/2010	ND	5.14	85.7	6.00	6.20	

Surrogate: 4-Bromofluorobenzene (PIL *96.5 %* *80-120*

oride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	<4.00	4.00	11/17/2010	ND	400	100	400	3.92	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	151	75.5	200	1.59	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	158	79.2	200	18.4	

Surrogate: 1-Chlorooctane *102 %* *70-130*

Surrogate: 1-Chlorooctadecane *106 %* *70-130*

Cardinal Laboratories *=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 C (3') (H021239-08)

Aluminum 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Aluminum	**5560**	10.0	11/12/2010	ND	4.1	102	4.00	0.734	GAL

Arsenic 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Arsenic	**1.75**	0.25	11/16/2010	ND	0.05	96.8	0.0500	7.75	GAL

Barium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Barium	**29.5**	0.25	11/16/2010	ND	0.05	103	0.0500	0.778	GAL

Bicarbonate 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Bicarbonate	**58.6**	5.00	11/27/2010	ND	988	98.8	1000	4.41	

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/13/2010	ND	1.84	92.0	2.00	1.50	
Toluene*	<0.050	0.050	11/13/2010	ND	1.80	90.1	2.00	3.59	
Ethylbenzene*	<0.050	0.050	11/13/2010	0.054	1.67	83.6	2.00	5.57	
Total Xylenes*	<0.150	0.150	11/13/2010	ND	5.14	85.7	6.00	6.20	

Surrogate: 4-Bromofluorobenzene (PIL *92.3 %* *80-120*

Cadmium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Cadmium	**0.08**	0.02	11/16/2010	ND	0.05	107	0.0500	2.28	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 C (3') (H021239-08)

Calcium, 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Calcium	**761**	50.0	11/12/2010	ND	4.0	100	4.00	0.249	GAL

Carbonate 310.1M mg/kg Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Carbonate	<0.00	0.00	11/27/2010	ND					

Chloride, SM4500Cl-B mg/kg Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	<4.00	4.00	11/20/2010	ND	400	100	400	3.92	

Chromium 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chromium	**3.61**	0.500	11/16/2010	ND	0.055	110	0.0500	1.27	GAL

Copper, 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Copper	<2.00	2.00	11/12/2010	ND	4.21	105	4.00	0.476	GAL

Iron 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Iron	**5870**	5.0	11/12/2010	ND	4.0	99.2	4.00	0.503	GAL

Lead 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Lead	**3.95**	0.05	11/16/2010	ND	0.05	102	0.0500	1.38	GAL

Magnesium, 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 C (3') (H021239-08)

Magnesium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Magnesium	**745**	50.0	11/17/2010	ND	3.9	97.5	4.00	0.00	GAL

Manganese 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Manganese	**53.2**	0.5	11/17/2010	ND	2.0	100	2.00	0.499	GAL

Mercury, 7471A — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Mercury	**0.006**	0.020	11/17/2010	ND	0.002	100	0.00200	0.00	GAL, J

Potassium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Potassium	**1210**	50.0	11/12/2010	ND	10.5	105	10.0	2.90	GAL

Selenium 200.8 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Selenium	**0.250**	0.100	11/15/2010	ND	0.243	97.2	0.250	3.64	GAL

Silver 200.8 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Silver	**0.047**	0.025	11/16/2010	ND	0.054	109	0.0500	4.69	GAL

Sodium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sodium	<50.0	50.0	11/12/2010	ND	16.7	103	16.2	0.601	GAL

Sulfate 375.4 — **mg/kg** — **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 1 C (3') (H021239-08)

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sulfate	**51.3**	25.0	11/29/2010	ND	46.1	115	40.0	2.19	

Total Alkalinity 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Total	**48.0**	4.00	11/27/2010	ND	810	81.0	1000	4.88	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	151	75.5	200	1.59	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	158	79.2	200	18.4	
Surrogate: 1-Chlorooctane	*96.5 %*	*70-130*							
Surrogate: 1-Chlorooctadecane	*98.9 %*	*70-130*							

Zinc 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Zinc	**11.9**	5.0	11/12/2010	ND	2.0	97.5	2.00	0.512	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 B (1') (H021239-09)

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/13/2010	ND	1.84	92.0	2.00	1.50	
Toluene*	<0.050	0.050	11/13/2010	ND	1.80	90.1	2.00	3.59	
Ethylbenzene*	<0.050	0.050	11/13/2010	0.054	1.67	83.6	2.00	5.57	
Total Xylenes*	<0.150	0.150	11/13/2010	ND	5.14	85.7	6.00	6.20	

Surrogate: 4-Bromofluorobenzene (PIL *98.5 %* *80-120*

Chloride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**48.0**	4.00	11/17/2010	ND	400	100	400	3.92	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	151	75.5	200	1.59	
DRO >C10-C28	**2090**	10.0	11/14/2010	ND	158	79.2	200	18.4	

Surrogate: 1-Chlorooctane *108 %* *70-130*

Surrogate: 1-Chlorooctadecane *114 %* *70-130*

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 B (3') (H021239-10)

Aluminum 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Aluminum	**6660**	10.0	11/12/2010	ND	4.1	102	4.00	0.734	GAL

Arsenic 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Arsenic	**1.80**	0.25	11/16/2010	ND	0.05	96.8	0.0500	7.75	GAL

Barium 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Barium	**28.3**	0.25	11/16/2010	ND	0.05	103	0.0500	0.778	GAL

Bicarbonate 310.1M mg/kg Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Bicarbonate	**137**	5.00	11/27/2010	ND	988	98.8	1000	4.41	

BTEX 8021B mg/kg Analyzed By: cms

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/13/2010	ND	1.84	92.0	2.00	1.50	
Toluene*	<0.050	0.050	11/13/2010	ND	1.80	90.1	2.00	3.59	
Ethylbenzene*	<0.050	0.050	11/13/2010	0.054	1.67	83.6	2.00	5.57	
Total Xylenes*	<0.150	0.150	11/13/2010	ND	5.14	85.7	6.00	6.20	

Surrogate: 4-Bromofluorobenzene (PIL *91.8 %* *80-120*

Cadmium 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Cadmium	**0.08**	0.02	11/16/2010	ND	0.05	107	0.0500	2.28	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 B (3') (H021239-10)

Calcium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Calcium	**1860**	50.0	11/12/2010	ND	4.0	100	4.00	0.249	GAL

Carbonate 310.1M — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Carbonate	<0.00	0.00	11/27/2010	ND					

Chloride, SM4500Cl-B — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	<4.00	4.00	11/20/2010	ND	416	104	400	0.00	

Chromium 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chromium	**4.61**	0.500	11/16/2010	ND	0.055	110	0.0500	1.27	GAL

Copper, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Copper	<2.00	2.00	11/12/2010	ND	4.21	105	4.00	0.476	GAL

Iron 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Iron	**6390**	5.0	11/12/2010	ND	4.0	99.2	4.00	0.503	GAL

Lead 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Lead	**3.77**	0.05	11/16/2010	ND	0.05	102	0.0500	1.38	GAL

Magnesium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 B (3') (H021239-10)

Magnesium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Magnesium	**1010**	50.0	11/17/2010	ND	3.9	97.5	4.00	0.00	GAL

Manganese 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Manganese	**63.1**	0.5	11/17/2010	ND	2.0	100	2.00	0.499	GAL

Mercury, 7471A — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Mercury	**0.009**	0.020	11/17/2010	ND	0.002	100	0.00200	0.00	GAL, J

Potassium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Potassium	**1210**	50.0	11/12/2010	ND	10.5	105	10.0	2.90	GAL

Selenium 200.8 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Selenium	**0.345**	0.100	11/15/2010	ND	0.243	97.2	0.250	3.64	GAL

Silver 200.8 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Silver	**0.034**	0.025	11/16/2010	ND	0.054	109	0.0500	4.69	GAL

Sodium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sodium	<50.0	50.0	11/12/2010	ND	16.7	103	16.2	0.601	GAL

Sulfate 375.4 — **mg/kg** — **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 B (3') (H021239-10)

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sulfate	<10.0	10.0	11/29/2010	ND	46.1	115	40.0	2.19	

Total Alkalinity 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Total	**112**	4.00	11/27/2010	ND	810	81.0	1000	4.88	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	152	75.8	200	9.73	
Surrogate: 1-Chlorooctane	*114 %*	*70-130*							
Surrogate: 1-Chlorooctadecane	*116 %*	*70-130*							

Zinc 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Zinc	**15.6**	5.0	11/12/2010	ND	2.0	97.5	2.00	0.512	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 B - 1 (1') (H021239-11)

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/13/2010	ND	1.84	92.0	2.00	1.50	
Toluene*	<0.050	0.050	11/13/2010	ND	1.80	90.1	2.00	3.59	
Ethylbenzene*	<0.050	0.050	11/13/2010	0.054	1.67	83.6	2.00	5.57	
Total Xylenes*	<0.150	0.150	11/13/2010	ND	5.14	85.7	6.00	6.20	

Surrogate: 4-Bromofluorobenzene (PIL *95.8 %* *80-120*

oride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**84.0**	4.00	11/17/2010	ND	400	100	400	3.92	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	**143**	10.0	11/14/2010	ND	152	75.8	200	9.73	

Surrogate: 1-Chlorooctane *97.9 %* *70-130*

Surrogate: 1-Chlorooctadecane *98.6 %* *70-130*

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 B - 1 (3') (H021239-12)

Aluminum 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Aluminum	**5460**	10.0	11/12/2010	ND	4.1	102	4.00	0.734	GAL

Arsenic 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Arsenic	**1.69**	0.25	11/16/2010	ND	0.05	96.8	0.0500	7.75	GAL

Barium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Barium	**36.9**	0.25	11/16/2010	ND	0.05	103	0.0500	0.778	GAL

Bicarbonate 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Bicarbonate	**107**	5.00	11/27/2010	ND	988	98.8	1000	4.41	

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/13/2010	ND	1.84	92.0	2.00	1.50	
Toluene*	<0.050	0.050	11/13/2010	ND	1.80	90.1	2.00	3.59	
Ethylbenzene*	<0.050	0.050	11/13/2010	0.054	1.67	83.6	2.00	5.57	
Total Xylenes*	<0.150	0.150	11/13/2010	ND	5.14	85.7	6.00	6.20	

Surrogate: 4-Bromofluorobenzene (PIL *113 %* *80-120*

Cadmium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Cadmium	**0.05**	0.02	11/16/2010	ND	0.05	107	0.0500	2.28	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 B - 1 (3') (H021239-12)

Calcium, 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Calcium	**4600**	50.0	11/12/2010	ND	4.0	100	4.00	0.249	GAL

Carbonate 310.1M mg/kg Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Carbonate	<0.00	0.00	11/27/2010	ND					

Chloride, SM4500Cl-B mg/kg Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	<4.00	4.00	11/20/2010	ND	416	104	400	0.00	

Chromium 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chromium	**4.84**	0.500	11/16/2010	ND	0.055	110	0.0500	1.27	GAL

Copper, 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Copper	**2.19**	2.00	11/12/2010	ND	4.21	105	4.00	0.476	GAL

Iron 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Iron	**5630**	5.0	11/12/2010	ND	4.0	99.2	4.00	0.503	GAL

Lead 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Lead	**3.97**	0.05	11/16/2010	ND	0.05	102	0.0500	1.38	GAL

Magnesium, 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 B - 1 (3') (H021239-12)

Magnesium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Magnesium	**875**	50.0	11/17/2010	ND	3.9	97.5	4.00	0.00	GAL

Manganese 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Manganese	**54.9**	0.5	11/17/2010	ND	2.0	100	2.00	0.499	GAL

Mercury, 7471A mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Mercury	**0.007**	0.020	11/17/2010	ND	0.002	100	0.00200	0.00	GAL, J

Potassium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Potassium	**1100**	50.0	11/12/2010	ND	10.5	105	10.0	2.90	GAL

Selenium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Selenium	**0.280**	0.100	11/15/2010	ND	0.243	97.2	0.250	3.64	GAL

Silver 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Silver	**0.049**	0.025	11/16/2010	ND	0.054	109	0.0500	4.69	GAL

Sodium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sodium	<50.0	50.0	11/12/2010	ND	16.7	103	16.2	0.601	GAL

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 B - 1 (3') (H021239-12)

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sulfate	<10.0	10.0	11/29/2010	ND	46.1	115	40.0	2.19	

Total Alkalinity 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Total	**88.0**	4.00	11/27/2010	ND	810	81.0	1000	4.88	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	152	75.8	200	9.73	
Surrogate: 1-Chlorooctane	*106 %*	*70-130*							
Surrogate: 1-Chlorooctadecane	*107 %*	*70-130*							

Zinc 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Zinc	**13.8**	5.0	11/12/2010	ND	2.0	97.5	2.00	0.512	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 C (1') (H021239-13)

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/13/2010	ND	1.84	92.0	2.00	1.50	
Toluene*	<0.050	0.050	11/13/2010	ND	1.80	90.1	2.00	3.59	
Ethylbenzene*	<0.050	0.050	11/13/2010	0.054	1.67	83.6	2.00	5.57	
Total Xylenes*	<0.150	0.150	11/13/2010	ND	5.14	85.7	6.00	6.20	

Surrogate: 4-Bromofluorobenzene (PIL *96.5 %* *80-120*

Chloride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	<4.00	4.00	11/17/2010	ND	400	100	400	3.92	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	152	75.8	200	9.73	

Surrogate: 1-Chlorooctane *114 %* *70-130*

Surrogate: 1-Chlorooctadecane *114 %* *70-130*

Cardinal Laboratories *=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 C (3') (H021239-14)

Aluminum 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Aluminum	**7290**	10.0	11/12/2010	ND	4.1	102	4.00	0.734	GAL

Arsenic 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Arsenic	**2.01**	0.25	11/16/2010	ND	0.05	96.8	0.0500	7.75	GAL

Barium 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Barium	**35.2**	0.25	11/16/2010	ND	0.05	103	0.0500	0.778	GAL

Bicarbonate 310.1M mg/kg Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Bicarbonate	**39.0**	5.00	11/27/2010	ND	988	98.8	1000	4.41	

BTEX 8021B mg/kg Analyzed By: cms

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/13/2010	ND	1.84	92.0	2.00	1.50	
Toluene*	<0.050	0.050	11/13/2010	ND	1.80	90.1	2.00	3.59	
Ethylbenzene*	<0.050	0.050	11/13/2010	0.054	1.67	83.6	2.00	5.57	
Total Xylenes*	<0.150	0.150	11/13/2010	ND	5.14	85.7	6.00	6.20	

Surrogate: 4-Bromofluorobenzene (PIL *93.5 %* *80-120*

Cadmium 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Cadmium	**0.04**	0.02	11/16/2010	ND	0.05	107	0.0500	2.28	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 C (3') (H021239-14)

Calcium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Calcium	**987**	50.0	11/12/2010	ND	4.0	100	4.00	0.249	GAL

Carbonate 310.1M — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Carbonate	<0.00	0.00	11/27/2010	ND					

Chloride, SM4500Cl-B — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	<4.00	4.00	11/20/2010	ND	416	104	400	0.00	

Chromium 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chromium	**5.69**	0.500	11/16/2010	ND	0.055	110	0.0500	1.27	GAL

Copper, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Copper	**2.01**	2.00	11/12/2010	ND	4.21	105	4.00	0.476	GAL

Iron 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Iron	**7100**	5.0	11/12/2010	ND	4.0	99.2	4.00	0.503	GAL

Lead 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Lead	**4.64**	0.05	11/16/2010	ND	0.05	102	0.0500	1.38	GAL

Magnesium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 C (3') (H021239-14)

Magnesium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Magnesium	**1030**	50.0	11/17/2010	ND	3.9	97.5	4.00	0.00	GAL

Manganese 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Manganese	**60.8**	0.5	11/17/2010	ND	2.0	100	2.00	0.499	GAL

Mercury, 7471A — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Mercury	**0.007**	0.020	11/17/2010	ND	0.002	100	0.00200	0.00	GAL, J

Potassium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Potassium	**1360**	50.0	11/12/2010	ND	10.5	105	10.0	2.90	GAL

Selenium 200.8 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Selenium	**0.290**	0.100	11/15/2010	ND	0.243	97.2	0.250	3.64	GAL

Silver 200.8 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Silver	**0.036**	0.025	11/16/2010	ND	0.054	109	0.0500	4.69	GAL

Sodium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sodium	<50.0	50.0	11/12/2010	ND	16.7	103	16.2	0.601	GAL

Sulfate 375.4 — **mg/kg** — **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 C (3') (H021239-14)

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sulfate	**25.7**	10.0	11/29/2010	ND	46.1	115	40.0	2.19	

Total Alkalinity 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Total	**32.0**	4.00	11/27/2010	ND	810	81.0	1000	4.88	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	152	75.8	200	9.73	
Surrogate: 1-Chlorooctane	*115 %*	*70-130*							
Surrogate: 1-Chlorooctadecane	*119 %*	*70-130*							

Zinc 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Zinc	**15.8**	5.0	11/12/2010	ND	2.0	97.5	2.00	0.512	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 C - 1 (1') (H021239-15)

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/13/2010	ND	1.84	92.0	2.00	1.50	
Toluene*	<0.050	0.050	11/13/2010	ND	1.80	90.1	2.00	3.59	
Ethylbenzene*	<0.050	0.050	11/13/2010	ND	1.67	83.6	2.00	5.57	
Total Xylenes*	<0.150	0.150	11/13/2010	ND	5.14	85.7	6.00	6.20	

Surrogate: 4-Bromofluorobenzene (PIL *101 %* *80-120*

ride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**4.00**	4.00	11/17/2010	ND	400	100	400	3.92	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	152	75.8	200	9.73	

Surrogate: 1-Chlorooctane *114 %* *70-130*

Surrogate: 1-Chlorooctadecane *115 %* *70-130*

Cardinal Laboratories *=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 C - 1 (3') (H021239-16)

Aluminum 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Aluminum	**3880**	10.0	11/12/2010	ND	4.1	102	4.00	0.734	GAL

Arsenic 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Arsenic	**1.47**	0.25	11/16/2010	ND	0.05	96.8	0.0500	7.75	GAL

Barium 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Barium	**20.5**	0.25	11/16/2010	ND	0.05	103	0.0500	0.778	GAL

Bicarbonate 310.1M mg/kg Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Bicarbonate	**78.1**	5.00	11/27/2010	ND	988	98.8	1000	4.41	

BTEX 8021B mg/kg Analyzed By: cms

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/13/2010	ND	1.84	92.0	2.00	1.50	
Toluene*	<0.050	0.050	11/13/2010	ND	1.80	90.1	2.00	3.59	
Ethylbenzene*	<0.050	0.050	11/13/2010	0.054	1.67	83.6	2.00	5.57	
Total Xylenes*	<0.150	0.150	11/13/2010	ND	5.14	85.7	6.00	6.20	

Surrogate: 4-Bromofluorobenzene (PIL *98.0 %* *80-120*

Cadmium 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Cadmium	**0.03**	0.02	11/16/2010	ND	0.05	107	0.0500	2.28	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 C - 1 (3') (H021239-16)

Calcium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Calcium	**574**	50.0	11/12/2010	ND	4.0	100	4.00	0.249	GAL

Carbonate 310.1M — **mg/kg** — **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Carbonate	<0.00	0.00	11/27/2010	ND					

Chloride, SM4500Cl-B — **mg/kg** — **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	<4.00	4.00	11/20/2010	ND	416	104	400	0.00	

Chromium 200.8 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chromium	**3.16**	0.500	11/16/2010	ND	0.055	110	0.0500	1.27	GAL

Copper, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Copper	<2.00	2.00	11/12/2010	ND	4.21	105	4.00	0.476	GAL

Iron 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Iron	**4270**	5.0	11/12/2010	ND	4.0	99.2	4.00	0.503	GAL

Lead 200.8 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Lead	**3.59**	0.05	11/16/2010	ND	0.05	102	0.0500	1.38	GAL

Magnesium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 C - 1 (3') (H021239-16)

Magnesium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Magnesium	**597**	50.0	11/17/2010	ND	3.9	97.5	4.00	0.00	GAL

Manganese 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Manganese	**35.6**	0.5	11/17/2010	ND	2.0	100	2.00	0.499	GAL

Mercury, 7471A mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Mercury	**0.005**	0.020	11/17/2010	ND	0.002	100	0.00200	0.00	GAL, J

Potassium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Potassium	**868**	50.0	11/12/2010	ND	10.5	105	10.0	2.90	GAL

Selenium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Selenium	**0.237**	0.100	11/15/2010	ND	0.243	97.2	0.250	3.64	GAL

Silver 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Silver	**0.039**	0.025	11/16/2010	ND	0.054	109	0.0500	4.69	GAL

Sodium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sodium	<50.0	50.0	11/12/2010	ND	16.7	103	16.2	0.601	GAL

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 10 C - 1 (3') (H021239-16)

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sulfate	<25.0	25.0	11/29/2010	ND	46.1	115	40.0	2.19	

Total Alkalinity 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Total	**64.0**	4.00	11/27/2010	ND	810	81.0	1000	4.88	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	152	75.8	200	9.73	
Surrogate: 1-Chlorooctane	*111 %*	*70-130*							
Surrogate: 1-Chlorooctadecane	*115 %*	*70-130*							

Zinc 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Zinc	**9.3**	5.0	11/12/2010	ND	2.0	97.5	2.00	0.512	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 A (1') (H021239-17)

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/13/2010	ND	1.84	92.0	2.00	1.50	
Toluene*	<0.050	0.050	11/13/2010	ND	1.80	90.1	2.00	3.59	
Ethylbenzene*	<0.050	0.050	11/13/2010	0.054	1.67	83.6	2.00	5.57	
Total Xylenes*	<0.150	0.150	11/13/2010	ND	5.14	85.7	6.00	6.20	

Surrogate: 4-Bromofluorobenzene (PIL *93.0 %* *80-120*

Chloride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**8.00**	4.00	11/17/2010	ND	400	100	400	3.92	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	152	75.8	200	9.73	

Surrogate: 1-Chlorooctane *120 %* *70-130*

Surrogate: 1-Chlorooctadecane *129 %* *70-130*

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 A (3') (H021239-18)

Aluminum 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Aluminum	**9830**	10.0	11/12/2010	ND	4.1	102	4.00	0.734	GAL

Arsenic 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Arsenic	**2.47**	0.25	11/16/2010	ND	0.05	96.8	0.0500	7.75	GAL

Barium 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Barium	**39.5**	0.25	11/16/2010	ND	0.05	103	0.0500	0.778	GAL

Bicarbonate 310.1M mg/kg Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Bicarbonate	**14.6**	5.00	11/27/2010	ND	988	98.8	1000	4.41	

BTEX 8021B mg/kg Analyzed By: cms

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/13/2010	ND	1.84	92.0	2.00	1.50	
Toluene*	<0.050	0.050	11/13/2010	ND	1.80	90.1	2.00	3.59	
Ethylbenzene*	<0.050	0.050	11/13/2010	0.054	1.67	83.6	2.00	5.57	
Total Xylenes*	<0.150	0.150	11/13/2010	ND	5.14	85.7	6.00	6.20	

Surrogate: 4-Bromofluorobenzene (PIL *94.8 %* *80-120*

Cadmium 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Cadmium	**0.04**	0.02	11/16/2010	ND	0.05	107	0.0500	2.28	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 A (3') (H021239-18)

Calcium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Calcium	**1420**	50.0	11/12/2010	ND	4.0	100	4.00	0.249	GAL

Carbonate 310.1M — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Carbonate	<0.00	0.00	11/27/2010	ND					

Chloride, SM4500Cl-B — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**16.0**	4.00	11/20/2010	ND	416	104	400	0.00	

Chromium 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chromium	**6.00**	0.500	11/16/2010	ND	0.055	110	0.0500	1.27	GAL

Copper, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Copper	**2.00**	2.00	11/12/2010	ND	4.21	105	4.00	0.476	GAL

Iron 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Iron	**8790**	5.0	11/12/2010	ND	4.0	99.2	4.00	0.503	GAL

Lead 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Lead	**4.91**	0.05	11/16/2010	ND	0.05	102	0.0500	1.38	GAL

Magnesium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 A (3') (H021239-18)

Magnesium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Magnesium	**1290**	50.0	11/17/2010	ND	3.9	97.5	4.00	0.00	GAL

Manganese 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Manganese	**56.3**	0.5	11/17/2010	ND	2.0	100	2.00	0.499	GAL

Mercury, 7471A — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Mercury	**0.008**	0.020	11/17/2010	ND	0.002	100	0.00200	0.00	GAL, J

Potassium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Potassium	**1760**	50.0	11/12/2010	ND	10.5	105	10.0	2.90	GAL

Selenium 200.8 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Selenium	**0.339**	0.100	11/15/2010	ND	0.243	97.2	0.250	3.64	GAL

Silver 200.8 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Silver	**0.044**	0.025	11/16/2010	ND	0.054	109	0.0500	4.69	GAL

Sodium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sodium	**102**	50.0	11/12/2010	ND	16.7	103	16.2	0.601	GAL

Sulfate 375.4 — **mg/kg** — **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 A (3') (H021239-18)

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sulfate	**177**	25.0	11/29/2010	ND	46.1	115	40.0	2.19	

Total Alkalinity 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Total	**12.0**	4.00	11/27/2010	ND	810	81.0	1000	4.88	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	152	75.8	200	9.73	
Surrogate: 1-Chlorooctane	*108 %*	*70-130*							
Surrogate: 1-Chlorooctadecane	*113 %*	*70-130*							

Zinc 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Zinc	**20.0**	5.0	11/12/2010	ND	2.0	97.5	2.00	0.512	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 B (1') (H021239-19)

BTEX 8021B mg/kg Analyzed By: cms

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/14/2010	ND	2.00	100	2.00	4.66	
Toluene*	**0.094**	0.050	11/14/2010	ND	1.89	94.7	2.00	4.58	
Ethylbenzene*	<0.050	0.050	11/14/2010	ND	1.73	86.7	2.00	3.75	
Total Xylenes*	<0.150	0.150	11/14/2010	ND	5.26	87.7	6.00	3.53	

Surrogate: 4-Bromofluorobenzene (PIL *93.1 %* *80-120*

oride, SM4500Cl-B mg/kg Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	<4.00	4.00	11/17/2010	ND	400	100	400	3.92	

TPH 8015M mg/kg Analyzed By: AB

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	152	75.8	200	9.73	

Surrogate: 1-Chlorooctane *109 %* *70-130*

Surrogate: 1-Chlorooctadecane *113 %* *70-130*

Cardinal Laboratories *=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 B (3') (H021239-20)

Aluminum 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Aluminum	**12400**	10.0	11/12/2010	ND	4.1	102	4.00	0.734	GAL

Arsenic 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Arsenic	**2.97**	0.25	11/16/2010	ND	0.05	96.8	0.0500	7.75	GAL

Barium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Barium	**46.9**	0.25	11/16/2010	ND	0.05	103	0.0500	0.778	GAL

Bicarbonate 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Bicarbonate	**63.4**	5.00	11/27/2010	ND	988	98.8	1000	4.41	

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/14/2010	ND	2.00	100	2.00	4.66	
Toluene*	<0.050	0.050	11/14/2010	ND	1.89	94.7	2.00	4.58	
Ethylbenzene*	<0.050	0.050	11/14/2010	ND	1.73	86.7	2.00	3.75	
Total Xylenes*	<0.150	0.150	11/14/2010	ND	5.26	87.7	6.00	3.53	

Surrogate: 4-Bromofluorobenzene (PIL *97.6 %* *80-120*

Cadmium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Cadmium	**0.05**	0.02	11/16/2010	ND	0.05	107	0.0500	2.28	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 B (3') (H021239-20)

Calcium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Calcium	**1810**	50.0	11/12/2010	ND	4.0	100	4.00	0.249	GAL

Carbonate 310.1M — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Carbonate	<0.00	0.00	11/27/2010	ND					

Chloride, SM4500Cl-B — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	<4.00	4.00	11/20/2010	ND	416	104	400	0.00	

Chromium 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chromium	**6.77**	0.500	11/16/2010	ND	0.055	110	0.0500	1.27	GAL

Copper, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Copper	**2.54**	2.00	11/12/2010	ND	4.21	105	4.00	0.476	GAL

Iron 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Iron	**10600**	5.0	11/12/2010	ND	4.0	99.2	4.00	0.503	GAL

Lead 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Lead	**5.97**	0.05	11/16/2010	ND	0.05	102	0.0500	1.38	GAL

Magnesium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 B (3') (H021239-20)

Magnesium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Magnesium	**1690**	50.0	11/17/2010	ND	3.9	97.5	4.00	0.00	GAL

Manganese 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Manganese	**66.6**	0.5	11/17/2010	ND	2.0	100	2.00	0.499	GAL

Mercury, 7471A — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Mercury	**0.008**	0.020	11/17/2010	ND	0.002	100	0.00200	0.00	GAL, J

Potassium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Potassium	**2260**	50.0	11/12/2010	ND	10.5	105	10.0	2.90	GAL

Selenium 200.8 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Selenium	**0.401**	0.100	11/15/2010	ND	0.243	97.2	0.250	3.64	GAL

Silver 200.8 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Silver	**0.062**	0.025	11/16/2010	ND	0.054	109	0.0500	4.69	GAL

Sodium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sodium	**79.8**	50.0	11/12/2010	ND	16.7	103	16.2	0.601	GAL

Sulfate 375.4 — **mg/kg** — **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 B (3') (H021239-20)

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sulfate	**34.5**	10.0	11/29/2010	ND	46.1	115	40.0	2.19	

Total Alkalinity 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Total	**52.0**	4.00	11/27/2010	ND	810	81.0	1000	4.88	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	152	75.8	200	9.73	

Surrogate: 1-Chlorooctane	*116 %*	*70-130*
Surrogate: 1-Chlorooctadecane	*120 %*	*70-130*

Zinc 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Zinc	**25.7**	5.0	11/12/2010	ND	2.0	97.5	2.00	0.512	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 B - 1 (1') (H021239-21)

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/14/2010	ND	2.00	100	2.00	4.66	
Toluene*	<0.050	0.050	11/14/2010	ND	1.89	94.7	2.00	4.58	
Ethylbenzene*	<0.050	0.050	11/14/2010	ND	1.73	86.7	2.00	3.75	
Total Xylenes*	<0.150	0.150	11/14/2010	ND	5.26	87.7	6.00	3.53	

Surrogate: 4-Bromofluorobenzene (PIL *102 %* *80-120*

Chloride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**8.00**	4.00	11/17/2010	ND	400	100	400	3.92	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	**284**	10.0	11/14/2010	ND	152	75.8	200	9.73	

Surrogate: 1-Chlorooctane *104 %* *70-130*

Surrogate: 1-Chlorooctadecane *108 %* *70-130*

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 B - 1 (3') (H021239-22)

Aluminum 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Aluminum	**4320**	10.0	11/12/2010	ND	4.1	102	4.00	0.734	GAL

Arsenic 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Arsenic	**1.42**	0.25	11/16/2010	ND	0.05	96.8	0.0500	7.75	GAL

Barium 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Barium	**20.4**	0.25	11/16/2010	ND	0.05	103	0.0500	0.778	GAL

Bicarbonate 310.1M mg/kg Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Bicarbonate	**19.5**	5.00	11/27/2010	ND	988	98.8	1000	4.41	

BTEX 8021B mg/kg Analyzed By: cms

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/14/2010	ND	2.00	100	2.00	4.66	
Toluene*	<0.050	0.050	11/14/2010	ND	1.89	94.7	2.00	4.58	
Ethylbenzene*	<0.050	0.050	11/14/2010	ND	1.73	86.7	2.00	3.75	
Total Xylenes*	<0.150	0.150	11/14/2010	ND	5.26	87.7	6.00	3.53	

Surrogate: 4-Bromofluorobenzene (PIL *100 %* *80-120*

Cadmium 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Cadmium	**0.04**	0.02	11/16/2010	ND	0.05	107	0.0500	2.28	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 B - 1 (3') (H021239-22)

Calcium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Calcium	**637**	50.0	11/12/2010	ND	4.0	100	4.00	0.249	GAL

Carbonate 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Carbonate	<0.00	0.00	11/27/2010	ND					

Chloride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**76.0**	4.00	11/20/2010	ND	416	104	400	0.00	

Chromium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chromium	**3.22**	0.500	11/16/2010	ND	0.055	110	0.0500	1.27	GAL

Copper, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Copper	<2.00	2.00	11/12/2010	ND	4.21	105	4.00	0.476	GAL

Iron 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Iron	**4920**	5.0	11/12/2010	ND	4.0	99.2	4.00	0.503	GAL

Lead 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Lead	**3.39**	0.05	11/16/2010	ND	0.05	102	0.0500	1.38	GAL

Magnesium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 B - 1 (3') (H021239-22)

Magnesium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Magnesium	**596**	50.0	11/17/2010	ND	3.9	97.5	4.00	0.00	GAL

Manganese 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Manganese	**39.3**	0.5	11/17/2010	ND	2.0	100	2.00	0.499	GAL

Mercury, 7471A — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Mercury	**0.006**	0.020	11/17/2010	ND	0.002	100	0.00200	0.00	GAL, J

Potassium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Potassium	**928**	50.0	11/12/2010	ND	10.5	105	10.0	2.90	GAL

Selenium 200.8 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Selenium	**0.206**	0.100	11/15/2010	ND	0.243	97.2	0.250	3.64	GAL

Silver 200.8 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Silver	**0.045**	0.025	11/16/2010	ND	0.054	109	0.0500	4.69	GAL

Sodium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sodium	**90.6**	50.0	11/12/2010	ND	16.7	103	16.2	0.601	GAL

Sulfate 375.4 — **mg/kg** — **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 B - 1 (3') (H021239-22)

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sulfate	**101**	10.0	11/29/2010	ND	46.1	115	40.0	2.19	

Total Alkalinity 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Total	**16.0**	4.00	11/27/2010	ND	810	81.0	1000	4.88	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	152	75.8	200	9.73	
Surrogate: 1-Chlorooctane	*113 %*	*70-130*							
Surrogate: 1-Chlorooctadecane	*118 %*	*70-130*							

Zinc 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Zinc	**9.8**	5.0	11/12/2010	ND	2.0	97.5	2.00	0.512	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 C (1') (H021239-23)

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/14/2010	ND	2.00	100	2.00	4.66	
Toluene*	<0.050	0.050	11/14/2010	ND	1.89	94.7	2.00	4.58	
Ethylbenzene*	<0.050	0.050	11/14/2010	ND	1.73	86.7	2.00	3.75	
Total Xylenes*	<0.150	0.150	11/14/2010	ND	5.26	87.7	6.00	3.53	

Surrogate: 4-Bromofluorobenzene (PIL *99.1 %* *80-120*

oride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	<4.00	4.00	11/17/2010	ND	416	104	400	3.77	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	152	75.8	200	9.73	

Surrogate: 1-Chlorooctane *105 %* *70-130*

Surrogate: 1-Chlorooctadecane *108 %* *70-130*

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 C (3') (H021239-24)

Aluminum 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Aluminum	**8880**	10.0	11/12/2010	ND	4.1	102	4.00	0.734	GAL

Arsenic 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Arsenic	**2.16**	0.25	11/16/2010	ND	0.05	96.8	0.0500	7.75	GAL

Barium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Barium	**40.0**	0.25	11/16/2010	ND	0.05	103	0.0500	0.778	GAL

Bicarbonate 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Bicarbonate	**97.6**	5.00	11/27/2010	ND	988	98.8	1000	4.41	

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/14/2010	ND	2.00	100	2.00	4.66	
Toluene*	<0.050	0.050	11/14/2010	ND	1.89	94.7	2.00	4.58	
Ethylbenzene*	<0.050	0.050	11/14/2010	ND	1.73	86.7	2.00	3.75	
Total Xylenes*	<0.150	0.150	11/14/2010	ND	5.26	87.7	6.00	3.53	

Surrogate: 4-Bromofluorobenzene (PIL *95.0 %* *80-120*

Cadmium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Cadmium	**0.02**	0.02	11/16/2010	ND	0.05	107	0.0500	2.28	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 C (3') (H021239-24)

Calcium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Calcium	**5810**	50.0	11/12/2010	ND	4.0	100	4.00	0.249	GAL

Carbonate 310.1M — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Carbonate	<0.00	0.00	11/27/2010	ND					

Chloride, SM4500Cl-B — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**8.00**	4.00	11/20/2010	ND	416	104	400	0.00	

Chromium 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chromium	**5.24**	0.500	11/16/2010	ND	0.055	110	0.0500	1.27	GAL

Copper, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Copper	<2.00	2.00	11/12/2010	ND	4.21	105	4.00	0.476	GAL

Iron 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Iron	**7890**	5.0	11/12/2010	ND	4.0	99.2	4.00	0.503	GAL

Lead 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Lead	**4.60**	0.05	11/16/2010	ND	0.05	102	0.0500	1.38	GAL

Magnesium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 C (3') (H021239-24)

Magnesium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Magnesium	**1240**	50.0	11/17/2010	ND	3.9	97.5	4.00	0.00	GAL

Manganese 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Manganese	**54.5**	0.5	11/17/2010	ND	2.0	100	2.00	0.499	GAL

Mercury, 7471A mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Mercury	**0.008**	0.020	11/17/2010	ND	0.002	100	0.00200	0.00	GAL, J

Potassium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Potassium	**1460**	50.0	11/12/2010	ND	10.5	105	10.0	2.90	GAL

Selenium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Selenium	**0.329**	0.100	11/15/2010	ND	0.243	97.2	0.250	3.64	GAL

Silver 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Silver	**0.046**	0.025	11/16/2010	ND	0.054	109	0.0500	4.69	GAL

Sodium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sodium	<50.0	50.0	11/12/2010	ND	16.7	103	16.2	0.601	GAL

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 11 C (3') (H021239-24)

Sulfate 375.4 mg/kg Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sulfate	**82.2**	10.0	11/29/2010	ND	46.1	115	40.0	2.19	

Total Alkalinity 310.1M mg/kg Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Total	**80.0**	4.00	11/27/2010	ND	810	81.0	1000	4.88	

TPH 8015M mg/kg Analyzed By: AB

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	152	75.8	200	9.73	
Surrogate: 1-Chlorooctane	*95.5 %*	*70-130*							
Surrogate: 1-Chlorooctadecane	*101 %*	*70-130*							

Zinc 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Zinc	**19.1**	5.0	11/12/2010	ND	2.0	97.5	2.00	0.512	GAL

Cardinal Laboratories *=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 A (1') (H021239-25)

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/14/2010	ND	2.00	100	2.00	4.66	
Toluene*	<0.050	0.050	11/14/2010	ND	1.89	94.7	2.00	4.58	
Ethylbenzene*	<0.050	0.050	11/14/2010	ND	1.73	86.7	2.00	3.75	
Total Xylenes*	<0.150	0.150	11/14/2010	ND	5.26	87.7	6.00	3.53	

Surrogate: 4-Bromofluorobenzene (PIL *99.1 %* *80-120*

Chloride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	<4.00	4.00	11/17/2010	ND	416	104	400	3.77	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	**79.0**	10.0	11/14/2010	ND	152	75.8	200	9.73	

Surrogate: 1-Chlorooctane *114 %* *70-130*

Surrogate: 1-Chlorooctadecane *119 %* *70-130*

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 A (3') (H021239-26)

Aluminum 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Aluminum	**13900**	10.0	11/12/2010	ND	4.1	102	4.00	0.734	GAL

Arsenic 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Arsenic	**2.90**	0.25	11/16/2010	ND	0.05	96.8	0.0500	7.75	GAL

Barium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Barium	**64.4**	0.25	11/16/2010	ND	0.05	103	0.0500	0.778	GAL

Bicarbonate 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Bicarbonate	**78.1**	5.00	11/27/2010	ND	988	98.8	1000	4.41	

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/14/2010	ND	2.00	100	2.00	4.66	
Toluene*	<0.050	0.050	11/14/2010	ND	1.89	94.7	2.00	4.58	
Ethylbenzene*	<0.050	0.050	11/14/2010	ND	1.73	86.7	2.00	3.75	
Total Xylenes*	<0.150	0.150	11/14/2010	ND	5.26	87.7	6.00	3.53	

Surrogate: 4-Bromofluorobenzene (PIL *98.2 %* *80-120*

Cadmium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Cadmium	**0.06**	0.02	11/16/2010	ND	0.05	107	0.0500	2.28	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 A (3') (H021239-26)

Calcium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Calcium	**3170**	50.0	11/12/2010	ND	4.0	100	4.00	0.249	GAL

Carbonate 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Carbonate	<0.00	0.00	11/27/2010	ND					

Chloride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**4.00**	4.00	11/20/2010	ND	416	104	400	0.00	

Chromium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chromium	**7.36**	0.500	11/16/2010	ND	0.055	110	0.0500	1.27	GAL

Copper, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Copper	**2.31**	2.00	11/12/2010	ND	4.21	105	4.00	0.476	GAL

Iron 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Iron	**11600**	5.0	11/12/2010	ND	4.0	99.2	4.00	0.503	GAL

Lead 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Lead	**6.56**	0.05	11/16/2010	ND	0.05	102	0.0500	1.38	GAL

Magnesium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 A (3') (H021239-26)

Magnesium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Magnesium	**2290**	50.0	11/17/2010	ND	3.9	97.5	4.00	0.00	GAL

Manganese 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Manganese	**67.4**	0.5	11/17/2010	ND	2.0	100	2.00	0.499	GAL

Mercury, 7471A — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Mercury	**0.008**	0.020	11/18/2010	ND	0.002	100	0.00200	0.00	GAL, J

Potassium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Potassium	**2910**	50.0	11/12/2010	ND	10.5	105	10.0	2.90	GAL

Selenium 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Selenium	**0.352**	0.100	11/15/2010	ND	0.243	97.2	0.250	3.64	GAL

Silver 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Silver	**0.035**	0.025	11/16/2010	ND	0.054	109	0.0500	4.69	GAL

Sodium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sodium	<50.0	50.0	11/12/2010	ND	16.7	103	16.2	0.601	GAL

Sulfate 375.4 — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 A (3') (H021239-26)

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sulfate	**127**	25.0	11/29/2010	ND	46.1	115	40.0	2.19	

Total Alkalinity 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Total	**64.0**	4.00	11/27/2010	ND	810	81.0	1000	4.88	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	152	75.8	200	9.73	
Surrogate: 1-Chlorooctane	*86.8 %*	*70-130*							
Surrogate: 1-Chlorooctadecane	*91.0 %*	*70-130*							

Zinc 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Zinc	**26.4**	5.0	11/12/2010	ND	2.0	97.5	2.00	0.512	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 A - 1 (1') (H021239-27)

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/14/2010	ND	2.00	100	2.00	4.66	
Toluene*	<0.050	0.050	11/14/2010	ND	1.89	94.7	2.00	4.58	
Ethylbenzene*	<0.050	0.050	11/14/2010	ND	1.73	86.7	2.00	3.75	
Total Xylenes*	<0.150	0.150	11/14/2010	ND	5.26	87.7	6.00	3.53	

Surrogate: 4-Bromofluorobenzene (PIL *97.1 %* *80-120*

ride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	<4.00	4.00	11/17/2010	ND	416	104	400	3.77	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	152	75.8	200	9.73	

Surrogate: 1-Chlorooctane *130 %* *70-130*

Surrogate: 1-Chlorooctadecane *135 %* *70-130*

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 A - 1 (3') (H021239-28)

Aluminum 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Aluminum	**8480**	10.0	11/12/2010	ND	4.1	102	4.00	0.734	GAL

Arsenic 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Arsenic	**2.24**	0.25	11/16/2010	ND	0.05	96.8	0.0500	7.75	GAL

Barium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Barium	**36.2**	0.25	11/16/2010	ND	0.05	103	0.0500	0.778	GAL

Bicarbonate 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Bicarbonate	**92.7**	5.00	11/27/2010	ND	988	98.8	1000	4.41	

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/14/2010	ND	2.00	100	2.00	4.66	
Toluene*	<0.050	0.050	11/14/2010	ND	1.89	94.7	2.00	4.58	
Ethylbenzene*	<0.050	0.050	11/14/2010	ND	1.73	86.7	2.00	3.75	
Total Xylenes*	<0.150	0.150	11/14/2010	ND	5.26	87.7	6.00	3.53	

Surrogate: 4-Bromofluorobenzene (PIL *100 %* *80-120*

Cadmium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Cadmium	**0.04**	0.02	11/16/2010	ND	0.05	107	0.0500	2.28	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 A - 1 (3') (H021239-28)

Calcium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Calcium	**3110**	50.0	11/12/2010	ND	4.0	100	4.00	0.249	GAL

Carbonate 310.1M — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Carbonate	<0.00	0.00	11/27/2010	ND					

Chloride, SM4500Cl-B — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	<4.00	4.00	11/20/2010	ND	416	104	400	0.00	

Chromium 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chromium	**5.93**	0.500	11/16/2010	ND	0.055	110	0.0500	1.27	GAL

Copper, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Copper	**2.69**	2.00	11/12/2010	ND	4.21	105	4.00	0.476	GAL

Iron 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Iron	**8270**	5.0	11/12/2010	ND	4.0	99.2	4.00	0.503	GAL

Lead 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Lead	**4.79**	0.05	11/16/2010	ND	0.05	102	0.0500	1.38	GAL

Magnesium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 A - 1 (3') (H021239-28)

Magnesium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Magnesium	**1400**	50.0	11/17/2010	ND	3.9	97.5	4.00	0.00	GAL

Manganese 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Manganese	**80.4**	0.5	11/17/2010	ND	2.0	100	2.00	0.499	GAL

Mercury, 7471A mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Mercury	**0.016**	0.020	11/18/2010	ND	0.002	100	0.00200	0.00	GAL, J

Potassium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Potassium	**1930**	50.0	11/12/2010	ND	10.5	105	10.0	2.90	GAL

Selenium 200.8 *mg/kg dry wt.* **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Selenium	**0.318**	0.100	11/15/2010	ND	0.243	97.2	0.250	3.64	GAL

Silver 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Silver	**0.048**	0.025	11/16/2010	ND	0.054	109	0.0500	4.69	GAL

Sodium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sodium	<50.0	50.0	11/12/2010	ND	16.7	103	16.2	0.601	GAL

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 A - 1 (3') (H021239-28)

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sulfate	**55.4**	10.0	11/29/2010	ND	46.1	115	40.0	2.19	

Total Alkalinity 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Total	**76.0**	4.00	11/27/2010	ND	810	81.0	1000	4.88	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	152	75.8	200	9.73	
Surrogate: 1-Chlorooctane	*101 %*	*70-130*							
Surrogate: 1-Chlorooctadecane	*109 %*	*70-130*							

Zinc 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Zinc	**20.0**	5.0	11/12/2010	ND	2.0	97.5	2.00	0.512	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 B (1') (H021239-29)

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/14/2010	ND	2.00	100	2.00	4.66	
Toluene*	<0.050	0.050	11/14/2010	ND	1.89	94.7	2.00	4.58	
Ethylbenzene*	**0.053**	0.050	11/14/2010	ND	1.73	86.7	2.00	3.75	
Total Xylenes*	<0.150	0.150	11/14/2010	ND	5.26	87.7	6.00	3.53	

Surrogate: 4-Bromofluorobenzene (PIL *95.8 %* *80-120*

Chloride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**16.0**	4.00	11/17/2010	ND	416	104	400	3.77	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/14/2010	ND	153	76.3	200	5.99	
DRO >C10-C28	<10.0	10.0	11/14/2010	ND	152	75.8	200	9.73	

Surrogate: 1-Chlorooctane *111 %* *70-130*

Surrogate: 1-Chlorooctadecane *114 %* *70-130*

Cardinal Laboratories *=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 B (3') (H021239-30)

Aluminum 200.7 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Aluminum	**7060**	10.0	11/12/2010	ND	4.1	102	4.00	0.734	GAL

Arsenic 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Arsenic	**1.69**	0.25	11/16/2010	ND	0.05	96.8	0.0500	7.75	GAL

Barium 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Barium	**54.6**	0.25	11/16/2010	ND	0.05	103	0.0500	0.778	GAL

Bicarbonate 310.1M mg/kg Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Bicarbonate	**185**	5.00	11/27/2010	ND	988	98.8	1000	4.41	

BTEX 8021B mg/kg Analyzed By: cms

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/14/2010	ND	2.00	100	2.00	4.66	
Toluene*	<0.050	0.050	11/14/2010	ND	1.89	94.7	2.00	4.58	
Ethylbenzene*	<0.050	0.050	11/14/2010	ND	1.73	86.7	2.00	3.75	
Total Xylenes*	<0.150	0.150	11/14/2010	ND	5.26	87.7	6.00	3.53	

Surrogate: 4-Bromofluorobenzene (PIL *91.8 %* *80-120*

Cadmium 200.8 mg/kg dry wt. Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Cadmium	**0.07**	0.02	11/16/2010	ND	0.05	107	0.0500	2.28	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 B (3') (H021239-30)

Calcium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Calcium	**10000**	50.0	11/12/2010	ND	4.0	100	4.00	0.249	GAL

Carbonate 310.1M — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Carbonate	<0.00	0.00	11/27/2010	ND					

Chloride, SM4500Cl-B — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**20.0**	4.00	11/20/2010	ND	416	104	400	0.00	

Chromium 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chromium	**3.35**	0.500	11/16/2010	ND	0.055	110	0.0500	1.27	GAL

Copper, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Copper	**2.28**	2.00	11/12/2010	ND	4.21	105	4.00	0.476	GAL

Iron 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Iron	**6460**	5.0	11/12/2010	ND	4.0	99.2	4.00	0.503	GAL

Lead 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Lead	**4.12**	0.05	11/16/2010	ND	0.05	102	0.0500	1.38	GAL

Magnesium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 B (3') (H021239-30)

Magnesium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Magnesium	**1100**	50.0	11/17/2010	ND	3.9	97.5	4.00	0.00	GAL

Manganese 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Manganese	**63.0**	0.5	11/17/2010	ND	2.0	100	2.00	0.499	GAL

Mercury, 7471A — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Mercury	**0.008**	0.020	11/18/2010	ND	0.002	100	0.00200	0.00	GAL, J

Potassium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Potassium	**1470**	50.0	11/12/2010	ND	10.5	105	10.0	2.90	GAL

Selenium 200.8 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Selenium	**0.309**	0.100	11/15/2010	ND	0.243	97.2	0.250	3.64	GAL

Silver 200.8 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Silver	**0.059**	0.025	11/16/2010	ND	0.054	109	0.0500	4.69	GAL

Sodium, 200.7 — **mg/kg dry wt.** — **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sodium	**157**	50.0	11/12/2010	ND	16.7	103	16.2	0.601	GAL

Sulfate 375.4 — **mg/kg** — **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 B (3') (H021239-30)

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sulfate	<10.0	10.0	11/29/2010	ND	46.1	115	40.0	2.19	

Total Alkalinity 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Total	**152**	4.00	11/27/2010	ND	810	81.0	1000	4.88	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/15/2010	ND	153	76.7	200	14.7	
DRO >C10-C28	<10.0	10.0	11/15/2010	ND	156	78.1	200	14.2	
Surrogate: 1-Chlorooctane	*123 %*	*70-130*							
Surrogate: 1-Chlorooctadecane	*129 %*	*70-130*							

Zinc 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Zinc	**16.9**	5.0	11/12/2010	ND	2.0	97.5	2.00	0.512	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 C (1') (H021239-31)

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/14/2010	ND	2.00	100	2.00	4.66	
Toluene*	<0.050	0.050	11/14/2010	ND	1.89	94.7	2.00	4.58	
Ethylbenzene*	<0.050	0.050	11/14/2010	ND	1.73	86.7	2.00	3.75	
Total Xylenes*	<0.150	0.150	11/14/2010	ND	5.26	87.7	6.00	3.53	

Surrogate: 4-Bromofluorobenzene (PIL *92.4 %* *80-120*

oride, SM4500Cl-B mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	<4.00	4.00	11/17/2010	ND	416	104	400	3.77	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/15/2010	ND	153	76.7	200	14.7	
DRO >C10-C28	<10.0	10.0	11/15/2010	ND	156	78.1	200	14.2	

Surrogate: 1-Chlorooctane *110 %* *70-130*

Surrogate: 1-Chlorooctadecane *112 %* *70-130*

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 * 101 E. MARLAND * HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 C (3') (H021239-32)

Aluminum 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Aluminum	**4260**	10.0	11/12/2010	ND	4.1	102	4.00	0.734	GAL

Arsenic 200.8 ***mg/kg dry wt.*** ***Analyzed By: JM***

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Arsenic	**1.17**	0.25	11/16/2010	ND	0.05	96.8	0.0500	7.75	GAL

Barium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Barium	**30.0**	0.25	11/16/2010	ND	0.05	103	0.0500	0.778	GAL

Bicarbonate 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Bicarbonate	**87.8**	5.00	11/27/2010	ND	988	98.8	1000	4.41	

BTEX 8021B mg/kg **Analyzed By: cms**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	11/14/2010	ND	2.00	100	2.00	4.66	
Toluene*	<0.050	0.050	11/14/2010	ND	1.89	94.7	2.00	4.58	
Ethylbenzene*	<0.050	0.050	11/14/2010	ND	1.73	86.7	2.00	3.75	
Total Xylenes*	<0.150	0.150	11/14/2010	ND	5.26	87.7	6.00	3.53	

Surrogate: 4-Bromofluorobenzene (PIL *90.9 %* *80-120*

Cadmium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Cadmium	**0.22**	0.02	11/16/2010	ND	0.05	107	0.0500	2.28	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 C (3') (H021239-32)

Calcium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Calcium	**1950**	50.0	11/12/2010	ND	4.0	100	4.00	0.249	GAL

Carbonate 310.1M — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Carbonate	<0.00	0.00	11/27/2010	ND					

Chloride, SM4500Cl-B — mg/kg — Analyzed By: HM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
..loride	<4.00	4.00	11/20/2010	ND	416	104	400	0.00	

Chromium 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chromium	**3.45**	0.500	11/16/2010	ND	0.055	110	0.0500	1.27	GAL

Copper, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Copper	**2.14**	2.00	11/12/2010	ND	4.21	105	4.00	0.476	GAL

Iron 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Iron	**5090**	5.0	11/12/2010	ND	4.0	99.2	4.00	0.503	GAL

Lead 200.8 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Lead	**3.38**	0.05	11/16/2010	ND	0.05	102	0.0500	1.38	GAL

Magnesium, 200.7 — mg/kg dry wt. — Analyzed By: JM

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 C (3') (H021239-32)

Magnesium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Magnesium	**708**	50.0	11/17/2010	ND	3.9	97.5	4.00	0.00	GAL

Manganese 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Manganese	**56.5**	0.5	11/17/2010	ND	2.0	100	2.00	0.499	GAL

Mercury, 7471A mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Mercury	**0.007**	0.020	11/18/2010	ND	0.002	100	0.00200	0.00	GAL, J

Potassium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Potassium	**1060**	50.0	11/12/2010	ND	10.5	105	10.0	2.90	GAL

Selenium 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Selenium	**0.230**	0.100	11/15/2010	ND	0.243	97.2	0.250	3.64	GAL

Silver 200.8 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Silver	**0.049**	0.025	11/16/2010	ND	0.054	109	0.0500	4.69	GAL

Sodium, 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sodium	<50.0	50.0	11/12/2010	ND	16.7	103	16.2	0.601	GAL

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

JOHN H. HENDRIX CORPORATION
CAROLYN DORAN HAYNES
P. O. BOX 3040
MIDLAND TX, 79702
Fax To: (575) 394-2653

Received:	11/05/2010	Sampling Date:	11/03/2010
Reported:	11/30/2010	Sampling Type:	Soil
Project Name:	JHHC SWMF NM-02-0021	Sampling Condition:	Cool & Intact
Project Number:	NONE GIVEN	Sample Received By:	Celey D. Keene
Project Location:	T24S,R36E,SEC15,W/2 NW/4 & W/2 SW/		

Sample ID: 12 C (3') (H021239-32)

Sulfate 375.4 mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Sulfate	**13.2**	10.0	11/29/2010	ND	46.1	115	40.0	2.19	

Total Alkalinity 310.1M mg/kg **Analyzed By: HM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Alkalinity, Total	**72.0**	4.00	11/27/2010	ND	810	81.0	1000	4.88	

TPH 8015M mg/kg **Analyzed By: AB**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	11/15/2010	ND	153	76.7	200	14.7	
DRO >C10-C28	<10.0	10.0	11/15/2010	ND	156	78.1	200	14.2	
Surrogate: 1-Chlorooctane	*135 %*	*70-130*							
Surrogate: 1-Chlorooctadecane	*137 %*	*70-130*							

Zinc 200.7 mg/kg dry wt. **Analyzed By: JM**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Zinc	**11.4**	5.0	11/12/2010	ND	2.0	97.5	2.00	0.512	GAL

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Notes and Definitions

Z-01	Surrogate outside historical limits.
J	Detected but below the Reporting Limit; therefore, result is an estimated concentration (CLP J-Flag).
GAL	Analysis subcontracted to Green Analytical Laboratories, a subsidiary of Cardinal Laboratories.
ND	Analyte NOT DETECTED at or above the reporting limit
RPD	Relative Percent Difference
**	Samples not received at proper temperature of 6°C or below.
***	Insufficient time to reach temperature.
-	Chloride by SM4500Cl-B does not require samples be received at or below 6°C
	Samples reported on an as received basis (wet) unless otherwise noted on report

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

101 East Marland - Hobbs, New Mexico 88240
Tel (575) 393-2326
Fax (575) 393-2476

Cardinal Laboratories, Inc.

CHAIN-OF-CUSTODY AND ANALYSIS REQUEST

LAB Order ID # _____

Company Name: John H. Hendrix Corporation	BILL TO Company: John H. Hendrix Corporation PO#
Project Manager: Carolyn Haynes	Project Manager: Carolyn Haynes
Address: (Street, City, Zip) PO Box 910, Eunice NM 88231	Address: (Street, City, Zip) Fax#: PO Box 3040, Midland TX 79702-3040
Phone #: (575) 394-2649 Fax#: (575) 394-2653	Phone #: (432) 684-6631 Email: cdoranhaynes@jhhc.org
Project #: John H. Hendrix Corporation	Project Name: JHHC Surface Waste Management Facility (NM-02-0021)
Project Location: T24S, R36E, Sec 15, W/2 NW/4 & W/2 SW/4, Lea County NM	Sampler Name: Gil Van Deventer

LAB # (LAB USE ONLY)	FIELD CODE	(G)rab or (C)omp	# CONTAINERS	MATRIX: WATER	SOIL	AIR	SLUDGE	PRESERVATIVE METHOD: HCL	HNO_3	$NaHSO_4$	H_2SO_4	ICE	None	SAMPLING: DATE	TIME	MTBE 8021B/602	BTEX 8021 B	TPH 8015M	PAH 8270C	RCRA Metals: Ag As Ba Cd Cr Pb Se Hg	WQCC Metals: Al Cu Fe Mn Zn	TCLP Volatiles	TCLP Semi Volatiles	TCLP Pesticides	RCI	GC/MS Vol. 8260B/624	GC/MS Semi. Vol. 8270C/625	Moisture Content	Cations (Ca, Mg, K, Na)	Anions (Cl, SO4, CO3, HCO3, T-ALK)	Total Dissolved Solids (SM2540C)	Chlorides (SM4500 B)	SPLP Chloride	Turn Around Time ~ 24 Hours
H 21234-1A,B	1A (1')	G	2		X							X		11/3/10	1520		X	X														X		
-2A,B,C	1A (3')	G	3		X							X		11/3/10	1530		X	X		X	X								X	X				
-3A,B	1B (1')	G	2		X							X		11/3/10	1540		X	X														X		
-4A,B,C	1B (3')	G	3		X							X		11/3/10	1550		X	X		X	X								X	X				
-5A,B	1B-1 (1')	G	2		X							X		11/3/10	1600		X	X														X		
-6A,B,C	1B-1 (3')	G	3		X							X		11/3/10	1610		X	X		X	X								X	X				
-7A,B	1C (1')	G	2		X							X		11/3/10	1620		X	X														X		
-8A,B,C	1C (3')	G	3		X							X		11/3/10	1630		X	X		X	X								X	X				
-9A,B	10B (1')	G	2		X							X		11/3/10	1400		X	X														X		
-10A,B,C	10B (3')	G	3		X							X		11/3/10	1410		X	X		X	X								X	X				

Relinquished by: [signature]	Date: 11/5/10	Time: 11:53	Received by: [signature] Date: 11/5/10 Time: 11:55 CST
Relinquished by: [signature]	Date: 11/5/10	Time: 12:40 MST	Received By: (Laboratory Staff) [signature] Date: 11/5/10 Time: 12:40 MST

Phone Results: ☐ Yes ☐ No
Fax Results: ☐ Yes ☐ No Additional Fax Number:

REMARKS:

Email Results to: cdoranhaynes@jhhc.org, gil@trident-environmental.com

Delivered By: (Circle One) Sampler - UPS - Bus - Other: 4oz. jars 0°C

Sample Condition: Cool: Yes ☑ No ☐ Intact: Yes ☑ No ☐

CHECKED BY: (Initials) [initials]

plastic bags 21°C

#26

101 East Marland - Hobbs, New Mexico 88240
Tel (575) 393-2326
Fax (575) 393-2476

Cardinal Laboratories, Inc.

CHAIN-OF-CUSTODY AND ANALYSIS REQUEST

LAB Order ID #: _____

Company Name: John H. Hendrix Corporation	BILL TO Company: John H. Hendrix Corporation PO#
Project Manager: Carolyn Haynes	Project Manager: Carolyn Haynes
Address: (Street, City, Zip) PO Box 910, Eunice NM 88231	Address: (Street, City, Zip) PO Box 3040, Midland TX 79702-3040 Fax#:
Phone #: (575) 394-2649 Fax#: (575) 394-2653	Phone #: (432) 684-6631 Email: cdoranhaynes@jhhc.org
Project #: John H. Hendrix Corporation	Project Name: JHHC Surface Waste Management Facility (NM-02-0021)
Project Location: T24S, R36E, Sec 15, W/2 NW/4 & W/2 SW/4, Lea County NM	Sampler Name: Gil Van Deventer

LAB # (LAB USE ONLY)	FIELD CODE	(G)rab or (C)omp	# CONTAINERS	MATRIX: WATER	SOIL	AIR	SLUDGE	PRESERVATIVE METHOD: HCL	HNO_3	$NaHSO_4$	H_2SO_4	ICE	None	SAMPLING: DATE	TIME	MTBE 8021B/802	BTEX 8021 B	TPH 8015M	PAH 8270C	RCRA Metals: Ag As Ba Cd Cr Pb Se Hg	WQCC Metals: Al Cu Fe Mn Zn	TCLP Volatiles	TCLP Semi Volatiles	TCLP Pesticides	RCI	GC/MS Vol. 8260B/624	GC/MS Semi. Vol. 8270C/625	Moisture Content	Cations (Ca, Mg, K, Na)	Anions (Cl, SO4, CO3, HCO3, T-ALK)	Total Dissolved Solids (SM2540C)	Chlorides (SM4500 B)	SPLP Chloride	Turn Around Time ~ 24 Hours
112239-11A,B	10B-1 (1')	G	2		X							X		11/3/10	1420		X	X														X		
12A,B,C	10B-1 (3')	G	3		X							X		11/3/10	1430		X	X		X	X								X	X				
13A,B	10C (1')	G	2		X							X		11/3/10	1215		X	X														X		
14A,B,C	10C (3')	G	3		X							X		11/3/10	1220		X	X		X	X								X	X				
15A,B	10C-1 (1')	G	2		X							X		11/3/10	1240		X	X														X		
16A,B,C	10C-1 (3')	G	3		X							X		11/3/10	1250		X	X		X	X								X	X				
17A,B	11A (1')	G	2		X							X		11/3/10	1150		X	X														X		
18A,B,C	11A (3')	G	3		X							X		11/3/10	1155		X	X		X	X								X	X				
19A,B	11B (1')	G	2		X							X		11/3/10	1120		X	X														X		
20A,B,C	11B (3')	G	3		X							X		11/3/10	1125		X	X		X	X								X	X				

Relinquished by:	Date: 11/5/10	Time: 11:53	Received by: Date: 11/5/10 Time: 11:55 CST
Relinquished by: CB	Date: 11/5/10	Time: 12:40 MST	Received By: (Laboratory Staff) Date: 11/5/10 Time: 12:40 MST

Phone Results: ☐ Yes ☐ No

Fax Results: ☐ Yes ☐ No Additional Fax Number:

REMARKS:

Email Results to:
cdoranhaynes@jhhc.org
gil@trident-environmental.com

Delivered By: (Circle One)
4 oz jars 0°C
Sampler - UPS - Bus - Other:
plastic bags 21°C

Sample Condition: Cool: Yes ☑ / No ☐ Intact: Yes ☑ / No ☐ #26

CHECKED BY: (Initials) CDL

101 East Marland - Hobbs, New Mexico 88240
Tel (575) 393-2326
Fax (575) 393-2476

Cardinal Laboratories, Inc.

CHAIN-OF-CUSTODY AND ANALYSIS REQUEST

LAB Order ID #:

Company Name: John H. Hendrix Corporation	BILL TO Company: John H. Hendrix Corporation PO#:
Project Manager: Carolyn Haynes	Project Manager: Carolyn Haynes
Address: (Street, City, Zip) PO Box 910, Eunice NM 88231	Address: (Street, City, Zip) Fax#: PO Box 3040, Midland TX 79702-3040
Phone #: (575) 394-2649 Fax#: (575) 394-2653	Phone #: (432) 684-6631 Email: cdoranhaynes@jhhc.org
Project #: John H. Hendrix Corporation	Project Name: JHHC Surface Waste Management Facility (NM-02-0021)
Project Location: T24S, R36E, Sec 15, W/2 NW/4 & W/2 SW/4, Lea County NM	Sampler Name: Gil Van Deventer

ANALYSIS REQUEST (Circle or Specify Method No.)

LAB # (LAB USE ONLY)	FIELD CODE	(G)rab or (C)omp	# CONTAINERS	MATRIX: WATER	SOIL	AIR	SLUDGE	PRESERVATIVE METHOD: HCL	HNO_3	$NaHSO_4$	H_2SO_4	ICE	None	SAMPLING: DATE	TIME	MTBE 8021B/602	BTEX 8021 B	TPH 8015M	PAH 8270C	RCRA Metals: Ag As Ba Cd Cr Pb Se Hg	WQCC Metals: Al Cu Fe Mn Zn	TCLP Volatiles	TCLP Semi Volatiles	TCLP Pesticides	RCI	GC/MS Vol. 8260B/624	GC/MS Semi. Vol. 8270C/625	Moisture Content	Cations (Ca, Mg, K, Na)	Anions (Cl, SO_4, CO_3, HCO_3, T-ALK)	Total Dissolved Solids (SM2540C)	Chlorides (SM4500 B)	SPLP Chloride	Turn Around Time - 24 Hours
H22239-21A,B	11B-1 (1')	G	2		X							X		11/3/10	1130		X	X														X		
-22A,B,C	11B-1 (3')	G	3		X							X		11/3/10	1135		X	X		X	X								X	X				
-23A,B	11C (1')	G	2		X							X		11/3/10	1100		X	X														X		
-24A,B	11C (3')	G	3		X							X		11/3/10	1110		X	X		X	X								X	X				
-25A,B	12A (1')	G	2		X							X		11/3/10	0945		X	X														X		
-26A,B,C	12A (3')	G	3		X							X		11/3/10	0950		X	X		X	X								X	X				
-27A,B	12A-1 (1')	G	2		X							X		11/3/10	1000		X	X														X		
-28A,B,C	12A-1 (3')	G	3		X							X		11/3/10	1005		X	X		X	X								X	X				
-29A,B	12B (1')	G	2		X							X		11/3/10	1015		X	X														X		
-30A,B,C	12B (3')	G	3		X							X		11/3/10	1020		X	X		X	X								X	X				
-31A,B	12C (1')	G	2		X							X		11/3/10	1040		X	X														X		
-32A,B,C	12C (3')	G	3		X							X		11/3/10	1050		X	X		X	X								X	X				

Relinquished by: Date: 11/5/10 Time: 11:55	Received by: Date: 11/5/10 Time: 11:55 CST	Phone Results	Yes / No
Relinquished by: Date: 11/5/10 Time: 12:40 MST	Received By: (Laboratory Staff) Date: 11/5/10 Time: 12:40 MST	Fax Results	Yes / No Additional Fax Number:
Delivered By: (Circle One) 4oz Jars 0°C	Sample Condition: Cool: Yes ✓ / No; Intact: Yes ✓ / No	CHECKED BY: (Initials)	REMARKS: Email Results to: cdoranhaynes@jhhc.org gil@trident-environmental.com
Sampler - UPS - Bus - Other: plastic bags 26°C	#26		

TRIDENT ENVIRONMENTAL

October 13, 2010

Mr. Brad Jones
New Mexico Energy, Minerals, & Natural Resources
Oil Conservation Division, Environmental Bureau
1220 S. St. Francis Drive
Santa Fe, New Mexico 87505

Re: Sample Location Map (Figure 1)
Vadose Zone Monitoring Report
Centralized Surface Waste Management Facility NM-02-0021
John H. Hendrix Corporation
Section 15, Township 24 South, Range 36 East, Lea County, New Mexico

Hi Brad:

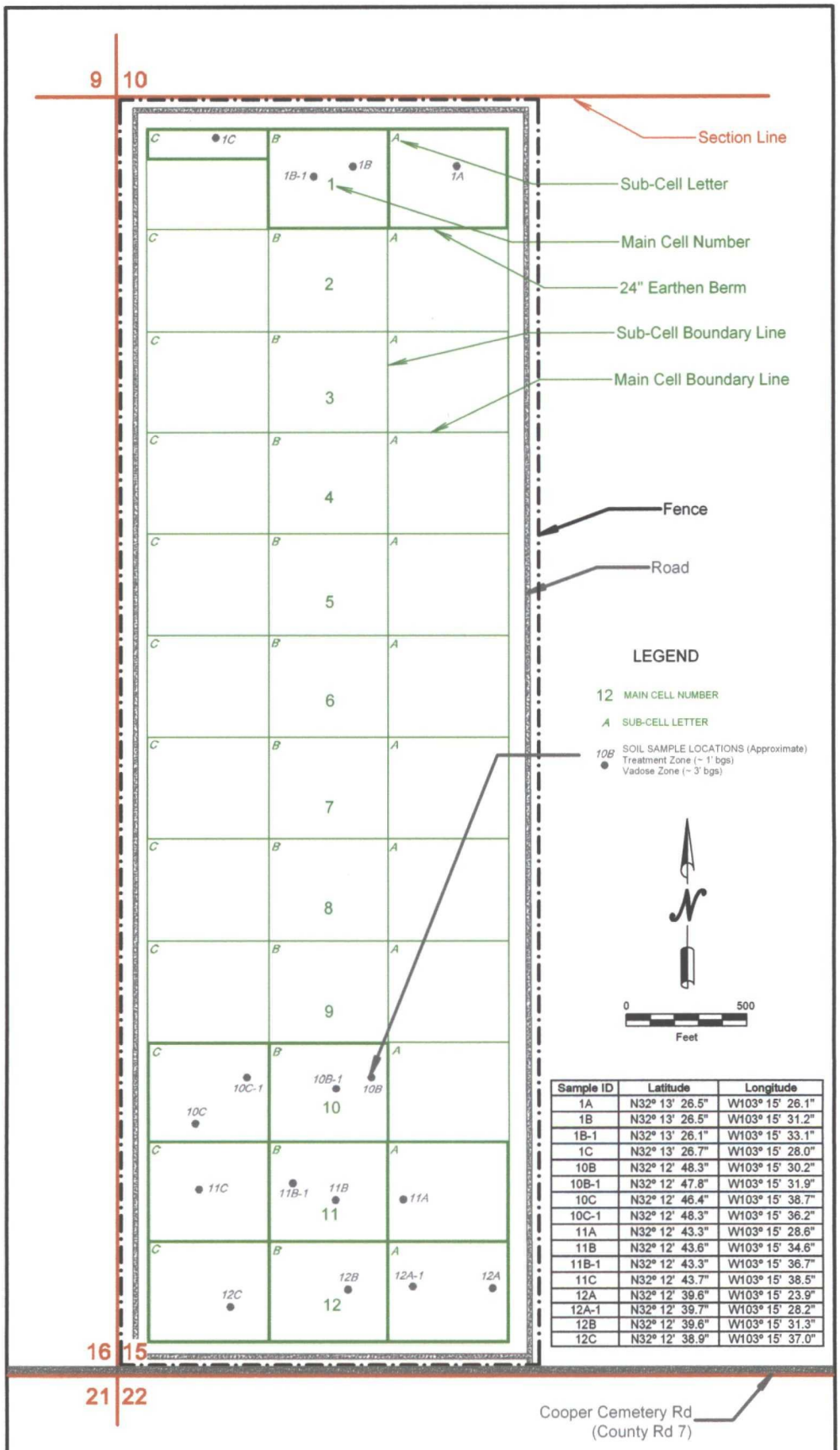
Enclosed is a color copy of the *Sample Location Map* (Figure 1) that I inadvertently left out from page 3 of the hard copy I mailed to you yesterday. Attached are two versions per your preference, one letter-size and one legal-size which can be inserted at page 3 and placed in the pocket of the binder, respectively.

Please feel free to call me at 432-638-8740 or Carolyn Haynes at 575-390-9689, if you have any questions.

Sincerely,

Gilbert J. Van Deventer, REM, PG
Trident Environmental - Project Manager

Enclosures



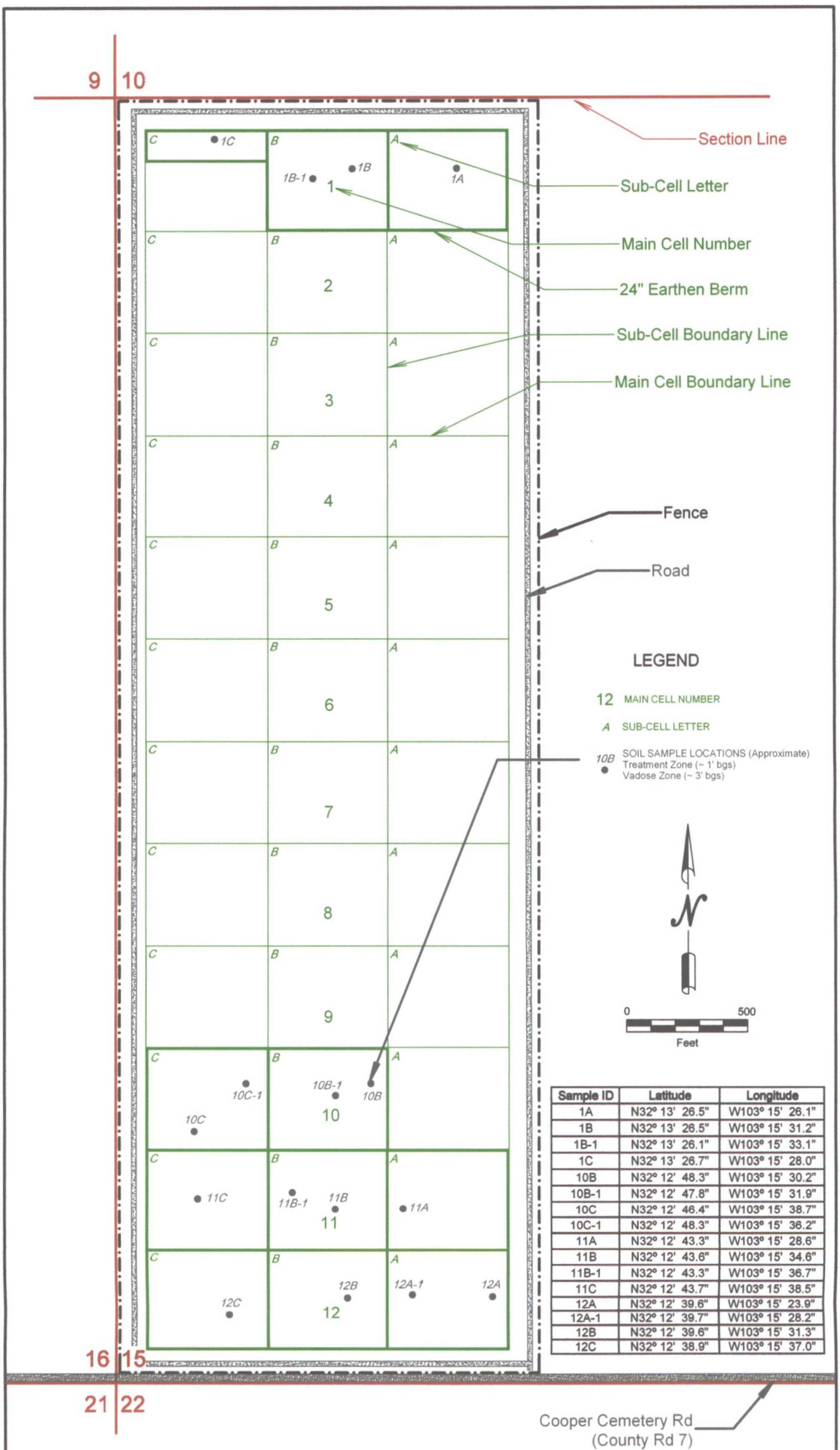
Sample ID	Latitude	Longitude
1A	N32° 13' 26.5"	W103° 15' 26.1"
1B	N32° 13' 26.5"	W103° 15' 31.2"
1B-1	N32° 13' 26.1"	W103° 15' 33.1"
1C	N32° 13' 26.7"	W103° 15' 28.0"
10B	N32° 12' 48.3"	W103° 15' 30.2"
10B-1	N32° 12' 47.8"	W103° 15' 31.9"
10C	N32° 12' 46.4"	W103° 15' 38.7"
10C-1	N32° 12' 48.3"	W103° 15' 36.2"
11A	N32° 12' 43.3"	W103° 15' 28.6"
11B	N32° 12' 43.6"	W103° 15' 34.6"
11B-1	N32° 12' 43.3"	W103° 15' 36.7"
11C	N32° 12' 43.7"	W103° 15' 38.5"
12A	N32° 12' 39.6"	W103° 15' 23.9"
12A-1	N32° 12' 39.7"	W103° 15' 28.2"
12B	N32° 12' 39.6"	W103° 15' 31.3"
12C	N32° 12' 38.9"	W103° 15' 37.0"

TRIDENT ENVIRONMENTAL

John H. Hendrix Corp.
Centralized Landfarm (NM-02-021)
T24S - R36E - Section 15 (W/2)
Lea County, New Mexico

FIGURE 1

Sample Location Map
April 7, 2010



Sample ID	Latitude	Longitude
1A	N32° 13' 26.5"	W103° 15' 26.1"
1B	N32° 13' 26.5"	W103° 15' 31.2"
1B-1	N32° 13' 26.1"	W103° 15' 33.1"
1C	N32° 13' 26.7"	W103° 15' 28.0"
10B	N32° 12' 48.3"	W103° 15' 30.2"
10B-1	N32° 12' 47.8"	W103° 15' 31.9"
10C	N32° 12' 46.4"	W103° 15' 38.7"
10C-1	N32° 12' 48.3"	W103° 15' 36.2"
11A	N32° 12' 43.3"	W103° 15' 28.6"
11B	N32° 12' 43.6"	W103° 15' 34.6"
11B-1	N32° 12' 43.3"	W103° 15' 36.7"
11C	N32° 12' 43.7"	W103° 15' 38.5"
12A	N32° 12' 39.6"	W103° 15' 23.9"
12A-1	N32° 12' 39.7"	W103° 15' 28.2"
12B	N32° 12' 39.6"	W103° 15' 31.3"
12C	N32° 12' 38.9"	W103° 15' 37.0"

TRIDENT ENVIRONMENTAL

John H. Hendrix Corp.
Centralized Landfarm (NM-02-021)
T24S - R36E - Section 15 (W/2)
Lea County, New Mexico

FIGURE 1

Sample Location Map
April 7, 2010

CERTIFIED MAIL
RETURN RECIEPT NO. 7010 0290 0003 1264 9024

October 11, 2010

Mr. Brad Jones
New Mexico Energy, Minerals, & Natural Resources
Oil Conservation Division, Environmental Bureau
1220 S. St. Francis Drive
Santa Fe, New Mexico 87505

Re: Vadose Zone Monitoring Report
Centralized Surface Waste Management Facility NM-02-0021
John H. Hendrix Corporation
Section 15, Township 24 South, Range 36 East, Lea County, New Mexico

Dear Mr. Jones:

Per your request, Trident Environmental, as agent for John H. Hendrix Corporation (JHHC), submits the attached *Vadose Zone Monitoring Report* to the New Mexico Oil Conservation Division (OCD) for the above-referenced centralized surface waste management facility (JHHC landfarm) as a response action to your email dated May 26, 2010 (attached).

Trident Environmental performed an assessment of the potential occurrence of downward migration (exceedence of background conditions) of constituents of concern (COCs) into the vadose zone (VZ) at the JHHC landfarm. The report provides detailed explanations of the comparisons, analyses, and assessments made.

It is important to note that depth to groundwater at the facility is greater than 147 ft below ground surface, further reducing the threat of constituents migrating downward through the VZ to pose risk to groundwater quality. Groundwater quality at the site was assessed prior to landfarming activities to establish baseline (background) conditions as explained in the *2009 Annual Operations and Monitoring Report* which was submitted to NMOCD on November 29, 2009.

We appreciate the opportunity to work with you on this project. Please feel free to call me at 432-638-8740 or Carolyn Haynes at 575-390-9689, if you have any questions.

Sincerely,

Gilbert J. Van Deventer, REM, PG
Trident Environmental - Project Manager

Enclosures

cc: Carolyn Haynes (JHHC)

Subject: RE: JHHC (NM-02-0021) 2010 Semi-annual lab reports
From: "Jones, Brad A., EMNRD" <brad.a.jones@state.nm.us>
Date: Wed, 26 May 2010 11:15:51 -0600
To: "Gil Van Deventer" <gil@trident-environmental.com>
CC: "Carolyn Haynes" <cdoranhaynes@jhhc.org>, "VonGonten, Glenn, EMNRD" <Glenn.VonGonten@state.nm.us>

Carolyn and Gil,

Pursuant to vadose zone monitoring requirements of Paragraph (3) of 19.15.36.15 NMAC, the operator "shall compare each result to the higher of the PQL or the background soil concentrations to determine whether a release has occurred." The document attached to the email below did not provide the comparison nor was there an assessment to whether a release has occurred. The intent and purpose of the vadose zone monitoring is to determine if the operations of the landfarm is causing downward migration of contaminates beneath the soils to be remediated. If it determined that the operation of the landfarm is contaminating the vadose zone, then pursuant to Paragraph (5) of 19.15.36.15 NMAC the operator shall submit a response action plan that addresses "changes in the landfarm's operation to prevent further contamination and, if necessary, a plan for remediating existing contamination." If the analytical results indicate that a release has occurred in the vadose zone and the assessment is not completed until the submittal of an annual report, then John H. Hendrix Corporation will find itself in violation of operational provisions of the Surface Waste Management Facility rule, 19.15.36 NMAC, regarding failure to complete certain tasks by specified deadlines and timelines within the rule. Please submit the comparison and John H. Hendrix Corporation's assessment and conclusion of the vadose zone monitoring event.

Brad
Brad A. Jones
Environmental Engineer
Environmental Bureau
NM Oil Conservation Division
1220 S. St. Francis Drive
Santa Fe, New Mexico 87505
E-mail: brad.a.jones@state.nm.us
Office: (505) 476-3487
Fax: (505) 476-3462

From: Gil Van Deventer [mailto:gil@trident-environmental.com]
Sent: Thursday, May 20, 2010 4:04 PM
To: Jones, Brad A., EMNRD
Cc: Carolyn Haynes
Subject: JHHC (NM-02-0021) 2010 Semi-annual lab reports

Facility: Centralized Surface Waste Management Facility (NM-02-0021)
Operator: John H. Hendrix Corporation
Location: W/2 SW/4 and W/2 NW/4, Sec 15, T-24-S, R-36-E, Lea County NM
Attachments: Laboratory analytical reports

Greetings Brad:

As agent for John H. Hendrix Corporation, Trident Environmental submits the attached laboratory analytical reports for the semi-annual sampling event which occurred at the above-referenced facility on April 7, 2010. The annual sampling event is scheduled for the third quarter, probably October, of this year, after which the annual report documenting all operations and monitoring activities performed during the year will be submitted to you.

Please let me know if you need hard copies of these reports at this time or if they can wait until the annual reporting process. If you have any questions please feel free to contact me, or Carolyn Haynes at (432) 684-6631.

Thanks - Gil

Gilbert J. Van Deventer, PG, REM

Trident Environmental
P. O. Box 12177
Odessa TX 79768-2177

Work/Mobile: 432-638-8740
Fax: 413-403-9968

October 11, 2010

VADOSE ZONE MONITORING ASSESSMENT REPORT

JOHN H. HENDRIX LANDFARM (NM-02-021)
CENTRALIZED SURFACE WASTE MANAGEMENT FACILITY
T24S, R36E, SECTION 15
LEA COUNTY, NEW MEXICO

Prepared by:

TRIDENT ENVIRONMENTAL

P. O. Box 12177
Odessa, Texas 79768

Prepared for:

John H. Hendrix Corp.

110 N. Marienfeld

Midland, Texas 79702

TABLE OF CONTENTS

FIGURES

TABLES

ATTACHMENTS

1.0 Executive Summary

As agent for John H. Hendrix Corp. (JHHC), Trident Environmental performed an assessment of the potential occurrence of downward migration (exceedence of background screening values) of constituents of concern (COCs) into the vadose zone (VZ) at the JHHC landfarm. This assessment was conducted using a combination of the following techniques:

- The analytical results of sixteen (16) background samples collected at the facility between November 29, 2004 and January 7, 2008, were statistically reviewed to determine if there is an adequate sample set to define background conditions for each metal COC.
- COC concentrations within the VZ were compared to concentrations in the treatment zone (TZ) to evaluate the possibility that migration could occur.
- Practical Quantitation Limits (PQLs) were reviewed and/or background screening values (BSVs) were calculated for the COC concentrations in the background samples for comparison with the most recent analytical results in the vadose zone.
- Statistical analysis of metal COC concentrations in the vadose zone were compared to those in the background data set to determine if there was a significant difference in the mean or median using a 95% confidence interval.
- Geochemical correlation plots were created to evaluate the range of naturally occurring trace metal COCs with major elements (iron and manganese).

The report provides detailed explanations of the comparisons, analyses, and assessments made to reach the following conclusions:

- There are no indications that BTEX and TPH have migrated into the VZ since there are no constituents of BTEX or TPH that exceeded the higher of the PQL or the background conditions.
- Chloride concentrations in the 16 mg/kg to 250 mg/kg range should be considered as naturally occurring and non-anthropogenic. Therefore, there are no indications that chloride has migrated into the VZ.
- Statistical analysis and geochemical correlation plots show no indications that trace metal COCs have migrated into the VZ, and that the ranges observed are consistent with naturally occurring concentrations.

It is important to note that depth to groundwater at the facility is greater than 147 ft below ground surface, further reducing the threat of constituents migrating downward through the VZ such that permissibly higher levels of COCs (higher than PQL or background concentrations) pose little risk to groundwater quality. Groundwater quality at the site was assessed prior to landfarming activities to establish baseline (background) conditions as explained in the *2009 Annual Operations and Monitoring Report* which was submitted to NMOCD on November 29, 2009.

Based on the findings of the vadose zone monitoring assessment there is no indication of COCs migrating downward to the VZ nor is there any indication a release has occurred due to JHHC operations. Activities and operations conducted at the JHHC landfarm are protective of public health, safety and the environment.

2.0 Sampling Procedures and Results

The facility consists of twelve main cells, numbered 1 through 12. Each 12 acre cell measures approximately 400 ft (north-south) by 1450 ft (east-west) as depicted in Figure 1. The main cells are subdivided into three sub-cells, lettered A, B, and C, each measuring approximately 400 ft x 480 ft (4.40 acres).

Soil samples were collected using a decontaminated hand auger, placed in pre-cleaned 4-ounce jars, properly labeled, and placed in an ice-filled cooler. Sample locations, as depicted in Figure 1, were recorded using a handheld global positioning device (Garmin *eTrex*™ GPS). The auger holes were backfilled with bentonite and hydrated with potable water.

During the semi-annual sampling event on April 7, 2010, samples were randomly collected at cells 1A, 1B, 1C, 10B, 10C, 11A, 11B, 11C, 12A, 12B, and 12C. The treatment zone (TZ) samples were analyzed for BTEX, TPH, and chloride, while the vadose zone samples were analyzed for BTEX, TPH, RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver), WQCC metals (iron, copper, manganese, and zinc) and major ions (total alkalinity, calcium, magnesium, potassium, sodium, chloride and sulfate). Samples were hand-delivered under chain of custody to Cardinal Laboratories (Hobbs, NM) for analysis.

A complete summary of TPH, BTEX, and chloride concentrations in the VZ and TZ are listed in Table 1. Metal concentrations for both zones are summarized in Table 2. Laboratory analytical reports, chains of custody, and sample locations are included in Attachment A.

Table 1
Summary of BTEX, TPH, and Chloride Concentrations - Soil Analytical Results

Cell No. Ltr.	Sample Date	Sample Zone	Sample ID (Depth)	Benzene (mg/kg)	BTEX (mg/kg)	GRO C6-C10 (mg/kg)	DRO C10-C28 (mg/kg)	TPH C6-C28 (mg/kg)	Chloride (mg/kg)
7B	11/29/04	Background	Facility (2' -3')	<0.025	<0.1	<10	<10	<20	<20
1A	03/02/06	Background	SS-1A (2' -3')	<0.025	<0.1	<10	<10	<20	5.01
	10/24/06	Vadose	1-A-1 (3' - 4')	<0.025	<0.125	<10	<10	<10	211
	10/24/06		1-A-2 (3' - 4')	<0.025	<0.125	<10	<10	<10	38.1
	04/10/07		1A (2' -3')	<0.003	<0.016	<0.065	<2.87	<2.93	<4.92
	04/10/07		1A-1 (2' -3')	<0.003	<0.016	<0.060	<2.72	<2.78	320
	10/15/07		1A (2' -3')	<0.003	<0.018	<0.058	4.06	4.06	<5.33
	10/15/07		1A-1 (2' -3')	<0.003	<0.020	<0.063	<3.20	<3.26	<5.57
	03/20/08		1A (2' -3')	<0.003	<0.018	<0.058	<3.25	<3.31	<5.59
	03/20/08		1A-1 (2' -3')	<0.003	<0.018	<0.055	<2.92	<2.98	<5.13
	04/07/10		1A (2' -3')	<0.050	<0.300	<10	<10	<20	*<16*
	10/24/06	Treatment	1-A-1 (0' -1')	<0.025	<0.125	<10	5.69	5.69	12.1
	10/24/06		1-A-2 (0' -1')	<0.025	<0.125	<10	<10	<10	15.0
	04/10/07		1A (0' -1')	<0.003	<0.016	<0.065	<2.76	<2.82	6.2
	04/10/07		1A-1 (0' -1')	<0.003	<0.016	<0.059	<2.87	<2.93	29
	10/09/07		1A (0' -1')	<0.003	<0.016	<0.058	<3.04	<3.10	<5.11
	10/09/07		1A-1 (0' -1')	<0.003	<0.017	<0.056	3.80	3.86	6.7
	03/13/08		1A (0' -1')	<0.003	<0.018	<0.056	<1.50	<1.56	90.1
	03/13/08		1A-1 (0' -1')	<0.003	<0.017	<0.057	<1.54	<1.60	12.8
	04/07/10		1A (0' -1')	<0.050	<0.300	<10	<10	<20	<16
1B	04/12/07	Background	SS-1B (2' -3')	<0.003	<0.016	<0.067	<2.83	<2.90	<4.96
	10/24/06	Vadose	1-B-1 (3' -4')	<0.025	<0.125	<10	11.3	**11.3**	140
	10/24/06		1-B-2 (3' -4')	<0.025	<0.125	<10	6.8	**6.8**	18.3
	04/12/07		1B (2' -3')	<0.003	<0.016	<0.063	<2.64	<2.70	21.0
	04/12/07		1B-1 (2' -3')	<0.003	<0.017	<0.059	<2.75	<2.81	<4.98
	10/15/07		1B (2' -3')	<0.003	<0.016	<0.063	4.88	**4.88**	<5.34
	03/20/08		1B (2' -3')	<0.003	<0.018	<0.055	<2.92	<2.97	<5.17
	03/20/08		1B-1 (2' -3')	<0.003	<0.016	<0.059	<3.21	<3.27	<5.53
	04/07/10		1B (2' -3')	<0.050	<0.300	<10	<10	*<20*	*<16*
	04/07/10		1B-1 (1.5')	<0.050	<0.300	<10	<10	*<20*	48
	10/24/06	Treatment	1-B-1 (0' -1')	<0.025	<0.125	<10	16.5	16.5	53.3
	10/24/06		1-B-2 (0' -1')	<0.025	<0.125	<10	9.79	9.79	87.0
	04/10/07		1B (0' -1')	<0.003	<0.016	<0.063	<2.79	<2.85	226
	04/10/07		1B-1 (0' -1')	<0.003	<0.015	<0.069	<2.83	<2.90	213
	10/09/07		1B (0' -1')	<0.003	<0.018	<0.061	5.65	5.65	74.7
	10/09/07		1B-1 (0' -1')	<0.003	<0.017	<0.055	6.53	6.53	92.0
	03/13/08		1B (0' -1')	<0.003	<0.016	<0.054	<1.44	<1.49	11.7
	03/13/08		1B-1 (0' -1')	<0.003	<0.017	<0.057	146	146	12.9
	04/07/10		1B (0' -1')	<0.050	<0.300	<10	<10	<20	<16
	04/07/10		1B-1 (0' -1')	<0.050	<0.300	<10	73.4	73.4	128

Table 1
Summary of BTEX, TPH, and Chloride Concentrations - Soil Analytical Results

Cell No. Ltr.	Sample Date	Sample Zone	Sample ID (Depth)	Benzene (mg/kg)	BTEX (mg/kg)	GRO C6-C10 (mg/kg)	DRO C10-C28 (mg/kg)	TPH C6-C28 (mg/kg)	Chloride (mg/kg)
	04/12/07	Background	SS-1C (0' -1')	<0.003	<0.016	<0.0625	<2.88	<2.94	<4.93
	03/25/09		SS-1C (2' -3')	<0.050	<0.300	<10	<10	*<20*	---
	10/01/09	Vadose	1C (2' -3')	<0.050	<0.300	<10	<10	*<20*	180
1C	04/07/10		1C (2' -3')	<0.050	<0.300	<10	<10	*<20*	96
	03/25/09		1C (0' -1')	<0.050	<0.300	<10	45.3	45.3	---
	10/01/09	Treatment	1C (0' -1')	<0.050	<0.300	<10	213	213	16
	04/07/10		1C (0' -1')	<0.050	<0.300	<10	206	206	<16
2A	01/07/08	Background	2A (2' -3')	<0.003	<0.016	<0.061	<5.67	<5.73	<5.01
2B	01/07/08	Background	2B (2' -3')	<0.003	<0.019	<0.071	<6.83	<6.90	<5.95
2C	01/07/08	Background	2C (2' -3')	<0.003	<0.018	<0.066	<6.20	<6.27	<5.43
10A	01/07/08	Background	10A (2' -3')	<0.003	<0.017	<0.061	<6.25	<6.31	<5.24
	01/07/08	Background	10B (2' -3')	<0.005	<0.046	<0.19	<6.2	<6.2	<5.21
	10/01/09		10B (2' -3')	<0.050	<0.300	<10	<10	*<20*	*<80*
	10/01/09	Vadose	10B-1 (2' -3')	<0.050	<0.300	<10	<10	*<20*	*<80*
	04/07/10		10B (2' -3')	<0.050	<0.300	<10	<10	*<20*	16
10B	04/07/10		10B-1 (2' -3')	<0.050	<0.300	<10	<10	*<20*	16
	10/01/09		10B (0' -1')	<0.050	<0.300	<50	11,000	11,000	400
	10/01/09	Treatment	10B-1 (0' -1')	<0.050	<0.300	<50	11,100	11,100	448
	04/07/10		10B (0' -1')	<0.050	<0.300	<50	19,700	19,700	416
	04/07/10		10B-1 (0' -1')	<0.050	<0.300	<50	17,300	17,300	320
	01/07/08	Background	10C (2' -3')	<0.005	<0.045	<0.19	<10	<10	<5.13
	10/07/08		10C (2' -3')	<0.001	<0.008	<16.5	<16.5	*<33*	---
	03/25/09		10C (2' -3')	<0.050	<0.300	<10	<10	*<20*	---
	03/25/09		10C-1 (2' -3')	<0.050	<0.300	<10	<10	*<20*	---
	10/01/09	Vadose	10C (2' -3')	<0.050	<0.300	<10	<10	*<20*	*<80*
	10/01/09		10C-1 (2' -3')	<0.050	<0.300	<10	<10	*<20*	*<80*
	04/07/10		10C (2' -3')	<0.050	<0.300	<10	<10	*<20*	16
10C	04/07/10		10C-1 (2' -3')	<0.050	<0.300	<10	<10	*<20*	32
	10/07/08		10C (0' -1')	<0.001	<0.007	<75.7	1,290	1,290	---
	03/25/09		10C (0' -1')	<0.050	<0.300	<10	2,340	2,340	---
	03/25/09		10C-1 (0' -1')	<0.050	<0.300	<10	152	152	---
	10/01/09	Treatment	10C (0' -1')	<0.050	<0.300	<10	454	454	<16
	10/01/09		10C-1 (0' -1')	<0.050	<0.300	<10	3,640	3,640	<16
	04/07/10		10C (0' -1')	<0.050	<0.300	<50	274	274	16
	04/07/10		10C-1 (0' -1')	<0.050	<0.300	<50	10,000	10,000	96

Table 1
Summary of BTEX, TPH, and Chloride Concentrations - Soil Analytical Results

Cell No. Ltr.	Sample Date	Sample Zone	Sample ID (Depth)	Benzene (mg/kg)	BTEX (mg/kg)	GRO C6-C10 (mg/kg)	DRO C10-C28 (mg/kg)	TPH C6-C28 (mg/kg)	Chloride (mg/kg)
11A	03/02/06	Background	11A (2' -3')	<0.025	<0.1	<10	<10	<20	4.67
	10/06/08	Vadose	11A (2' -3')	<0.001	<0.007	<15.7	<15.7	*<31.4*	<5.00
	03/25/09		11A (2' -3')	<0.050	<0.300	<10	<10	*<20*	---
	10/01/09		11A (2' -3')	<0.050	<0.300	<10	<10	*<20*	60
	04/07/10		11A (2' -3')	<0.050	<0.300	<10	<10	*<20*	224
	10/06/08	Treatment	11A (0' -1')	<0.001	<0.007	<15.5	621	621	<5.00
	03/25/09		11A (0' -1')	<0.050	<0.300	<10	<10	<20	---
	10/01/09		11A (0' -1')	<0.050	<0.300	<10	27.0	27.0	<16
	04/07/10		11A (0' -1')	<0.050	<0.300	<10	161	161	16
11B	01/07/08	Background	11B (2' -3')	<0.005	<0.051	<0.19	<10	<10	<5.13
	03/20/08	Vadose	11B (2' -3')	<0.003	<0.017	<0.060	<3.18	<3.24	<5.39
	03/20/08		11B-1 (2' -3')	<0.003	<0.019	<0.061	<3.11	<3.17	<5.35
	10/06/08		11B (2' -3')	<0.001	<0.007	<15.6	<15.6	*<31.2*	52.1
	10/06/08		11B-1 (2' -3')	<0.001	<0.008	<16.2	<16.2	*<32.4*	473
	03/25/09		11B (2' -3')	<0.050	<0.300	<10	<10	*<20*	---
	10/01/09		11B (2' -3')	<0.050	<0.300	<10	<10	*<20*	40
	10/01/09		11B-1 (2' -3')	<0.050	<0.300	<10	<10	*<20*	260
	04/07/10		11B (2' -3')	<0.050	<0.300	<10	<10	*<20*	32
	04/07/10		11B-1 (2' -3')	<0.050	<0.300	<10	<10	*<20*	192
	03/13/08	Treatment	11B (0' -1')	<0.001	<0.007	2.78	5910	5913	931
	03/13/08		11B-1 (0' -1')	<0.001	<0.007	2.91	6170	6173	1170
	10/06/08		11B (0' -1')	<0.003	0.0533	<15.5	2230	2230	495
	10/06/08		11B-1 (0' -1')	<0.003	0.066	<15.6	1080	1080	451
	03/25/09		11B (0' -1')	<0.050	<0.300	<10	298	298	---
	10/01/09		11B-1 (0' -1')	<0.050	<0.300	<10	38.1	38.1	<16
	10/01/09		11B (0' -1')	<0.050	0.286	<10	1,140	1,140	160
	04/07/10		11B (0' -1')	<0.050	<0.300	<10	71.8	71.8	96
	04/07/10		11B-1 (0' -1')	<0.050	<0.300	<50	468	468	64
11C	10/15/07	Background	11C (2' -3')	<0.005	<0.045	<0.19	<10	<10	<5.13
	10/15/07	Vadose	11C (2' -3')	<0.003	<0.018	<0.059	4.49	4.49	<5.47
	03/20/08		11C (2' -3')	<0.003	<0.021	<0.069	<3.44	<3.51	<6.05
	03/20/08		11C-1 (2' -3')	<0.003	<0.019	<0.066	<3.28	<3.35	<5.65
	10/06/08		11C (2' -3')	<0.001	<0.008	<16.3	<16.3	*<32.6*	*<10.0*
	03/25/09		11C (2' -3')	<0.050	<0.300	<10	<10	*<20*	---
	03/25/09		11C-1 (2' -3')	<0.050	<0.300	<10	<10	*<20*	---
	10/01/09		11C (2' -3')	<0.050	<0.300	<10	<10	*<20*	*<80*
	04/07/10		11C (2' -3')	<0.050	<0.300	<10	<10	*<20*	*<16*
	03/13/08	Treatment	11C (0' -1')	<0.003	<0.016	0.081	635	635	42.9
	03/13/08		11C-1 (0' -1')	<0.003	<0.017	<0.054	1300	1300	30.1
	10/06/08		11C (0' -1')	<0.001	<0.008	<15.8	519	519	<10.0
	03/25/09		11C (0' -1')	<0.050	<0.300	<10	34.3	34.3	---
	03/25/09		11C-1 (0' -1')	<0.050	<0.300	<10	78.1	78.1	---
	10/01/09		11C (0' -1')	<0.050	<0.300	<10	15.4	15.4	<16
	04/07/10		11C (0' -1')	<0.050	<0.300	<10	253	253	32

Table 1
Summary of BTEX, TPH, and Chloride Concentrations - Soil Analytical Results

Cell No. Ltr.	Sample Date	Sample Zone	Sample ID (Depth)	Benzene (mg/kg)	BTEX (mg/kg)	GRO C6-C10 (mg/kg)	DRO C10-C28 (mg/kg)	TPH C6-C28 (mg/kg)	Chloride (mg/kg)
12A	03/02/06	Background	12A (2' -3')	<0.025	<0.1	<10	<10	<20	8.86
	03/20/08	Vadose	12A (2' -3')	<0.003	<0.018	<0.057	<3.07	<3.13	<5.40
	10/06/08		12A (2' -3')	<0.001	<0.008	<16.0	<16.0	*<32.0*	*<10.0*
	03/25/09		12A (2' -3')	<0.050	<0.300	<10	<10	<20	---
	10/01/09		12A (2' -3')	<0.050	<0.300	<10	<10	<20	60
	10/01/09		12A-1 (2' -3')	<0.050	<0.300	<10	<10	<20	60
	04/07/10		12A (2' -3')	<0.050	<0.300	<10	<10	<20	*<16*
	04/07/10		12A-1 (2' -3')	<0.050	<0.300	<10	<10	<20	16
	03/20/08	Treatment	12A (0' -1')	<0.003	<0.019	<0.066	518	518	<5.72
	10/06/08		12A (0' -1')	<0.001	<0.008	<15.7	198	198	<5.00
	03/25/09		12A (0' -1')	<0.050	<0.300	<10	118	118	---
	10/01/09		12A (0' -1')	<0.050	<0.300	<10	37.2	37.2	<16
	10/01/09		12A-1 (0' -1')	<0.050	<0.300	<10	21.4	21.4	<16
	04/07/10		12A (0' -1')	<0.050	<0.300	<10	332	332	<16
	04/07/10		12A-1 (0' -1')	<0.050	<0.300	<10	82.0	82.0	<16
12B	04/12/07	Background	12B (2' -3')	<0.004	<0.044	<0.18	<10	<10	<4.88
	03/02/06	Vadose	SS-B (2' -3')	<0.025	<0.1	<10	<10	*<20*	4.98
	03/02/06		SS-E (2' -3')	<0.025	<0.125	<10	<10	*<20*	15.2
	10/25/06		12B-1 (3' - 4')	<0.025	<0.125	<10	<10	<10	60
	10/25/06		12B-2 (3' - 4')	<0.025	<0.125	<10	<10	<10	151
	04/12/07		12B (2' -3')	<0.003	<0.017	<0.061	<2.81	<2.81	21.2
	10/16/07		12B (2' -3')	<0.003	<0.018	<0.065	5.46	5.53	<5.65
	03/20/08		12B (2' -3')	<0.003	<0.019	<0.058	<3.26	<3.32	171
	10/06/08		12B (2' -3')	<0.001	<0.008	<16.0	<16.0	*<32.0*	30.7
	03/25/09		12B (2' -3')	<0.050	<0.300	<10	<10	*<20*	---
	10/01/09		12B (2' -3')	<0.050	<0.300	<10	<10	*<20*	60
	04/07/10		12B (2' -3')	<0.050	<0.300	<10	<10	*<20*	96
	03/02/06	Treatment	SS-B (0' -1')	<0.025	<0.1	<10	707	707	---
	03/02/06		SS-E (0' -1')	<0.025	<0.1	<10	79.1	79.1	---
	10/25/06		12B-1 (0' -1')	<0.025	<0.125	<10	397	397	151
	10/25/06		12B-2 (0' -1')	<0.025	<0.125	<10	98.1	98.1	18.0
	04/12/07		12B (0' -1')	<0.003	<0.016	<0.061	285	285	23.6
	10/09/07		12B (0' -1')	<0.003	<0.017	<0.055	886	886	6.54
	03/13/08		12B (0' -1')	<0.003	<0.020	<0.068	569	569	36.6
	10/06/08		12B (0' -1')	<0.001	<0.008	<15.8	243	243	<5.00
	03/25/09		12B (0' -1')	<0.050	<0.300	<10	67.8	67.8	---
	10/01/09		12B (0' -1')	<0.050	<0.300	<10	<10	<20	<16
	04/07/10		12B (0' -1')	<0.050	<0.300	<10	<10	<20	<16

Table 1
Summary of BTEX, TPH, and Chloride Concentrations - Soil Analytical Results

Cell No. Ltr.	Sample Date	Sample Zone	Sample ID (Depth)	Benzene (mg/kg)	BTEX (mg/kg)	GRO C6-C10 (mg/kg)	DRO C10-C28 (mg/kg)	TPH C6-C28 (mg/kg)	Chloride (mg/kg)
12C	04/17/07	Background	12C (2' -3')	<0.003	<0.017	<0.053	<2.90	<2.90	<4.97
	03/02/06	Vadose	SS-C (2' -3')	<0.025	<0.1	<10	<10	*<20*	42.8
	03/02/06		SS-D (2' -3')	<0.025	<0.125	<10	<10	*<20*	4.92
	10/25/06		12C-1 (3' - 4')	<0.025	<0.125	<10	<10	*<10*	15.0
	10/25/06		12C-2 (3' - 4')	<0.025	<0.125	<10	<10	*<10*	27.6
	04/12/07		12C (2' -3')	<0.003	<0.018	<0.056	<2.73	<2.79	<4.56
	04/12/07		12C-1 (2' -3')	<0.003	<0.017	<0.062	10.1	10.1	<4.98
	10/16/07		12C (2' -3')	<0.003	<0.018	<0.055	<2.68	<2.73	<5.57
	03/20/08		12C (2' -3')	<0.003	<0.017	<0.060	<3.08	*<3.14*	<5.22
	03/20/08		12C-1 (2' -3')	<0.003	<0.018	<0.057	<3.25	*<3.31*	<5.42
	10/06/08		12C (2' -3')	<0.001	<0.008	<15.7	16.6	16.6	<5.00
	10/06/08		12C-1 (2' -3')	<0.001	<0.008	<15.9	67.1	67.1	<5.00
	03/25/09		12C (2' -3')	<0.050	<0.300	<10	<10	*<20*	---
	03/25/09		12C-1 (2' -3')	<0.050	<0.300	<10	<10	*<20*	---
	10/01/09		12C (2' -3')	<0.050	<0.300	<10	<10	*<20*	*<80*
	04/07/10		12C (2' -3')	<0.050	<0.300	<10	<10	*<20*	*<16*
	04/10/07	Treatment	12C (0' -1')	<0.003	<0.016	<0.063	175	175	*<4.99*
	04/10/07		12C-1 (0' -1')	<0.003	<0.016	<0.061	218	218	<4.90
	10/09/07		12C (0' -1')	<0.003	<0.017	<0.053	3.80	3.80	<5.00
	10/09/07		12C-1 (0' -1')	<0.003	<0.018	<0.060	9.95	9.95	<5.07
	03/13/08		12C (0' -1')	<0.003	<0.019	<0.069	236	236	<5.67
	03/13/08		12C-1 (0' -1')	<0.003	<0.018	<0.057	681	681	<5.22
	10/06/08		12C (0' -1')	<0.001	<0.007	<15.4	729	729	<5.00
	10/06/08		12C-1 (0' -1')	<0.001	<0.007	<15.3	36.7	36.7	<5.00
	03/25/09		12C (0' -1')	<0.050	<0.300	<10	<10	<20	---
	03/25/09		12C-1 (0' -1')	<0.050	<0.300	<10	66.6	66.6	---
	10/01/09		12C (0' -1')	<0.050	<0.300	<10	26.4	26.4	<16
	04/07/10		12C (0' -1')	<0.050	<0.300	<10	108	108	16

Table 2
Summary of Metal Concentrations - Soil Analytical Results

Cell No.	Sample Date	Sample Zone	Sample ID (Depth in Ft)	Metals (mg/kg)							
				As	Ag	Ba	Cd	Cr	Pb	Hg	Se
7B	11/29/04	Background	Facility (2' -3')	3.65	<0.25	507	0.341	3.01	0.5	<0.25	<0.2
1A	04/12/07	Background	SS-1A (2' -3')	3.23	<0.094	55.4	0.196	13.4	6.84	<0.016	1.70
	04/10/07	Treatment	1A (0' -1')	1.94	<0.090	62.9	0.111	5.92	3.57	<0.015	0.98
	04/10/07		1A-1 (0' -1')	2.34	1.14	96.2	0.120	5.86	3.37	<0.014	1.14
	10/09/07		1A (0' -1')	1.95	<0.096	73.6	<0.096	5.90	3.37	<0.016	0.313
	10/09/07		1A-1 (0' -1')	2.21	0.150	91.3	0.173	5.76	3.65	<0.015	0.356
	03/13/08		1A (0' -1')	2.29	<0.096	75.0	0.114	5.75	3.27	<0.016	0.730
	03/13/08		1A-1 (0' -1')	1.96	<0.100	64.0	0.105	5.88	3.31	<0.014	0.798
	10/24/06	Vadose	1-A-1 (3' -4')	1.79	0.543	22.0	<0.173	6.83	3.56	0.013	<0.751
	10/24/06		1-A-2 (3' -4')	1.09	0.435	13.7	<0.173	4.86	2.54	0.012	<0.751
	04/10/07		1A (2' -3')	2.99	<0.089	49.4	0.231	12.4	5.70	<0.014	1.43
	04/12/07		1A-1 (2' -3')	1.79	<0.099	27.0	<0.099	7.22	3.51	<0.015	0.987
	10/15/07		1A (2' -3')	1.27	<0.094	18.2	<0.094	5.68	2.80	<0.015	0.491
	10/15/07		1A-1 (2' -3')	2.82	<0.088	46.8	<0.107	11.5	6.09	<0.015	0.871
	03/20/08		1A (2' -3')	4.18	<0.112	53.5	0.258	14.1	7.64	*<0.083*	1.55
	03/20/08		1A-1 (2' -3')	1.61	<0.097	25.3	<0.097	6.83	3.57	*<0.076*	1.01
	04/07/10		1A (2' -3')	0.877	<0.25	19.5	0.151	3.79	2.88	*<0.1*	<0.5
1B	04/12/07	Background	SS-1B (2' -3')	3.05	<0.086	48.4	0.178	12.5	6.30	<0.014	1.46
	04/10/07	Treatment	1-B (0' -1')	1.82	<0.088	51.5	0.103	6.04	3.63	<0.015	0.943
	04/10/07		1-B-1 (0' -1')	2.05	<0.086	82.2	0.121	5.61	3.58	<0.014	0.850
	10/09/07		1B (0' -1')	1.97	<0.091	85.5	<0.091	6.70	3.91	<0.036	0.350
	10/09/07		1B-1 (0' -1')	1.82	<0.087	70.0	<0.087	6.35	3.72	<0.015	0.292
	03/13/08		1B (0' -1')	1.73	<0.100	44.5	<0.100	6.41	3.56	<0.016	0.758
	03/13/08		1B-1 (0' -1')	2.09	<0.102	126	0.116	6.68	3.97	<0.017	1.04
	10/24/06	Vadose	1-B-1 (3' -4')	2.31	0.210	35.8	<0.173	10.2	5.25	0.009	<0.751
	10/24/06		1-B-2 (3' -4')	0.981	0.099	21.1	<0.173	5.80	3.02	0.007	<0.751
	04/10/07		1B (2' -3')	2.14	<0.087	31.8	0.134	8.30	4.36	<0.015	1.12
	04/12/07		1B-1 (2' -3')	1.73	<0.094	29.3	0.103	7.46	3.75	<0.015	0.950
	10/15/07		1B (2' -3')	1.97	<0.095	39.2	0.101	8.34	4.57	<0.015	0.843
	03/20/08		1B (2' -3')	1.38	<0.094	25.6	0.115	5.90	3.44	<0.015	0.798
	03/20/08		1B-1 (2' -3')	1.88	<0.105	31.3	0.127	7.49	4.01	<0.018	0.889
	04/07/10		1B (2' -3')	0.845	*<0.25*	19.5	0.180	3.95	2.77	*<0.1*	<0.5
	04/07/10		1B-1 (1.5')	1.57	*<0.25*	17.6	0.247	4.25	3.86	*<0.1*	<0.5
1C	04/12/07	Background	SS-1C (2' -3')	2.24	<0.175	46.8	0.142	9.14	5.13	<0.04	1.35
	10/01/09	Vadose	1C (2' -3')	3.15	*<1.0*	68.6	0.422	11.3	6.20	*<0.1*	0.464
	04/07/10		1C (2' -3')	2.00	*<0.25*	53.1	0.320	7.73	6.78	*<0.1*	<0.5
2A	01/07/08	Background	2A (2' -3')	0.839	<0.092	15.4	<0.092	3.77	2.39	<0.016	0.589
2B	01/07/08	Background	2B (2' -3')	1.72	<0.109	26.0	<0.109	5.89	3.67	<0.018	0.990
2C	01/07/08	Background	2C (2' -3')	2.84	<0.100	51.4	0.130	9.64	5.77	<0.016	1.49
10A	01/07/08	Background	10A (2' -3')	1.63	<0.100	34.1	<0.100	6.55	4.09	<0.015	1.19
10B	01/07/08	Background	10B (2' -3')	1.24	<0.2	23.0	<0.3	5.24	3.05	<0.04	1.01
	10/01/09	Vadose	10B (2' -3')	0.862	*<1.0*	21.8	0.180	4.90	2.33	*<0.1*	0.155
	10/01/09		10B-1 (2' -3')	1.08	*<1.0*	22.2	0.209	5.20	2.97	*<0.1*	0.295
	04/07/10		10B (2' -3')	0.988	<0.25	24.9	0.238	4.78	3.63	*<0.1*	<0.5
	04/07/10		10B-1 (2' -3')	1.03	<0.25	29.5	0.222	4.87	4.07	*<0.1*	<0.5
10C	01/07/08	Background	10C (2' -3')	1.43	<0.2	23.5	<0.3	5.31	3.36	<0.04	1.08
	10/07/08	Vadose	10-C (2' -3')	*<5.00*	*<2.00*	12.9	*<2.50*	12.7	*<6.00*	*0.019*	*<5.00*
	10/01/09		10C (2' -3')	1.70	*<1.0*	26.2	0.261	6.40	3.90	*<0.1*	0.485
	10/01/09		10C-1 (2' -3')	1.86	*<1.0*	32.4	0.245	9.10	3.74	*<0.1*	0.401
	04/07/10		10C (2' -3')	1.72	<0.25	42.7	0.292	6.93	5.62	*<0.1*	<0.5
	04/07/10		10C-1 (2' -3')	1.51	<0.25	36.1	0.256	5.39	4.70	*<0.1*	<0.5

Table 2
Summary of Metal Concentrations - Soil Analytical Result

Cell No.	Sample Date	Sample Zone	Sample ID (Depth in Ft)	Metals (mg/kg)							
				As	Ag	Ba	Cd	Cr	Pb	Hg	Se
11A	01/07/08	Background	11A (2' -3')	1.53	<0.2	27.1	<0.3	5.93	3.46	<0.04	0.938
	10/06/08	Vadose	11A (2' -3')	*<5.00*	14.8	112	*<2.50*	14.9	*<6.00*	<0.013	*<5.00*
	10/01/09		11A (2' -3')	2.42	<1.0	40.9	0.272	10.2	4.79	*<0.1*	0.480
	04/07/10		11A (2' -3')	2.07	<0.25	60.8	0.391	7.56	6.39	*<0.1*	<0.5
11B	01/07/08	Background	11B (2' -3')	1.23	<0.2	21.8	<0.3	4.98	3.53	<0.04	0.735
	03/13/08	Treatment	11B (0' -1')	4.66	<0.095	131	0.172	7.57	4.31	<0.014	1.05
	03/13/08		11B-1 (0' -1')	4.47	<0.098	130	0.157	7.09	3.91	<0.015	0.702
	03/20/08	Vadose	11B (2' -3')	2.52	<0.099	47.6	0.168	9.58	5.31	<0.015	1.25
	03/20/08		11B-1 (2' -3')	2.21	<0.100	37.2	0.152	8.91	5.04	<0.017	1.26
	10/06/08		11B (2' -3')	5.75	4.65	18.1	*<2.50*	12.9	14.9	<0.013	*<5.00*
	10/06/08		11B-1 (2' -3')	*<5.00*	*<2.00*	25.0	*<2.50*	15.8	*<6.00*	<0.013	*<5.00*
	10/01/09		11B (2' -3')	2.44	*<1.0*	48.5	0.260	10.2	4.67	*<0.1*	0.378
	10/01/09		11B-1 (2' -3')	1.74	*<1.0*	29.2	0.288	7.60	4.31	*<0.1*	0.189
	04/07/10		11B (2' -3')	0.90	<0.25	18.9	0.181	4.09	3.21	*<0.1*	<0.5
	04/07/10		11B-1 (2' -3')	1.55	<0.25	60.5	0.292	6.91	5.86	*<0.1*	<0.5
11C	10/15/07	Background	SS-11C (2' -3')	2.67	<0.2	300	0.113	5.47	2.62	<0.04	0.490
	10/09/07	Treatment	11C (0' -1')	1.97	<0.090	143	0.102	7.50	4.10	<0.014	0.316
	03/13/08		11C (0' -1')	1.97	<0.100	109	0.109	7.35	3.87	<0.015	0.930
	03/13/08		11C-1 (0' -1')	1.88	<0.101	70.6	0.132	7.49	4.16	<0.014	0.646
	10/15/07	Vadose	11C (2' -3')	2.05	<0.095	50	<0.095	8.49	4.26	<0.015	0.766
	03/20/08		11C-1 (2' -3')	3.01	<0.099	57.7	0.206	11.7	6.19	<0.016	1.16
	03/20/08		11C (2' -3')	2.13	<0.104	231	0.132	1.94	1.09	<0.016	0.367
	10/06/08		11C (2' -3')	8.95	*<2.00*	25.4	*<2.50*	19.7	13.8	<0.014	*<5.00*
	10/01/09		11C (2' -3')	1.07	<1.0	25.2	0.213	5.70	2.86	*<0.1*	<0.100
	04/07/10		11C (2' -3')	1.30	<0.25	38.4	0.271	6.02	5.00	*<0.1*	<0.5
12A	04/12/07	Background	SS-12A (2' -3')	2.90	<0.2	50.8	0.176	11.4	5.61	<0.04	1.40
	04/10/07	Treatment	12A (0' - 1')	3.44	<0.94	73.6	0.218	9.55	7.39	<0.014	1.10
	10/09/07		12A (0' - 1')	7.09	<0.096	72.4	<0.096	6.30	5.23	<0.016	0.264
	03/13/08		12A (0' - 1')	3.81	<0.103	96.3	0.146	7.52	5.62	<0.017	0.841
	04/12/07	Vadose	12A (2' -3')	2.13	*<0.98*	191	0.130	2.85	1.42	<0.015	0.489
	10/16/07		12A (2' -3')	2.08	<0.108	38.7	<0.108	8.81	4.41	<0.016	0.654
	10/16/07		12A-1 (2' -3')	2.14	<0.100	39.4	<0.100	8.56	4.54	<0.017	0.806
	03/20/08		12A (2' -3')	2.51	<0.102	45.0	0.172	9.80	5.35	<0.015	1.21
	10/06/08		12A (2' -3')	*<5.00*	10.7	27.6	*<2.50*	18.7	*<6.00*	<0.015	*<5.00*
	10/01/09		12A (2' -3')	2.76	<1.0	66.7	0.309	12.2	6.16	*<0.1*	0.284
	10/01/09		12A-1 (2' -3')	1.67	<1.0	35.7	0.228	8.50	3.94	*<0.1*	<0.100
	04/07/10		12A (2' -3')	1.82	<0.25	63.3	0.328	7.89	7.27	*<0.1*	<0.5
	04/07/10		12A-1 (2' -3')	1.92	<0.25	55.1	0.375	8.78	7.45	*<0.1*	<0.5
12B	01/07/08	Background	SS-12B (2' -3')	2.58	<0.2	236	0.202	5.76	3.08	<0.04	1.07
	04/10/07	Treatment	12B (0' -1')	4.09	<0.088	214	0.148	9.92	5.05	<0.014	1.18
	10/09/07		12B (0' -1')	2.38	<0.095	140	<0.095	7.19	5.11	<0.015	0.406
	03/13/08		12B (0' -1')	2.31	<0.117	84.2	0.153	8.43	4.76	<0.017	1.23
	03/02/06	Vadose	SS-B (2' -3')	0.89	0.778	19.8	<0.148	5.21	2.34	0.008	<1.29
	03/02/06		SS-C (2' -3')	1.29	<0.377	25.8	<0.148	6.85	2.79	0.017	<1.29
	10/25/06		12B-1 (3' -4')	2.08	0.189	259	<0.346	1.10	0.405	0.010	<1.50
	10/25/06		12B-2 (3' -4')	<0.852	0.208	157	<0.346	<0.488	1.05	0.008	<1.50
	04/12/07		12B (2' -3')	1.98	<0.050	112	0.141	4.92	2.57	<0.008	0.939
	10/16/07		12B (2' -3')	2.19	0.103	175	0.125	7.58	3.51	<0.016	0.690
	03/20/08		12B (2' -3')	2.70	<0.093	59.0	0.188	10.5	6.12	<0.016	1.340
	10/06/08		12B (2' -3')	*<5.00*	*<2.00*	24.9	*<2.50*	21.4	8.25	<0.013	*<5.00*
	10/01/09		12B (2' -3')	1.51	<1.0	37.7	0.276	7.10	3.66	*<0.1*	<0.100
	04/07/10		12B (2' -3')	1.68	<0.25	39.5	0.289	6.38	5.27	*<0.1*	<0.5

Table 2
Summary of Metal Concentrations - Soil Analytical Results

Cell No.	Sample Date	Sample Zone	Sample ID (Depth in Ft)	Metals (mg/kg)							
				As	Ag	Ba	Cd	Cr	Pb	Hg	Se
12C	04/12/07	Background	SS-12C (2' -3')	1.89	<0.2	62.6	0.152	6.43	3.60	<0.04	1.34
	04/10/07	Treatment	12C (0' -1')	1.90	<0.097	36.7	0.128	6.73	4.48	<0.016	0.89
	04/10/07		12C-1 (0' -1')	2.01	<0.093	50.1	0.126	6.89	3.66	<0.014	0.99
	10/09/07		12C (0' -1')	1.18	<0.085	31.2	<0.085	5.03	3.55	<0.037	0.271
	10/09/07		12C-1 (0' -1')	1.61	<0.091	52.5	0.099	6.05	4.01	<0.015	0.263
	03/13/08		12C (0' -1')	1.84	<0.114	117	0.140	6.41	4.16	<0.017	0.981
	03/13/08		12C-1 (0' -1')	2.17	<0.104	89.5	0.149	7.28	5.00	<0.016	0.551
	03/02/06	Vadose	SS-D (2' -3')	1.30	0.092	27.2	<0.148	7.21	3.00	0.021	<1.29
	03/02/06		SS-E (2' -3')	1.05	<0.377	26.4	<0.148	6.90	2.95	0.012	<1.29
	10/25/06		12C-1 (3' -4')	3.34	3.92	834	<0.346	2.20	1.21	0.006	<1.50
	10/25/06		12C-2 (3' -4')	3.57	0.332	833	<0.346	2.06	0.837	0.007	<1.50
	04/17/07		12C (2' -3')	2.04	<0.099	33.8	0.180	7.93	4.47	<0.015	1.72
	04/17/07		12C-1 (2' -3')	2.34	<0.099	38.5	0.205	8.98	4.74	<0.014	1.61
	10/16/07		12C (2' -3')	1.87	<0.099	86.4	0.101	6.77	3.28	<0.016	0.634
	03/20/08		12C (2' -3')	1.39	<0.105	36.6	<0.105	6.06	3.32	<0.016	0.83
	03/20/08		12C-1 (2' -3')	1.88	<0.099	102	0.154	5.84	3.26	<0.016	0.74
	10/06/08		12C (2' -3')	*<5.00*	*<2.00*	21.8	*<2.50*	7.25	*<6.00*	<0.013	<5.00
	10/06/08		12C-1 (2' -3')	9.95	17.5	24.9	<2.50	15.7	9.20	<0.013	<5.00
	10/01/09		12C (2' -3')	1.21	<1.0	44.4	0.257	5.10	2.07	*<0.1*	0.240
	04/07/10		12C (2' -3')	0.87	<0.25	27.8	0.195	4.23	3.32	*<0.1*	<0.5

3.0 Comparison of Hydrocarbon and Chloride Concentrations in Vadose Zone

During the most recent sampling event on April 7, 2010, there were no indications of hydrocarbon concentrations in the vadose zone above reporting limits (RL), which were 0.05 mg/kg for each constituent of BTEX and 20.0 mg/kg for TPH (combined fractions of GRO and DRO). A summary of the most recent BTEX, TPH, and chloride concentrations observed on April 7, 2010, is shown in Table 3. Laboratory analytical reports and chain of custody documentation for the April 7, 2010 sampling event is included in Attachment A.

Table 3
Comparison of BTEX, TPH, and Chloride to Background and RLs

Cell No.	Sample ID	Vadose Zone Concentrations for Hydrocarbon and Chloride Constituents (mg/kg)								
		B	T	E	X	BTEX	GRO	DRO	TPH	Cl
1A	1A	<0.05	<0.05	<0.05	<0.30	<0.45	<10	<10	<20	<16
1B	1B	<0.05	<0.05	<0.05	<0.30	<0.45	<10	<10	<20	<16
	1B-1	<0.05	<0.05	<0.05	<0.30	<0.45	<10	<10	<20	48
1C	1C	<0.05	<0.05	<0.05	<0.30	<0.45	<10	<10	<20	96
10B	10B	<0.05	<0.05	<0.05	<0.30	<0.45	<10	<10	<20	16
	10B-1	<0.05	<0.05	<0.05	<0.30	<0.45	<10	<10	<20	16
10C	10C	<0.05	<0.05	<0.05	<0.30	<0.45	<10	<10	<20	16
	10C-1	<0.05	<0.05	<0.05	<0.30	<0.45	<10	<10	<20	32
11A	11A	<0.05	<0.05	<0.05	<0.30	<0.45	<10	<10	<20	224
11B	11B	<0.05	<0.05	<0.05	<0.30	<0.45	<10	<10	<20	32
	11B-1	<0.05	<0.05	<0.05	<0.30	<0.45	<10	<10	<20	192
11C	11C	<0.05	<0.05	<0.05	<0.30	<0.45	<10	<10	<20	<16
12A	12A	<0.05	<0.05	<0.05	<0.30	<0.45	<10	<10	<20	<16
	12A-1	<0.05	<0.05	<0.05	<0.30	<0.45	<10	<10	<20	16
12B	12B	<0.05	<0.05	<0.05	<0.30	<0.45	<10	<10	<20	96
12C	12C	<0.05	<0.05	<0.05	<0.30	<0.45	<10	<10	<20	<16
Reporting Limit (RL)		0.05	0.05	0.05	0.30	0.45	10	10	20	16

There are no indications that BTEX and TPH have migrated into the vadose zone since there are no constituents of BTEX or TPH that exceeded the higher of the lab RL or the background soil concentrations.

Chloride concentrations in the VZ exceeded the higher of the RL or the background soil concentration only in cells 1B (48 mg/kg), 1C (96 mg/kg), 10C (32 mg/kg), 11A (224 mg/kg), 11B (192 mg/kg), and 12B (96 mg/kg); however, these levels are well below concentrations considered protective of groundwater which is greater than 100 ft below ground surface. In addition, chloride concentrations in the TZ have always been well below concentrations considered protective of groundwater. In fact, with the exception of TPH in active cells 10B and 10C, all treatment zone soils at the JHHC landfarm have been remediated such that they meet the closure performance standards specified in NMAC 19.15.36.15(F) as follows:

(1) Benzene, as determined by EPA SW-846 method 8021B, does not exceed 0.2 mg/kg.

(2) Total BTEX, as determined by EPA SW-846 method 8021B, does not exceed 50 mg/kg.

(3) The GRO and DRO combined fractions (TPH), as determined by EPA SW-846 method 8015M, does not exceed 500 mg/kg.

(4) Chloride, as determined by EPA method 4500-Cl B, does not exceed 1,000 mg/kg (the landfarm is located where ground water is more than 100 feet below the lowest elevation at which the JHHC has placed the treatment zone soils).

It is also important to note that the chloride concentrations in the TZ have consistently been less than the VZ values in cells 1C, 11A, 11B, and 12B, which allows no explanation for a source of chloride mass in the TZ to potentially migrate into the VZ and result in a higher concentration than that measured in the TZ. Chloride concentrations in the 16 mg/kg to 250 mg/kg range, or even up to 1,000 mg/kg when depth to groundwater exceeds 100 ft below ground surface, do not pose a threat of downward migration and are not detrimental to human health or the environment.

4.0 Comparison of Background to Vadose Zone Concentrations for Metal COCs

It is well known that comparing a site concentration to the mean (average) background concentration is an inadequate predictor of contamination. Since it is unlikely that the COCs are uniformly present at the same concentration throughout the soil mass, it is necessary to collect an adequate number of samples from the soil of interest to determine the range or spread of concentrations that may exist. Knowing the variability in COC concentration is crucial since it allows quantification of the amount of uncertainty around the mean that is attributable to variations in soil concentration. Therefore, a statistical approach is being used to assess the possible occurrence of downward migration of trace metal COCs into the VZ. A geochemical correlation method will also be used to evaluate the probability whether certain trace metal COCs are anthropogenic or naturally occurring.

Table 4 below summarizes the methods used for comparisons of background to vadose zone concentrations for trace metal COCs.

Table 4
Methods for Comparison of Background to Vadose Zone Concentrations

Method	Metal Constituent of Concern							
	As	Ag	Ba	Cd	Cr	Pb	Hg	Se
4.1 Background Screening Value	X		X		X	X		X
4.2 Practical Quantitation Limit		X					X	
4.3.1 Unpaired t-test (Welch's)	X			X		X		
4.3.2 Mann-Whitney			X		X			
5.0 Geochemical Correlation	X			X	X	X		

PQL method used for COCs with multiple below detection limit values.
Unpaired t-test method used for COCs with normal distribution pattern.
Mann-Whitney method used for COCs that do not show normal distribution pattern.
Geochemical correlation used to evaluate anthropogenic vs. naturally occurring.

4.1 Background Screening Values for Trace Metal COCs

The metal COC concentrations of sixteen (16) background samples collected at the facility between November 29, 2004 and January 7, 2008, were evaluated to determine a background screening value (BSV). Background screening values for arsenic (As), silver (Ag), barium (Ba), cadmium (Cd), chromium (Cr), lead (Pb), mercury (Hg), and selenium (Se) were conservatively determined by adding two standard deviations (2σ) to the mean value (μ) or substituting the highest recorded background value, whichever was higher, as shown in Table 5 below. Doubling the mean or adding three standard deviations to the mean would be less conservative. A background data set composed of only 16 samples for a 200 acre facility does not span the full range of the naturally occurring levels present; therefore use of the highest background concentration observed for a metal COC is also a very conservative approach. Trace metal COCs above the background screening level are then further evaluated using applicable statistical and geochemical methods. Mean background values for available trace metal COCs reported by the United States Geological Survey (Professional Paper 1270; *Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States*; 1984) (Attachment B) are also provided for comparison.

Table 5
Background Screening Values for Trace metal COCs

Cell No.	Date	Background Concentrations for Metal Constituent of Concern (mg/kg)							
		As	Ag	Ba	Cd	Cr	Pb	Hg	Se
7B	11/29/04	3.65	<0.25	507	0.341	3.01	0.5	<0.25	<0.2
1A	04/12/07	3.23	<0.094	55.4	0.196	13.4	6.84	<0.016	1.70
1B	04/12/07	3.05	<0.086	48.4	0.178	12.5	6.30	<0.014	1.46
1C	04/12/07	2.24	<0.175	46.8	0.142	9.14	5.13	<0.04	1.35
2A	01/07/08	0.839	<0.092	15.4	<0.092	3.8	2.39	<0.016	0.589
2B	01/07/08	1.72	<0.109	26.0	<0.109	5.89	3.67	<0.018	0.990
2C	01/07/08	2.84	<0.100	51.4	0.130	9.64	5.77	<0.016	1.49
10A	01/07/08	1.63	<0.100	34.1	<0.100	6.55	4.09	<0.015	1.19
10B	01/07/08	1.24	<0.2	23.0	<0.100	5.24	3.05	<0.04	1.01
10C	01/07/08	1.43	<0.2	23.5	<0.101	5.31	3.36	<0.04	1.08
11A	01/07/08	1.53	<0.2	27.1	<0.102	5.93	3.46	<0.04	0.938
11B	01/07/08	1.23	<0.2	21.8	<0.101	4.98	3.53	<0.04	0.735
11C	10/15/07	2.67	<0.2	300	0.113	5.47	2.62	<0.04	0.490
12A	04/12/07	2.90	<0.2	50.8	0.176	11.4	5.61	<0.04	1.40
12B	01/07/08	2.58	<0.2	236	0.202	5.76	3.08	<0.04	1.07
12C	04/12/07	1.89	<0.2	62.6	0.152	6.43	3.60	<0.04	1.34
Mean (μ)		2.17	<0.163	95.6	0.181	7.15	3.94	<0.044	1.12
St Dev (σ)		0.838	<0.055	136	0.067	3.11	1.63	<0.056	0.345
Mean + 2 St Dev ($\mu + 2\sigma$)		3.84	<0.273	368	0.315	13.4	7.20	<0.156	1.81
Background Screening Value		3.84	<0.273	507	0.341	13.4	7.20	<0.156	1.81
Average (USGS PP 1270)		7.2	---	580	---	54	19	0.09	0.39

Concentrations below the MDLs were not included in calculating the mean or standard deviation.
Background screening value is the greater of $\mu + 2\sigma$ or highest observed concentration, whichever is greater.

4.2 Practical Quantitation Limits for Trace metal COCs

Non-detect results are not applicable in calculating background screening values, as their replacement values are assumed quantities with no measure of uncertainty. Manipulating the non-detect data would only obscure the calculation of a background screening value. Thus, in cases of multiple non-detect occurrences, such as with silver and mercury, the Practical Quantitation Limit (PQL) which is similar to the reporting limit (RL), can be used for comparison to vadose zone concentrations. There is no single method for defining or determining the PQL. Many PQLs listed in the federal regulations are based on consensus rather than rigorous technical assessments. Soils usually present even more difficulty for analysis compared to groundwater because they have a more complex matrix to separate the contaminants from, often there are more contaminants present, and usually a smaller analytical sample is used. Also, there is often a wider range of contaminant concentrations to deal with. For these reasons, PQLs for soils are even more subject to variation than for groundwater. Laboratories provide a PQL or RL that is typically 3 to10 times the method detection limit (MDL) or instrument detection limit (IDL) and is considered the lowest concentration that can be accurately measured, as opposed to

just detected. Therefore, since the background sample RLs vary for each analysis, a single practical quantitation limit (PQL) for each trace metal COC was conservatively determined by adding three standard deviations (3σ) to the mean value (μ) of the RLs. In the case of silver and mercury, PQLs of 0.588 mg/kg, and 0.118 mg/kg, respectively, were determined as shown in Table 6 below.

Table 6
Practical Quantitation Limits of Background Samples

Cell	Reporting Limits for Metal Constituents of Concern (mg/kg)							
	As	**Ag**	**Ba**	**Cd**	**Cr**	**Pb**	**Hg**	**Se**
1A	0.0935	0.467	0.467	0.0935	0.467	0.0155	0.0935	0.140
1B	0.0862	0.431	0.431	0.0862	0.431	0.0155	0.0862	0.129
1C	0.0877	0.439	0.439	0.0877	0.439	0.0155	0.0877	0.132
2A	0.0918	0.459	0.459	0.0918	0.459	0.0157	0.0918	0.138
2B	0.1090	0.546	0.546	0.1090	0.546	0.0180	0.1090	0.164
2C	0.1000	0.502	0.502	0.1000	0.502	0.0163	0.1000	0.151
10A	0.1000	0.501	0.501	0.1000	0.501	0.0145	0.1000	0.150
10B	0.1000	0.501	0.501	0.1000	0.501	0.0157	0.1000	0.150
10C	0.1010	0.503	0.503	0.1010	0.503	0.0152	0.1010	0.151
11A	0.1020	0.509	0.509	0.1020	0.509	0.0163	0.1020	0.153
11B	0.1010	0.505	0.505	0.1010	0.505	0.0162	0.1010	0.151
11C	0.1060	0.531	0.531	0.1060	0.531	0.0173	0.1060	0.159
12A	0.0971	0.485	0.485	0.0971	0.485	0.0141	0.0971	0.146
12B	0.0971	0.485	0.485	0.0971	0.485	0.0146	0.0971	0.146
12C	0.0877	0.439	0.439	0.0877	0.439	0.0146	0.0877	0.132
Mean (μ)	0.0973	0.487	0.487	0.0973	0.487	0.0157	0.0973	0.146
St Dev (σ)	0.0067	0.0338	0.0338	0.0067	0.0338	0.0011	0.0067	0.010
PQL = (μ + 3σ)	0.118	0.588	0.588	0.118	0.588	0.019	0.118	0.176

Background screening values for trace metal COCs in Table 5 and the PQLs in Table 6 above are compared with the most recent sampling results on April 7, 2010, in Table 7 below to determine if the recent vadose zone concentrations for trace metal COCs exceed the higher of background screening values or PQLs and further evaluated.

Table 7
Vadose Zone Concentrations for Metal Constituents of Concern
(April 7, 2010)

Cell No.	Sample ID	Vadose Zone Concentrations for Metal Constituents of Concern (mg/kg) Sampling Date: April 7, 2010							
		As	Ag	Ba	Cd	Cr	Pb	Hg	Se
1A	1A	1.61	<0.25	19.5	0.151	3.79	2.88	<0.1	<0.5
1B	1B	0.845	<0.25	19.5	0.180	3.95	2.77	<0.1	<0.5
	1B-1	1.57	<0.25	17.6	0.247	4.25	3.86	<0.1	<0.5
1C	1C	2.00	<0.25	53.1	0.32	7.73	6.78	<0.1	<0.5
10B	10B	0.988	<0.25	0.988	0.238	4.78	3.63	<0.1	<0.5
	10B-1	1.03	<0.25	1.03	0.222	4.87	4.07	<0.1	<0.5
10C	10C	1.72	<0.25	42.7	0.292	6.93	5.62	<0.1	<0.5
	10C-1	1.51	<0.25	36.1	0.256	5.39	4.70	<0.1	<0.5
11A	11A	2.07	<0.25	60.8	**0.391**	7.56	6.39	<0.1	<0.5
11B	11B	0.90	<0.25	18.9	0.181	4.09	3.21	<0.1	<0.5
	11B-1	1.55	<0.25	60.5	0.292	6.91	5.86	<0.1	<0.5
11C	11C	1.30	<0.25	38.4	0.271	6.02	5.00	<0.1	<0.5
12A	12A	1.82	<0.25	63.3	0.328	7.89	**7.27**	<0.1	<0.5
	12A-1	1.92	<0.25	55.1	**0.375**	8.78	**7.45**	<0.1	<0.5
12B	12B	1.68	<0.25	39.5	0.289	6.38	5.27	<0.1	<0.5
12C	12C	0.869	<0.25	27.8	0.195	4.23	3.32	<0.1	<0.5
Background screening value		3.84	0.273	507	0.341	13.4	7.20	0.156	1.81
Practical Quantitation Limit		0.118	0.588	0.588	0.118	0.588	0.019	0.118	0.176

Values in boldface type indicate trace metal COC concentrations in vadose zone exceed the higher of the PQL, BSV, or highest background concentration observed.

Although it was not required by permit, analyses for metals in the treatment zone (TZ) were performed twice in 2007 and once in 2008 (Table 2). It is important to note that most of those analyses do not indicate any metal COC concentrations in the TZ above the background screening values, which supports the conclusion that trace metal concentrations in the VZ are naturally higher (non-anthropogenic) than the TZ. It is also important to note that most metal COC concentrations in the TZ were actually less than the VZ values, which allows no explanation for a source of metal COC mass in the TZ to potentially migrate into the VZ and result in a higher concentration than that measured in the TZ.

4.3 Statistical Comparisons of Background to VZ Concentrations for Trace metal COCs

Arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), and lead (Pb) were also evaluated using commercial statistical software - GraphPad **InStat**® (version 3.10) - utilizing methods described further in the following sections. Sixteen (16) random background concentrations for these 5 trace metal COCs were compared with the most recent 16 random VZ concentrations at the JHHC landfarm. Silver (Ag), mercury (Hg), and selenium (Se) were not included in the following statistical evaluation because multiple non-detect values in either or both data sets

cannot be used. Output from the statistical analyses is included in Attachment C and a copy of the GraphPad **InStat**® documentation is included in Attachment D.

The first step is to determine if the samples are normally distributed (Gaussian bell-shaped pattern) such that the appropriate statistical test can be applied. It is important to note that with a small data set of 16 or fewer soil samples it is difficult to conclude if the values truly are normally distributed, particularly when values are below detection limits. Statisticians agree that normality tests are most useful when the sample size is a few dozen or greater, and no less than a dozen. **InStat**® tests for normality using the Kolmogorov-Smirnov (KS) test. The KS value quantifies the discrepancy between the distribution of the data and an ideal Gaussian distribution. A summary of data sets that pass or fail the normal distribution test are listed in Table 8 below.

Table 8
Normal Distribution Pattern of Sample Sets

COC	Passed Normality Test?	
	Background	Vadose Zone
Arsenic (As)	Yes (P>0.10)	Yes (P>0.10)
Barium (Ba)	No (P<0.0001)	Yes (P>0.10)
Cadmium (Cd)	Yes (P=0.0648)	Yes (P>0.10)
Chromium (Cr)	No (P=0.0039)	Yes (P>0.10)
Lead (Pb)	Yes (P>0.10)	Yes (P>0.10)

To pass the normality test the P value should be 0.05 (5%) or greater. All data sets passed the normality test with the exception of the background samples for barium and chromium. The barium background data set had a very low P value due to the wide range in values (15.4 mg/kg to 507 mg/kg) that were not normally distributed. The chromium background data set also failed the normality test with a probability value (P) of 0.0039 due to a discordant range in values. The cadmium background data set narrowly passed the normality test with a probability value (P) of 0.0648.

4.3.1 Unpaired t test with Welch Correction

An unpaired t-test (with Welch correction) can be applied for arsenic, cadmium, and lead where both the background and VZ sample pairs passed the normality test to determine if the VZ mean is significantly greater than or similar to the background mean. The GraphPad **InStat**® output for these tests and others are included in Attachment B.

The P value is a probability, with a value ranging from zero to one. If the sample populations have the same mean, the P value indicates the probability of observing such a large difference (or larger) between sample means. If the P value is small, one could conclude that the difference is quite unlikely to be caused by random sampling and the populations have different means.

Arsenic showed a significant (two-tailed P value is 0.0064) difference between the mean background and the mean VZ samples (-0.7054); however, the mean background was *greater* than the mean VZ data set, thus the t-test indicates no evidence of migration of arsenic to the VZ.

Cadmium showed a significant (two-tailed P value is 0.0091) difference between the mean background and the mean VZ samples (0.08314), however the background data set was limited to only nine samples and an unequal sample size to the sixteen VZ samples; therefore, the difference can be attributed to chance (Type I error) and the test is inconclusive. Larger background and VZ data sets would be more appropriate for application of this statistical method. It is also important to note that there is a small range of cadmium concentrations in both the background and VZ data sets, with a minimum 0.113 mg/kg value compared to a maximum of 0.391 mg/kg). Also, this small range of values represents only one to four times the RL (~0.1 mg/kg).

Lead showed no significant (two-tailed P value is 0.1065) difference between the mean background and the mean VZ samples (0.9425), therefore, the t-test indicates no evidence of migration of lead to the VZ.

4.3.2 Non-parametric Mann-Whitney Test

Where either of the sample pairs do not approximate a normal distribution, as was the case for the barium and chromium background samples, then a non-parametric test (Mann-Whitney) can be used to determine if the VZ median is significantly greater than or similar to the background median.

Barium showed no significant (two-tailed P value is 0.2504) difference between the median background and the median VZ samples (-10.35). In addition, the background median was *greater* than the VZ median; therefore, the non-parametric Mann-Whitney test indicates no evidence of migration of barium to the VZ.

Chromium showed no significant (two-tailed P value is 0.3414) difference between the median background and the median VZ samples (-0.205). In addition, the background median was *greater* than the VZ median; therefore, the non-parametric Mann-Whitney test indicates no evidence of migration of chromium to the VZ.

5.0 Geochemical Evaluation Method

The geochemical evaluation methodology described in this section was used to distinguish samples that may be anthropogenic from those that contain only naturally occurring levels of COCs. VZ-to-background comparisons of trace elements in soil based solely on statistical techniques are prone to high false positive indications, particularly when there is a small data set making it hard to distinguish real differences from random variability. Trace element distributions in soil tend to span a wide range of concentrations and can be highly right-skewed, approximating lognormal distributions. Background data sets, such as at the JHHC landfarm, are typically too small to capture this range. The geochemical correlations used herein are predicated on natural associations of trace elements with specific minerals in the soil matrix. Linear trends with positive slopes are expected for scatter plots of specific trace versus major elements in non-anthropogenic samples. Individual samples identified by their positions significantly *above* the trend may be suspect of anthropogenic origin. In addition to pinpointing which samples may be anthropogenic, this technique provides mechanistic explanations for naturally elevated element concentrations, information that a purely statistical approach cannot provide. Such geochemical correlations have been successfully performed at numerous facilities undergoing risk-based and remedial assessments across the United States, and have been long used for geochemical prospecting in the mining industry. A copy of a relevant paper (*Identifying Metals Contamination in Soil: A Geochemical Approach*; by Myers & Thorbjornsen) using this technique is included in Attachment E.

Divalent metals such as arsenic, cadmium, chromium, and lead tend to form cationic species in solution and are attracted to clays and fine-grained soils, which tend to maintain a negative charge. Iron, manganese, and aluminum in the form of oxides, hydroxides, oxy-hydroxides, and hydrous oxides, can be a major component of clays and fine-grained soils, and have an affinity to absorb certain trace elements, particularly arsenic, cadmium, chromium, and lead. Iron, manganese, and aluminum oxides are typically fine-grained, amorphous or poorly crystallized and have a large surface area, high cation exchange capacity, and a high negative surface charge. In soils the iron and manganese oxides also commonly occur as coatings on minerals and finely dispersed particles. Soils characterized by a high percentage of finer-grained material, will thus exhibit higher concentrations of iron and manganese with proportionally higher concentrations of associated trace elements.

Geochemical correlation plots were used to depict VZ comparisons of arsenic, cadmium, chromium, and lead concentrations against iron (Fe) and manganese (Mn) concentrations. There have been no analyses for aluminum at the site; however, analyses for iron and manganese from the VZ were obtained during the most recent sampling event on April 7, 2010. Therefore, iron and manganese can be evaluated against arsenic, cadmium, chromium, and lead to distinguish anthropogenic sources of COCs from the naturally occurring trend. The samples with the highest COC concentrations also contain the highest iron concentrations, indicating that those samples are preferentially enriched in iron oxides. The first few feet of native vadose zone soils at the JHHC landfarm primarily consist of a reddish-brown silty fine sand overlying an indurated caliche layer. The soil lithology at the site is consistent with relatively abundant amounts of major elements of iron, manganese, and aluminum. If contamination was present in one or more site samples, they would contain an excess amount of the COC relative to iron or manganese and hence a different COC/iron or COC/manganese ratio, and would lie above the linear trend line. It

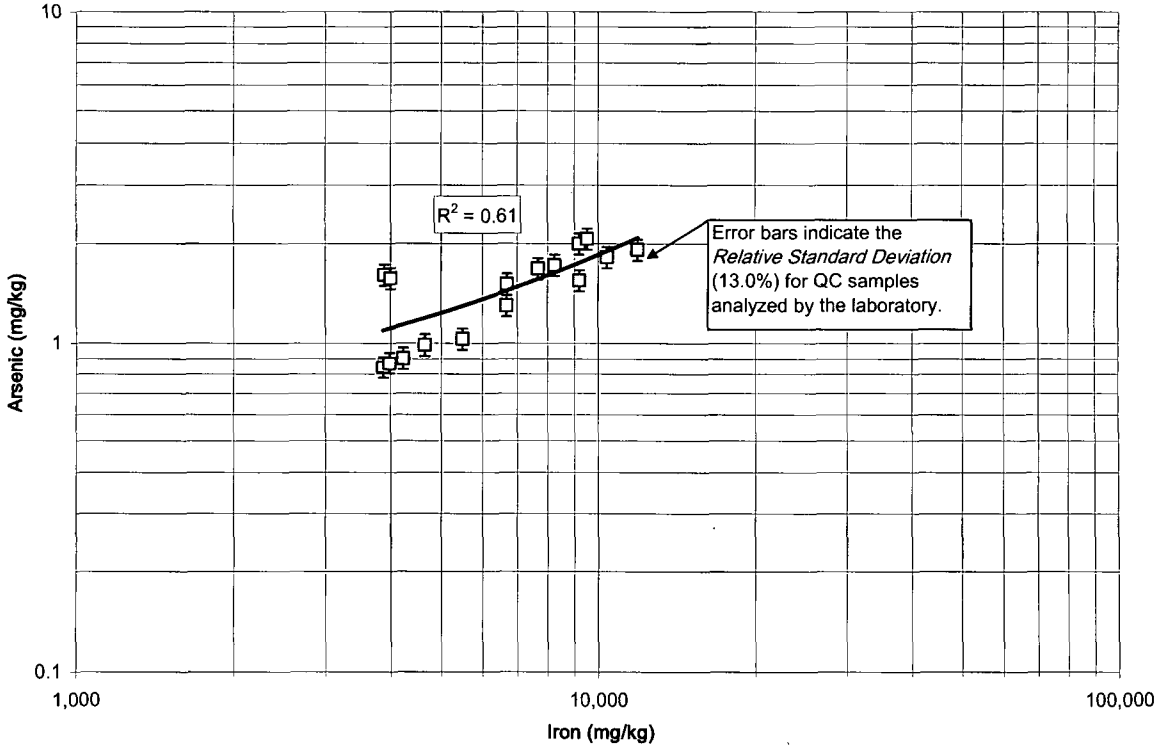
is beyond the scope of this report and project to identify the many possible common naturally occurring mineral associations between the trace elements (metal COCs) and major elements (aluminum, iron, and manganese). For example, arsenic is present in more than 200 mineral species, the most common of which is arsenopyrite.

Non-detect samples are not included in the geochemical correlation plots, as their replacement values (such as one-half the Practical Quantitation Limit) are assumed quantities that have no meaning in the geochemical context. Manipulating the non-detect data would only obscure the relationships that the correlation plots attempt to depict.

5.1 Geochemical Evaluation of Arsenic and Iron

Arsenic concentrations in the VZ during the most recent sampling event on April 7, 2010, did not exceed the background screening values established in section 4.1 and also passed the unpaired t-test in which there was no significant difference between the background mean and vadose zone mean; however the geochemical correlation between arsenic plotted against iron is presented herein to further demonstrate the naturally occurring trend of these elements. The graph below depicts a strong correlation ($R^2 = 0.61$) between arsenic and iron.

Figure 2 - Arsenic versus Iron in Vadose Zone



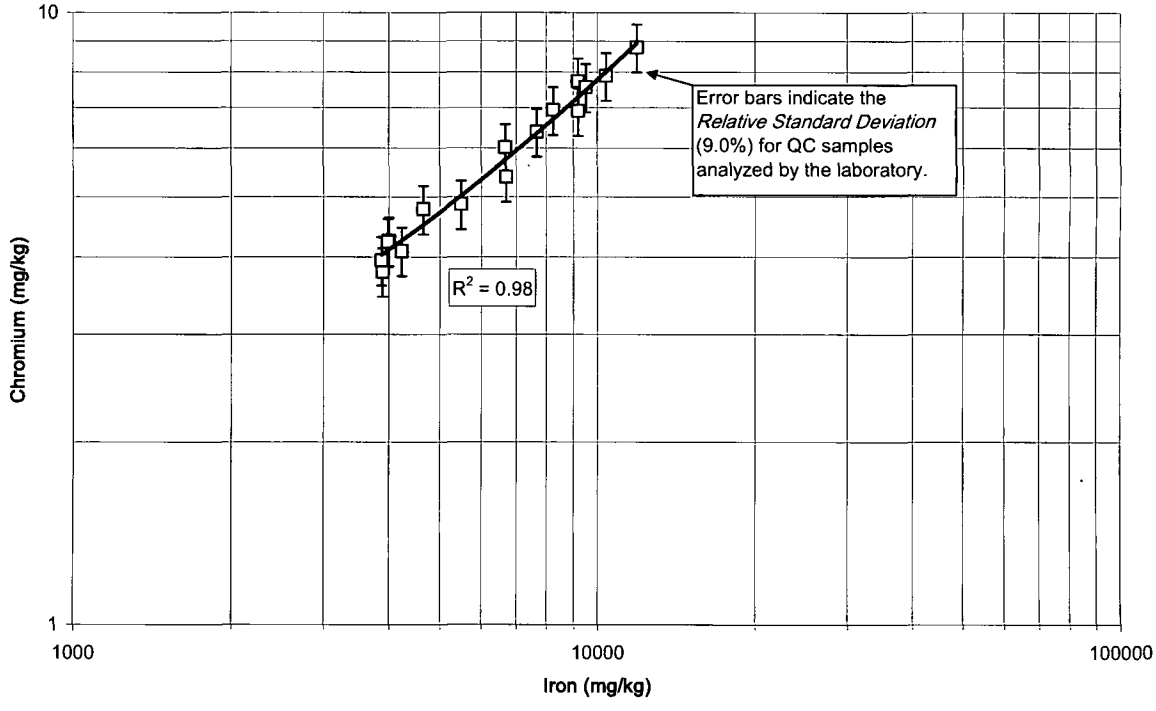
If arsenic contamination was present in one or more site samples, they would contain an excess amount of arsenic relative to iron and hence a different As/Fe ratio, and would lie off the trend.

No such samples are present; therefore there is no indication of arsenic migrating downward into the VZ.

5.2 Geochemical Evaluation of Chromium and Iron

Chromium concentrations in the VZ during the most recent sampling event on April 7, 2010, did not exceed the background screening values established in section 4.1 and also passed the non-parametric Mann-Whitney test in which there was no significant difference between the background median and vadose zone median; however the geochemical correlation between chromium plotted against iron is presented herein to further demonstrate the naturally occurring trend of these elements. The graph below depicts a strong correlation ($R^2 = 0.98$) between chromium and iron.

Figure 3 - Chromium versus Iron in Vadose Zone

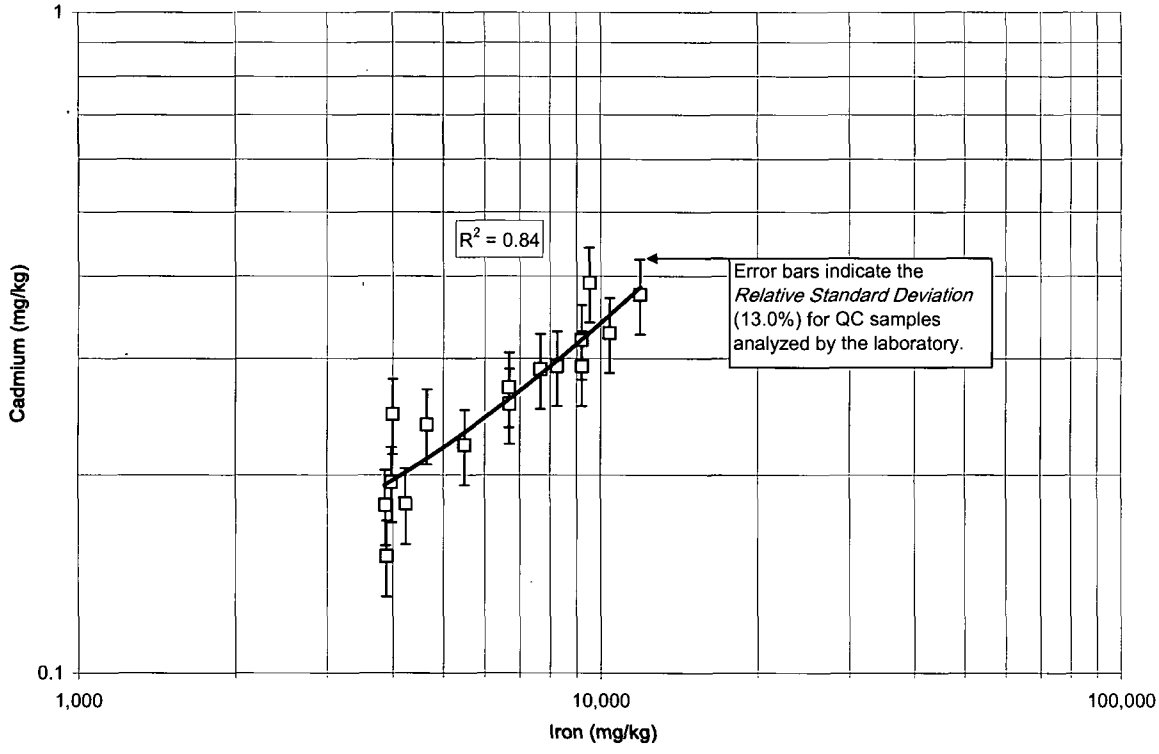


If chromium contamination was present in one or more site samples, they would contain an excess amount of chromium relative to iron and hence a different Cr/Fe ratio, and would lie off the trend. No such samples are present; therefore there is no indication of chromium migrating downward into the VZ.

5.3 Geochemical Evaluation of Cadmium and Iron

Cadmium concentrations in the VZ during the most recent sampling event on April 7, 2010, did not exceed the background screening value of 0.341 mg/kg established in section 4.1 with the exception of a slight exceedence in cell 11A (0.391 mg/kg) and cell 12A (0.375 mg/kg). The unpaired t test for cadmium was inconclusive due to the limited background data set and likely non-random distribution of samples. Nonetheless, the geochemical correlation between cadmium plotted against iron is presented herein to further demonstrate the naturally occurring trend of these elements together. The following graph depicts a strong correlation ($R^2 = 0.84$) between cadmium and iron.

Figure 4 - Cadmium versus Iron in Vadose Zone

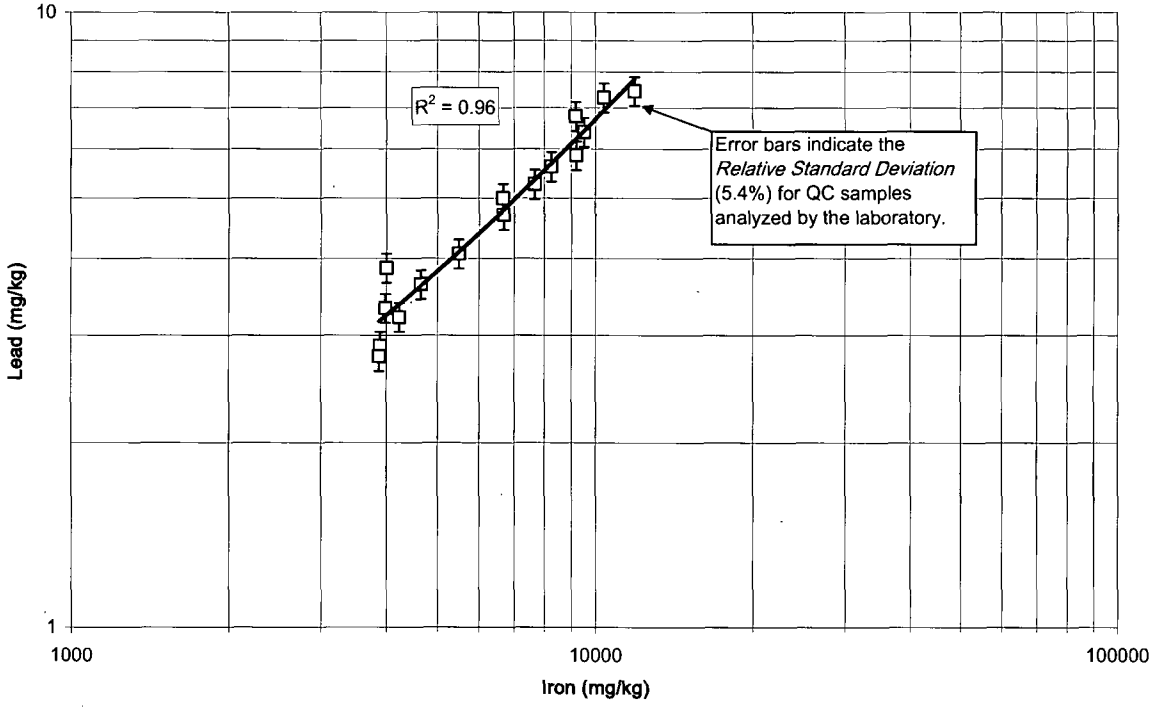


If cadmium contamination was present in one or more site samples, they would contain an excess amount of cadmium relative to iron and hence a different Cd/Fe ratio, and would lie off the trend. No such samples are present; therefore there is no indication of cadmium migrating downward into the VZ.

5.4 Geochemical Evaluation of Lead and Iron

Lead concentrations in the VZ during the most recent sampling event on April 7, 2010, did not exceed the background screening value of 7.20 mg/kg established in section 4.1 with the exception of a slight exceedence in cell 12A (7.27 mg/kg and 7.45 mg/kg). Lead also passed the unpaired t-test in which there was no significant difference between the background mean and vadose zone mean. Nonetheless, the geochemical correlation between lead plotted against iron is presented herein to further demonstrate the naturally occurring trend of these elements together. The graph below depicts a strong correlation ($R^2 = 0.96$) between lead and iron.

Figure 5 - Lead versus Iron in Vadose Zone

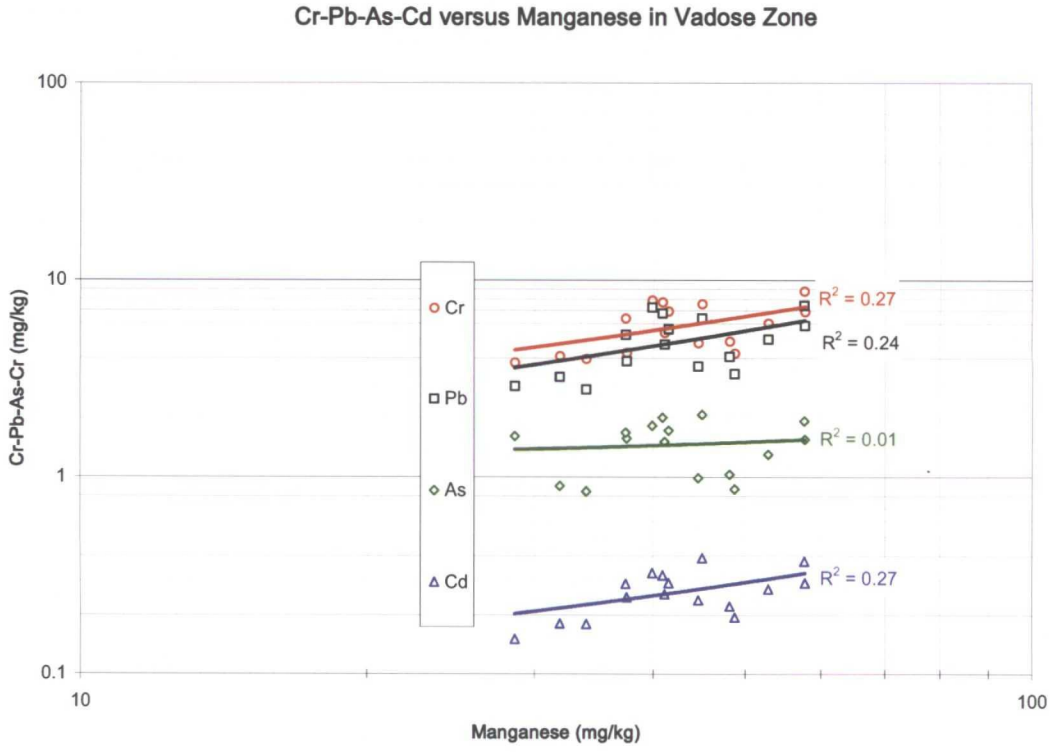


If lead contamination was present in one or more site samples, they would contain an excess amount of lead relative to iron and hence a different Pb/Fe ratio, and would lie off the trend. No such samples are present; therefore there is no indication of lead migrating downward into the VZ.

5.5 Geochemical Evaluation of Trace metal COCs and Manganese

Arsenic, chromium, cadmium, and lead concentrations were also plotted against manganese to evaluate if there was a common association between the trace elements with manganese, as depicted in the following graph.

Although the goodness of fit (R^2) values for these comparisons were lower than those for iron, distinct positive slopes are evident, indicating that generally higher manganese concentrations correlated with higher concentrations of the trace elements.



6.0 Conclusions

As described in the previous sections, several methods including PQL and background screening value comparisons, statistical analysis, increasing/decreasing trends, relational trends in the TZ and VZ, and geochemical correlations, were used to rigorously assess the vadose zone monitoring data to determine if any release of COCs occurred from JHHC operations at the landfarm. A summary of conclusions from this assessment is listed below:

- There are no indications that BTEX and TPH have migrated into the vadose zone since there are no constituents of BTEX or TPH that exceeded the higher of the PQL or the background soil concentrations.
- Chloride concentrations in the VZ exceeded the laboratory reporting limit in cells 1B, 1C, 10C, 11A, 11B, and 12B, however, chloride concentrations in the 16 mg/kg to 250 mg/kg range should be considered as naturally occurring and non-anthropogenic. In addition, there are no indications that chloride has migrated into the vadose zone.
- Certain trace metal COCs (cadmium and lead) slightly exceeded the higher of the PQL or background screening value; however, statistical analysis and geochemical correlation plots show no indications that trace metal COCs have migrated into the vadose zone.

Based on this assessment there is no indication of COCs migrating downward to the vadose zone nor is there any indication a release has occurred due to JHHC operations. Activities and operations conducted at the JHHC landfarm are protective of public health, safety and the environment.

ATTACHMENT A

Laboratory Analytical Reports

And

Chain of Custody Documentation

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

April 27, 2010

Carolyn Haynes
John H. Hendrix Corporation
P.O. Box 910
Eunice, NM 88231

Re: JHHC Surface Waste Management Facility (NM-02-0021)

Enclosed are the results of analyses for sample number H19626, received by the laboratory on 04/09/10 at 11:30 am.

Cardinal Laboratories is accredited through Texas NELAP for:

Method SW-846 8021	Benzene, Toluene, Ethyl Benzene, and Total Xylenes
Method SW-846 8260	Benzene, Toluene, Ethyl Benzene, and Total Xylenes
Method TX 1005	Total Petroleum Hydrocarbons

Certificate number T104704398-08-TX. Accreditation applies to solid and chemical materials and non-potable water matrices.

Cardinal Laboratories is accredited though the State of Colorado Department of Public Health and Environment for:

Method EPA 552.2	Haloacetic Acids (HAA-5)
Method EPA 524.2	Total Trihalomethanes (TTHM)
Method EPA 524.2	Regulated VOCs (V2, V3)

Accreditation applies to public drinking water matrices.

Total Number of Pages of Report: 17 (includes Chain of Custody)

Sincerely,

Celey D. Keene
Laboratory Director

This report conforms with NELAP requirements.

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575) 394-2653

Receiving Date: 04/09/10
Reporting Date: 04/26/10
Project Number: JOHN H. HENDRIX CORP.
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2°C
Sample Received By: AB
Analyzed By: JM

TOTAL METALS

LAB NO.	SAMPLE ID	As (mg/kg)	Ag (mg/kg)	Ba (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Pb (mg/kg)	Hg (mg/kg)	Se (mg/kg)
ANALYSIS DATE:		04/22/10	04/22/10	04/22/10	04/22/10	04/22/10	04/22/10	04/20/10	04/22/10
H19626-2	10B (2' - 3')	0.988	<0.25	24.9	0.2383	4.78	3.63	< 0.1	<0.5
H19626-4	10B-1 (2' - 3')	1.03	<0.25	29.5	0.2217	4.87	4.07	<0.1	<0.5
H19626-6	10C (2' - 3')	1.72	<0.25	42.7	0.2924	6.93	5.62	<0.1	<0.5
H19626-8	10C-1 (2' - 3')	1.51	<0.25	36.1	0.2561	5.39	4.70	<0.1	<0.5
H19626-10	11A (2' - 3')	2.07	<0.25	60.8	0.3914	7.56	6.39	<0.1	<0.5
H19626-12	11B (2' - 3')	0.895	<0.25	18.9	0.1809	4.09	3.21	<0.1	<0.5
H19626-14	11B-1 (2' - 3')	1.55	<0.25	60.5	0.2921	6.91	5.86	<0.1	<0.5
H19626-16	11C (2' - 3')	1.30	<0.25	38.4	0.2709	6.02	5.00	<0.1	<0.5
H19626-18	12A (2' - 3')	1.82	<0.25	63.3	0.3282	7.89	7.27	<0.1	<0.5
H19626-20	12A-1 (2' - 3')	1.92	<0.25	55.1	0.3746	8.78	7.45	<0.1	<0.5
H19626-22	12B (2' - 3')	1.68	<0.25	39.5	0.2886	6.38	5.27	<0.1	<0.5
H19626-24	12C (2' - 3')	0.869	<0.25	27.8	0.1948	4.23	3.32	<0.1	<0.5
H19626-26	1A (2'-3')	0.877	<0.25	19.5	0.1510	3.79	2.88	<0.1	<0.5
H19626-28	1B (2'-3')	0.845	<0.25	17.6	0.1797	3.95	2.77	<0.1	<0.5
H19626-30	1B-1 (1.5')	1.57	<0.25	77.2	0.2466	4.25	3.86	<0.1	<0.5
H19626-32	1C (2' - 3')	2.00	<0.25	53.1	0.3198	7.73	6.78	<0.1	<0.5
Quality Control		0.0505	0.0488	0.0496	0.0526	0.051	0.0510	0.0021	0.248
True Value QC		0.050	0.050	0.050	0.050	0.050	0.050	0.0020	0.250
% Recovery		101	97.6	99.2	105	102	102	105	99.2
Relative Standard Deviation		7.4	<0.1	4.1	13.0	9.0	5.4	4.9	<0.1
METHODS: EPA 600/4-91/010,3050		6020	6020	6020	6020	6020	6020	7471	6020

Analyses subcontracted to Green Analytical Laboratories, a subsidiary of Cardinal Laboratories.

Chemist

04/27/10
Date

H19626M J Hendrix

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575) 394-2653

Receiving Date: 04/09/10
Reporting Date: 04/26/10
Project Number: JOHN H HENDRIX CORP.
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2°C
Sample Received By: AB
Analyzed By: JM

TOTAL METALS

LAB NO.	SAMPLE ID	Cu (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
ANALYSIS DATE:		04/22/10	04/16/10	04/22/10	04/22/10
H19626-2	10B (2' - 3')	2.12	4,650	44.6	8.35
H19626-4	10B-1 (2' - 3')	2.13	5,490	48.1	8.95
H19626-6	10C (2' - 3')	1.67	8,250	41.5	11.7
H19626-8	10C-1 (2' - 3')	1.93	6,690	41.1	9.91
H19626-10	11A (2' - 3')	13.6	9,520	45.0	15.0
H19626-12	11B (2' - 3')	1.46	4,230	31.9	5.25
H19626-14	11B-1 (2' - 3')	2.45	9,210	57.7	11.3
H19626-16	11C (2' - 3')	2.06	6,680	52.8	11.0
H19626-18	12A (2' - 3')	1.87	10,400	39.9	12.9
H19626-20	12A-1 (2' - 3')	2.29	11,900	57.6	15.7
H19626-22	12B (2' - 3')	1.67	7,670	37.4	10.8
H19626-24	12C (2' - 3')	1.97	3,980	48.7	6.61
H19626-26	1A (2'-3')	1.34	3,890	28.6	4.50
H19626-28	1B (2'-3')	1.45	3,870	34.0	4.81
H19626-30	1B-1 (1.5')	1.74	4,000	37.5	9.93
H19626-32	1C (2' - 3')	2.10	9,190	40.9	15.1
Quality Control		0.0517	5.23	0.0492	0.044
True Value QC		0.050	5.00	0.050	0.050
% Recovery		103	105	98.4	88.0
Relative Standard Deviation		15.8	1.6	5.3	10.6
METHODS: EPA 600/4-91/010,3050		6020	6010	6020	6020

Analyses subcontracted to Green Analytical Laboratories, a subsidiary of Cardinal Laboratories.

Chemist

4/27/10
Date

H19626M J. Hendrix

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575) 394-2653

Receiving Date: 04/09/10
Reporting Date: 04/26/10
Project Number: JOHN H. HENDRIX CORPORATION
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: JM/HM

LAB NUMBER	SAMPLE ID	Na* (mg/kg)	Ca* (mg/kg)	Mg* (mg/kg)	K* (mg/kg)
ANALYSIS DATE:		04/16/10	04/16/10	04/16/10	04/16/10
H19626-2	10B (2' - 3')	< 50	870	691	962
H19626-4	10B-1 (2' - 3')	< 50	1,060	832	1,050
H19626-6	10C (2' - 3')	< 50	1,370	1,220	1,440
H19626-8	10C (2' - 3')	< 50	2,250	1,030	1,230
H19626-10	11A (2' - 3')	256	9,830	1,710	2,070
H19626-12	11B (2' - 3')	< 50	831	515	796
Quality Control		8.31	5.25	4.99	10.4
True Value QC		8.10	5.00	5.00	10.0
% Recovery		102	105	99.8	104
Relative Percent Difference		0.6	1.5	1.3	2.2
METHODS:		3050/6010	3050/6010	3050/6010	3050/6010

LAB NUMBER	SAMPLE ID	Cl (mg/kg)	SO_4 (mg/kg)	CO_3 (mg/kg)	HCO_3 (mg/kg)	T-Alkalinity ($mgCaCO_3$/kg)
ANALYSIS DATE:		04/22/10	04/22/10	04/23/10	04/23/10	04/23/10
H19626-2	10B (2' - 3')	16	< 40	0	97.6	80
H19626-4	10B-1 (2' - 3')	16	< 40	0	176	144
H19626-6	10C (2' - 3')	16	46	0	78.0	64
H19626-8	10C (2' - 3')	32	156	0	312	256
H19626-10	11A (2' - 3')	224	464	0	293	240
H19626-12	11B (2' - 3')	32	<40	0	215	176
Quality Control		490	43.7	NR	988	NR
True Value QC		500	40.0	NR	1000	NR
% Recovery		98.0	109	NR	98.8	NR
Relative Percent Difference		2.0	3.0	NR	4.8	NR
METHODS:		SM4500-Cl-B	375.4	310.1	310.1	310.1

*Analyses subcontracted to Green Analytical a subsidiary of Cardinal Laboratories.

Chemist

4/27/10
Date

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575) 394-2653

Receiving Date: 04/09/10
Reporting Date: 04/26/10
Project Number: JOHN H. HENDRIX CORPORATION
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: JM/HM

LAB NUMBER	SAMPLE ID	Na* (mg/kg)	Ca* (mg/kg)	Mg* (mg/kg)	K* (mg/kg)
ANALYSIS DATE:		04/16/10	04/16/10	04/16/10	04/16/10
H19626-14	11B-1 (2' - 3')	< 50	1,880	1,470	1,780
H19626-16	11C (2' - 3')	< 50	1,330	1,000	1,380
H19626-18	12A (2' - 3')	< 50	1,930	1,850	2,040
H19626-20	12A-1 (2' - 3')	53.4	2,650	2,190	2,810
H19626-22	12B (2' - 3')	547	541	1,430	1,530
H19626-24	12C (2' - 3')	< 50	1,650	599	800
Quality Control		8.31	5.25	4.99	10.4
True Value QC		8.10	5.00	5.00	10.0
% Recovery		102	105	99.8	104
Relative Percent Difference		0.6	1.5	1.3	2.2
METHODS:		3050/6010	3050/6010	3050/6010	3050/6010

LAB NUMBER	SAMPLE ID	Cl (mg/kg)	SO_4 (mg/kg)	CO_3 (mg/kg)	HCO_3 (mg/kg)	T-Alkalinity ($mgCaCO_3/kg$)
ANALYSIS DATE:		04/22/10	04/22/10	04/23/10	04/23/10	04/23/10
H19626-14	11B-1 (2' - 3')	192	< 40	0	273	224
H19626-16	11C (2' - 3')	< 16	< 40	0	156	128
H19626-18	12A (2' - 3')	< 16	58.6	0	97.6	80
H19626-20	12A-1 (2' - 3')	16	146	0	312	256
H19626-22	12B (2' - 3')	96	< 40	0	566	464
H19626-24	12C (2' - 3')	< 16	< 40	16	366	352
Quality Control		490	43.5	NR	988	NR
True Value QC		500	40.0	NR	1000	NR
% Recovery		98.0	109	NR	98.8	NR
Relative Percent Difference		2.0	3.0	NR	4.8	NR
METHODS:		SM4500-Cl-B	375.4	310.1	310.1	310.1

*Analyses subcontracted to Green Analytical a subsidiary of Cardinal Laboratories.

Chemist

04/26/10
Date

H19626CA J. Hendrix

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575) 394-2653

Receiving Date: 04/09/10
Reporting Date: 04/26/10
Project Number: JOHN H. HENDRIX CORPORATION
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: JM/ HM

LAB NUMBER	SAMPLE ID	Na* (mg/kg)	Ca* (mg/kg)	Mg* (mg/kg)	K* (mg/kg)
ANALYSIS DATE:		04/16/10	04/16/10	04/16/10	04/16/10
H19626-26	1A (2' - 3')	155	390	443	660
H19626-28	1B (2' - 3')	54.3	500	433	700
H19626-30	1B-1 (1.5')	157	32,500	1,590	939
H19626-32	1C (2' - 3')	< 50	1,840	1,560	1,880
Quality Control		8.31	49.7	51.5	3.01
True Value QC		8.10	50.0	50.0	3.00
% Recovery		102	99.4	103	100
Relative Percent Difference		0.6	3.2	1.9	2.7
METHODS:		3050/6010	3050/6010	3050/6010	3050/6010

LAB NUMBER	SAMPLE ID	Cl (mg/kg)	SO_4 (mg/kg)	CO_3 (mg/kg)	HCO_3 (mg/kg)	T-Alkalinity ($mgCaCO_3/kg$)
ANALYSIS DATE:		04/22/10	04/22/10	04/23/10	04/23/10	04/23/10
H19626-26	1A (2' - 3')	< 16	< 40	0	176	144
H19626-28	1B (2' - 3')	< 16	307	0	97.6	80
H19626-30	1B-1 (1.5')	48	< 40	0	508	416
H19626-32	1C (2' - 3')	96	< 40	0	195	160
Quality Control		490	44.6	NR	988	NR
True Value QC		500	40.0	NR	1000	NR
% Recovery		98.0	112	NR	98.8	NR
Relative Percent Difference		2.0	2.0	NR	4.8	NR
METHODS:		SM4500-Cl-B	375.4	310.1	310.1	310.1

*Analyses subcontracted to Green Analytical a subsidiary of Cardinal Laboratories.

Chemist

4/27/10
Date

H19626CA 1 Hendrix

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575) 394-2653

Receiving Date: 04/09/10
Reporting Date: 04/12/10
Project Owner: JOHN H. HENDRIX CORPORATION
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY NM

Analysis Date: 04/12/10
Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2°C
Sample Received By: AB
Analyzed By: HM

LAB NO.	SAMPLE ID	Cl^- (mg/kg)
H19626-1	10B (0' -1')	416
H19626-3	10B-1 (0' -1')	320
H19626-5	10C (0' -1')	16
H19626-7	10C-1 (0' -1')	96
H19626-9	11A (0' -1')	16
H19626-11	11B (0' -1')	96
H19626-13	11B-1 (0' -1')	64
H19626-15	11C (0' - 1')	32
H19626-17	12A (0' -1')	< 16
H19626-19	12A-1 (0' - 1')	< 16
H19626-21	12B (0' - 1')	< 16
H19626-23	12C (0' - 1')	16
H19626-25	1A (0' - 1')	< 16
H19626-27	1B (0' - 1')	< 16
H19626-29	1B-1 (0' -1')	128
H19626-31	1C (0' - 1')	< 16
Quality Control		500
True Value QC		500
% Recovery		100
Relative Percent Difference		4.1

METHOD: Standard Methods	4500-Cl B

Note: Analyses performed on 1:4 w:v aqueous extracts.
Not accredited for chloride.

Chemist

4/27/10
Date

H19626 J. Hendrix

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575)394-2653

Receiving Date: 04/09/10
Reporting Date: 04/14/10
Project Owner: JHHC
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: AB

LAB NUMBER	SAMPLE ID	GRO (C_6-C_{10}) (mg/kg)	DRO (>C_{10}-C_{28}) (mg/kg)
ANALYSIS DATE:		04/12/10	04/12/10
H19626-1	10B (0'-1')	<50.0	19,700
H19626-2	10B (2'-3')	<10.0	<10.0
H19626-3	10B-1 (0'-1')	<50.0	17,300
H19626-4	10B-1 (2'-3')	<10.0	<10.0
H19626-5	10C (0'-1')	<10.0	274
H19626-6	10C (2'-3')	<10.0	<10.0
H19626-7	10C-1 (0'-1')	<50.0	10,000
H19626-8	10C-1 (2'-3')	<10.0	<10.0
H19626-9	11A (0'-1')	<10.0	161
H19626-10	11A (2'-3')	<10.0	<10.0
H19626-11*	11B (0'-1')	<10.0	71.8
H19626-12	11B (2'-3')	<10.0	<10.0
Quality Control		517	483
True Value QC		500	500
% Recovery		103	96.6
Relative Percent Difference		1.2	10.7

METHOD: SW-846 8015 M
Not accredited for GRO/DRO. Reported on wet weight.
*One or more TPH surrogates outside historical limits due to matrix interference.

Chemist

04/27/10
Date

H19626 T JHC

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575)394-2653

Receiving Date: 04/09/10
Reporting Date: 04/14/10
Project Owner: JHHC
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: AB

LAB NUMBER	SAMPLE ID	GRO (C_6-C_{10}) (mg/kg)	DRO (>C_{10}-C_{28}) (mg/kg)
ANALYSIS DATE:		04/14/10	04/14/10
H19626-13	11B-1 (0'-1')	<50.0	468
H19626-14	11B-1 (2'-3')	<10.0	<10.0
H19626-15	11C (0'-1')	<10.0	253
H19626-16	11C (2'-3')	<10.0	<10.0
H19626-17	12A (0'-1')	<10.0	332
H19626-18*	12A (2'-3')	<10.0	<10.0
H19626-19	12A-1 (0'-1')	<10.0	82.0
H19626-20*	12A-1 (2'-3')	<10.0	<10.0
H19626-21	12B (0'-1')	<10.0	<10.0
H19626-22	12B (2'-3')	<10.0	<10.0
Quality Control		486	563
True Value QC		500	500
% Recovery		97.2	113
Relative Percent Difference		0.6	10.2

METHOD: SW-846 8015 M
Not accredited for GRO/DRO. Reported on wet weight.
*One or more TPH surrogates outside historical limits due to matrix interference.

Chemist

Date

H19626 T JHC

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575)394-2653

Receiving Date: 04/09/10
Reporting Date: 04/14/10
Project Owner: JHHC
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: AB

LAB NUMBER	SAMPLE ID	GRO (C_6-C_{10}) (mg/kg)	DRO (>C_{10}-C_{28}) (mg/kg)
ANALYSIS DATE:		04/14/10	04/14/10
H19626-23	12C (0'-1')	<10.0	108
H19626-24	12C (2'-3')	<10.0	<10.0
H19626-25	1A (0'-1')	<10.0	<10.0
H19626-26	1A (2'-3')	<10.0	<10.0
H19626-27	1B (0'-1')	<10.0	<10.0
H19626-28	1B (2'-3')	<10.0	<10.0
H19626-29	1B-1 (0'-1')	<10.0	73.4
H19626-30	1B-1 (1.5')	<10.0	<10.0
H19626-31	1C (0'-1')	<10.0	206
Quality Control		486	563
True Value QC		500	500
% Recovery		97.2	113
Relative Percent Difference		0.6	10.2

METHOD: SW-846 8015 M
Not accredited for GRO/DRO. Reported on wet weight.

Chemist

Date

H19626 T JHC

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575)394-2653

Receiving Date: 04/09/10
Reporting Date: 04/14/10
Project Owner: JHHC
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: AB

LAB NUMBER	SAMPLE ID	GRO (C_6-C_{10}) (mg/kg)	DRO (>C_{10}-C_{28}) (mg/kg)
ANALYSIS DATE:		04/15/10	04/15/10
H19626-32	1C (2'-3')	<10.0	<10.0
Quality Control		481	544
True Value QC		500	500
% Recovery		96.2	109
Relative Percent Difference		0.2	11.9

METHOD: SW-846 8015 M
Not accredited for GRO/DRO. Reported on wet weight.

Chemist

Date

H19626 T JHC

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575)394-2653

Receiving Date: 04/09/10
Reporting Date: 04/14/10
Project Owner: JHHC
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: ZL

LAB NO.	SAMPLE ID	BENZENE (mg/kg)	TOLUENE (mg/kg)	ETHYL BENZENE (mg/kg)	TOTAL XYLENES (mg/kg)
ANALYSIS DATE:		04/12/10	04/12/10	04/12/10	04/12/10
H19626-1	10B (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-2	10B (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-3	10B-1 (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-4	10B-1 (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-5	10C (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-6	10C (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-7	10C-1 (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-8	10C-1 (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-9	11A (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-10	11A (2'-3')	<0.050	<0.050	<0.050	<0.300
Quality Control		0.051	0.050	0.052	0.154
True Value QC		0.050	0.050	0.050	0.150
% Recovery		102	100	104	103
Relative Percent Difference		5.6	18.0	9.7	16.7

METHODS: BTEX - SW-846 8021B;

TEXAS NELAP ACCREDITATION T104704398-08-TX FOR BENZENE, TOLUENE, ETHYL BENZENE, AND TOTAL XYLENES. Reported on wet weight.

Lab Director

Date 04/27/10

H19626 BTEX JHHC

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575)394-2653

Receiving Date: 04/09/10
Reporting Date: 04/14/10
Project Owner: JHHC
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: ZL

LAB NO.	SAMPLE ID	BENZENE (mg/kg)	TOLUENE (mg/kg)	ETHYL BENZENE (mg/kg)	TOTAL XYLENES (mg/kg)
ANALYSIS DATE:		04/12/10	04/12/10	04/12/10	04/12/10
H19626-11	11B (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-12	11B (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-13	11B-1 (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-14	11B-1 (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-15	11C (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-16	11C (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-17	12A (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-18	12A (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-19	12A-1 (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-20	12A-1 (2'-3')	<0.050	<0.050	<0.050	<0.300
Quality Control		0.051	0.050	0.052	0.154
True Value QC		0.050	0.050	0.050	0.150
% Recovery		102	100	104	103
Relative Percent Difference		5.6	18.0	9.7	16.7

METHODS: BTEX - SW-846 8021B;

TEXAS NELAP ACCREDITATION T104704398-08-TX FOR BENZENE, TOLUENE, ETHYL BENZENE, AND TOTAL XYLENES. Reported on wet weight.

Lab Director

04/27/10
Date

H19626 BTEX JHHC

CARDINAL LABORATORIES

PHONE (575) 393-2326 • 101 E. MARLAND • HOBBS, NM 88240

ANALYTICAL RESULTS FOR
JOHN H. HENDRIX CORPORATION
ATTN: CAROLYN HAYNES
P.O. BOX 910
EUNICE, NM 88231
FAX TO: (575)394-2653

Receiving Date: 04/09/10
Reporting Date: 04/14/10
Project Owner: JHHC
Project Name: JHHC SURFACE WASTE MANAGEMENT FACILITY (NM-02-0021)
Project Location: T24S, R36E, SEC 15, W/2 NW/4 & W/2 SW/4, LEA COUNTY, NM

Sampling Date: 04/07/10
Sample Type: SOIL
Sample Condition: COOL & INTACT @ 2.0°C
Sample Received By: AB
Analyzed By: ZL

LAB NO.	SAMPLE ID	BENZENE (mg/kg)	TOLUENE (mg/kg)	ETHYL BENZENE (mg/kg)	TOTAL XYLENES (mg/kg)
ANALYSIS DATE:		04/13/10	04/13/10	04/13/10	04/13/10
H19626-21	12B (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-22	12B (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-23	12C (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-24	12C (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-25	1A (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-26	1A (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-27	1B (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-28	1B (2'-3')	<0.050	<0.050	<0.050	<0.300
H19626-29	1B-1 (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-30	1B-1 (1.5')	<0.050	<0.050	<0.050	<0.300
H19626-31	1C (0'-1')	<0.050	<0.050	<0.050	<0.300
H19626-32	1C (2'-3')	<0.050	<0.050	<0.050	<0.300
Quality Control		0.046	0.043	0.045	0.130
True Value QC		0.050	0.050	0.050	0.150
% Recovery		92.0	86.0	90.0	86.7
Relative Percent Difference		2.7	<1.0	2.2	3.2

METHODS: BTEX - SW-846 8021B;

TEXAS NELAP ACCREDITATION T104704398-08-TX FOR BENZENE, TOLUENE, ETHYL BENZENE, AND TOTAL XYLENES. Reported on wet weight.

Lab Director

Date

H19626 BTEX JHHC

101 East Marland - Hobbs, New Mexico 88240
Tel (575) 393-2326
Fax (575) 393-2476

Cardinal Laboratories, Inc.

CHAIN-OF-CUSTODY AND ANALYSIS REQUEST

LAB Order ID # _____

Company Name: John H. Hendrix Corporation	BILL TO Company: John H. Hendrix Corporation PO#:
Project Manager: Carolyn Haynes	Project Manager: Carolyn Haynes
Address (Street, City, Zip): PO Box 910, Eunice NM 88231	Address (Street, City, Zip): PO Box 3040, Midland TX 79702-3040 Fax#:
Phone #: (575) 394-2649 Fax#: (575) 394-2653	Phone #: (432) 684-6631 Email: cdoranhaynes@jhhc.org
Project #: John H. Hendrix Corporation	Project Name: JHHC Surface Waste Management Facility (NM-02-0021)
Project Location: T24S, R36E, Sec 15, W/2 NW/4 & W/2 SW/4, Lea County NM	Sampler Name: Gil Van Deventer

LAB # (LAB USE ONLY)	FIELD CODE	(G)rab or (C)omp	# CONTAINERS	MATRIX: WATER	SOIL	AIR	SLUDGE	PRESERVATIVE METHOD: HCL	HNO_3	$NaHSO_4$	H_2SO_4	ICE	None	SAMPLING: DATE	TIME	MTBE 8021B/602	BTEX 8021 B	TPH 8015M	PAH 8270C	RCRA Metals: Ag As Ba Cd Cr Pb Se Hg	WQCC Metals: Ag As Ba Cd Cr Pb Se Hg Cu Fe Mn Zn	TCLP Volatiles	TCLP Semi Volatiles	TCLP Pesticides	RCI	GC/MS Vol. 8260B/624	GC/MS Semi. Vol. 8270C/625	Moisture Content	Cations (Ca, Mg, K, Na)	Anions (Cl, SO4, CO3, HCO3, T-ALK)	Total Dissolved Solids (SM2540C)	Chlorides (325.3 / SM4500 B)	SPLP Chloride	Turn Around Time ~ 24 Hours
H19626-1	10B (0' - 1')	G	1		X							X		4/7/10	1700		X	X													X		
-2	10B (2' - 3')	G	1		X							X		4/7/10	1705		X	X			X								X	X			
-3	10B-1 (0' - 1')	G	1		X							X		4/7/10	1730		X	X													X		
-4	10B-1 (2' - 3')	G	1		X							X		4/7/10	1735		X	X			X								X	X			
-5	10C (0' - 1')	G	1		X							X		4/7/10	1350		X	X													X		
-6	10C (2' - 3')	G	1		X							X		4/7/10	1355		X	X			X								X	X			
-7	10C-1 (0' - 1')	G	1		X							X		4/7/10	1410		X	X													X		
-8	10C-1 (2' - 3')	G	1		X							X		4/7/10	1415		X	X			X								X	X			
-9	11A (0' - 1')	G	1		X							X		4/7/10	1130		X	X													X		
-10	11A (2' - 3')	G	1		X							X		4/7/10	1135		X	X			X								X	X			

Relinquished by:	Date: 4/9/10	Time: 11:30	Received by: Date: 4/9/10 Time: 11:30
Relinquished by:	Date:	Time:	Received By: (Laboratory Staff) Date: Time:

Phone Results: ☐ Yes ☐ No
Fax Results: ☐ Yes ☐ No Additional Fax Number:

REMARKS:

Email Results to:
cdoranhaynes@jhhc.org
gil@trident-environmental.com

Delivered By: (Circle One)
Sampler - UPS - Bus - Other:

Sample Condition: Cool: Yes ☒ No ☐ Intact: Yes ☒ No ☐

CHECKED BY (Initials)

#26 2.0°C

101 East Marland · Hobbs, New Mexico 88240
Tel (575) 393-2326
Fax (575) 393-2476

Cardinal Laboratories, Inc.

CHAIN-OF-CUSTODY AND ANALYSIS REQUEST

LAB Order ID # _____

Company Name: John H. Hendrix Corporation	BILL TO Company: John H. Hendrix Corporation PO#
Project Manager: Carolyn Haynes	Project Manager: Carolyn Haynes
Address: (Street, City, Zip) PO Box 910, Eunice NM 88231	Address: (Street, City, Zip) PO Box 3040, Midland TX 79702-3040 Fax#:
Phone #: (575) 394-2649 Fax#: (575) 394-2653	Phone #: (432) 684-6631 Email: cdoranhaynes@jhhc.org
Project #: John H. Hendrix Corporation	Project Name: JHHC Surface Waste Management Facility (NM-02-0021)
Project Location: T24S, R36E, Sec 15, W/2 NW/4 & W/2 SW/4, Lea County NM	Sampler Name: Gil Van Deventer

LAB # (LAB USE ONLY)	FIELD CODE	(G)rab or (C)omp	# CONTAINERS	MATRIX: WATER	SOIL	AIR	SLUDGE	PRESERVATIVE METHOD: HCL	HNO_3	$NaHSO_4$	H_2SO_4	ICE	None	SAMPLING: DATE	TIME	MTBE 8021B/602	BTEX 8021 B	TPH 8015M	PAH 8270C	RCRA Metals: Ag As Ba Cd Cr Pb Se Hg	WQCC Metals: Ag As Ba Cd Cr Pb Se Hg Cu Fe Mn Zn	TCLP Volatiles	TCLP Semi Volatiles	TCLP Pesticides	RCI	GC/MS Vol. 8260B/624	GC/MS Semi. Vol. 8270C/625	Moisture Content	Cations (Ca, Mg, K, Na)	Anions (Cl, SO4, CO3, HCO3, ALK)	Total Dissolved Solids (SM2540C)	Chlorides (325.3 / SM4500 D)	SPLP Chloride	Turn Around Time ~ 24 Hours
H19626-11	11B (0' - 1')	G	1		X							X		4/7/10	1200		X	X													X		
-12	11B (2' - 3')	G	1		X							X		4/7/10	1205		X	X			X								X	X			
-13	11B-1 (0' - 1')	G	1		X							X		4/7/10	1220		X	X													X		
-14	11B-1 (2' - 3')	G	1		X							X		4/7/10	1225		X	X			X								X	X			
-15	11C (0' - 1')	G	1		X							X		4/7/10	1300		X	X													X		
-16	11C (2' - 3')	G	1		X							X		4/7/10	1305		X	X			X								X	X			
-17	12A (0' - 1')	G	1		X							X		4/7/10	1030		X	X													X		
-18	12A (2' - 3')	G	1		X							X		4/7/10	1035		X	X			X								X	X			
-19	12A-1 (0' - 1')	G	1		X							X		4/7/10	1100		X	X													X		
-20	12A-1 (2' - 3')	G	1		X							X		4/7/10	1105		X	X			X								X	X			

Relinquished by: [signature]	Date: 4/9/10	Time: 11:30	Received by [signature]
Relinquished by:	Date:	Time:	Received By (Laboratory Staff)
Delivered By: (Circle One) Sampler - UPS - Bus - Other:	Sample Condition: Cool: Yes [X] No; Intact: Yes [X] No	CHECKED BY: (Initials) [signature]	

Received by: Date: 4/9/10 Time: 11:30

Phone Results: [ ] Yes [ ] No

Fax Results: [ ] Yes [ ] No Additional Fax Number:

REMARKS:

Email Results to:
cdoranhaynes@jhhc.org
gil@trident-environmental.com

#26 2.0°C

101 East N. ...d - Hobbs New Mexico 88240
Tel (575) 393-2326
Fax (575) 393-2476

Cardinal Laboratories, Inc.

CHAIN-OF-CUSTODY AND ANALYSIS REQUEST

LAB Order ID # _____

Company Name	BILL TO Company:	PO#
John H. Hendrix Corporation	John H. Hendrix Corporation	
Project Manager:	**Project Manager:**	
Carolyn Haynes	Carolyn Haynes	
Address (Street, City, Zip)	**Address: (Street, City, Zip)**	**Fax#**
PO Box 910, Eunice NM 88231	PO Box 3040, Midland TX 79702-3040	
Phone # **Fax#**	**Phone #:** **Email**	
(575) 394-2649 (575) 394-2653	(432) 684-6631 cdoranhaynes@jhhc.org	
Project #	**Project Name:**	
John H. Hendrix Corporation	JHHC Surface Waste Management Facility (NM-02-0021)	
Project Location	**Sampler Name:**	
T24S, R36E, Sec 15, W/2 NW/4 & W/2 SW/4, Lea County NM	Gil Van Deventer	

ANALYSIS REQUEST

(Circle or Specify Method No.)

LAB # (LAB USE ONLY)	FIELD CODE	(G)rab or (C)omp	# CONTAINERS	MATRIX: WATER	SOIL	AIR	SLUDGE	PRESERVATIVE METHOD: HCL	HNO_3	$NaHSO_4$	H_2SO_4	ICE	None	SAMPLING: DATE	TIME	MTBE 8021B/602	BTEX 8021 B	TPH 8015M	PAH 8270C	RCRA Metals: Ag As Ba Cd Cr Pb Se Hg	WQCC Metals: Ag As Ba Cd Cr Pb Se Hg Cu Fe Mn Zn	TCLP Volatiles	TCLP Semi Volatiles	TCLP Pesticides	RCI	GC/MS Vol. 8260B/624	GC/MS Semi. Vol. 8270C/625	Moisture Content	Cations (Ca, Mg, K, Na)	Anions (Cl, SO4, CO3, HCO3, ALK)	Total Dissolved Solids (SM2540C)	Chlorides (325.3 / SM4500 B)	SPLP Chloride	Turn-Around Time ~ 24 Hours
419626-21	12B (0' - 1')	G	1		X							X		4/7/10	1240		X	X												X		
-22	12B (2' - 3')	G	1		X							X		4/7/10	1245		X	X			X								X	X			
-23	12C (0' - 1')	G	1		X							X		4/7/10	1330		X	X														X	
-24	12C (2' - 3')	G	1		X							X		4/7/10	1335		X	X			X								X	X			
-25	1A (0' - 1')	G	1		X							X		4/7/10	1630		X	X														X	
-26	1A (2' - 3')	G	1		X							X		4/7/10	1635		X	X			X								X	X			
-27	1B (0' - 1')	G	1		X							X		4/7/10	1500		X	X														X	
-28	1B (2' - 3')	G	1		X							X		4/7/10	1505		X	X			X								X	X			
-29	1B-1 (0' - 1')	G	1		X							X		4/7/10	1530		X	X														X	
-30	1B-1 ~~(2' - 3')~~ (1.5')	G	1		X							X		4/7/10	1535		X	X			X								X	X			
-31	1C (0' - 1')	G	1		X							X		4/7/10	1430		X	X														X	
-32	1C (2' - 3')	G	1		X							X		4/7/10	1435		X	X			X								X	X			

Relinquished by:	Date:	Time:	Received by:	Date:	Time:
	4/9/10	11:20am		4/9/10	11:30
Relinquished by:	**Date:**	**Time:**	**Received By: (Laboratory Staff)**	**Date:**	**Time:**

Phone Results		Yes		No	
Fax Results		Yes		No	Additional Fax Number:

REMARKS:

Email Results to:
cdoranhaynes@jhhc.org
gil@trident-environmental.com

Delivered By: (Circle One)	Sample Condition	CHECKED BY
Sampler - UPS - Bus - Other:	Cool: Yes [X] No [ ] Intact: Yes [X] No [ ]	(Initials)

#26 2.0°C

ATTACHMENT B

USGS Professional Paper 1270

Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States; 1984

Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States

By HANSFORD T. SHACKLETTE *and* JOSEPHINE G. BOERNGEN

U.S. GEOLOGICAL SURVEY PROFESSIONAL PAPER 1270

An account of the concentrations of 50 chemical elements in samples of soils and other regoliths

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1984

UNITED STATES DEPARTMENT OF THE INTERIOR

WILLIAM P. CLARK, *Secretary*

GEOLOGICAL SURVEY

Dallas L. Peck, *Director*

Library of Congress Cataloging in Publication Data
Shacklette, Hansford T.
Element concentrations in soils and other surficial materials of the conterminous United States.
(Geological Survey professional paper ; 1270)
Bibliography: 105 p.
Supt. of Docs. No.: I 19.16
1. Soils—United States—Composition.
I. Boerngen, Josephine G. II. Title. III. Series
S599.A1S5 631.4'7'73 82-600084

AACR2

For sale by the Distribution Branch, U.S. Geological Survey,
604 South Pickett Street, Alexandria, VA 22304

CONTENTS

ILLUSTRATIONS

TABLES

ELEMENT CONCENTRATIONS IN SOILS AND OTHER SURFICIAL MATERIALS OF THE CONTERMINOUS UNITED STATES

By HANSFORD T. SHACKLETTE and JOSEPHINE G. BOERNGEN

ABSTRACT

Samples of soils or other regoliths, taken at a depth of approximately 20 cm from locations about 80 km apart throughout the conterminous United States, were analyzed for their content of elements. In this manner, 1,318 sampling sites were chosen, and the results of the sample analyses for 50 elements were plotted on maps. The arithmetic and geometric mean, the geometric deviation, and a histogram showing frequencies of analytical values are given for 47 elements.

The lower concentrations of some elements (notably, aluminum, barium, calcium, magnesium, potassium, sodium, and strontium) in most samples of surficial materials from the Eastern United States, and the greater abundance of heavy metals in the same materials of the Western United States, indicates a regional geochemical pattern of the largest scale. The low concentrations of many elements in soils characterize the Atlantic Coastal Plain. Soils of the Pacific Northwest generally have high concentrations of aluminum, cobalt, iron, scandium, and vanadium, but are low in boron. Soils of the Rocky Mountain region tend to have high concentrations of copper, lead, and zinc. High mercury concentrations in surficial materials are characteristic of Gulf Coast sampling sites and the Atlantic coast sites of Connecticut, Massachuetts, and Maine. At the State level, Florida has the most striking geochemical pattern by having soils that are low in the concentrations of most elements considered in this study. Some smaller patterns of element abundance can be noted, but the degree of confidence in the validity of these patterns decreases as the patterns become less extensive.

INTRODUCTION

The abundance of certain elements in soils and other surficial materials is determined not only by the element content of the bedrock or other deposits from which the materials originated, but also by the effects of climatic and biological factors as well as by influences of agricultural and industrial operations that have acted on the materials for various periods of time. The diversity of these factors in a large area is expected to result in a corresponding diversity in the element contents of the surficial materials.

At the beginning of this study (1961), few data were available on the abundance of elements in surficial materials of the United States as a whole. Most of the early reports discussed only the elements that were of economic importance to mining or agriculture in a metallogenic area or State; and the data, for the most part, cannot be evaluated with reference to average, or normal, amounts in undisturbed materials because they were based on samples of deposits expected to have anomalous amounts of certain elements, or were based only on samples from cultivated fields.

We began a sampling program in 1961 that was designed to give estimates of the range of element abundance in surficial materials that were unaltered or very little altered from their natural condition, and in plants that grew on these deposits, throughout the conterminous United States. We believed that analyses of the surficial materials would provide a measure of the total concentrations of the elements that were present at the sampling sites, and that analysis of the plants would give an estimate of the relative concentrations among sites of the elements that existed in a chemical form that was available to plants. Because of the great amount of travel necessary to complete this sampling, we asked geologists and others of the U.S. Geological Survey to assist by collecting samples when traveling to and from their project areas and to contribute appropriate data they may have collected for other purposes. The reponse to this request, together with the samples and data that we had collected, resulted in our obtaining samples of surficial materials and plants from 863 sites. The analyses of surficial materials sampled in this phase of the study were published for 35 elements by plotting element concentrations, in two to five frequency classes, on maps (Shacklette, Hamilton, and others, 1971).

Soon after the publication of the results of this study, interest in environmental matters, particularly in the effects of contamination and industrial pollution, increased greatly. At the same time, technological advances in analytical methods and data processing facilitated measurements of geochemical and other parameters of the environment. In response to the need for background data for concentrations of certain elements of particular environmental concern, the samples of surficial materials that were collected for the first study (Shacklette, Hamilton, and others, 1971) (with some ad-

ditional samples) were analyzed for other elements, and the results were published in U.S. Geological Survey Circulars: for mercury, Shacklette, Boerngen, and Turner (1971); for lithium and cadmium, by Shacklette, and others (1973); and for selenium, fluorine, and arsenic, Shacklette and others (1974).

The collection of samples for this study continued, as opportunities arose, until autumn 1975, resulting in the sampling of an additional 355 sites that were selected to give a more uniform geographical coverage of the conterminous United States. This sampling continuation is referred to as phase two. These samples were analyzed, and the data were merged with those of the original samples to produce the results given in the present report. In addition, the availability of analytical methods for elements not included in the earlier reports permitted data to be given on these elements in the more recently collected samples.

The collection localities and dates, sample descriptions, and analytical values for each sample in the present report were published by Boerngen and Shacklette (1981). The elemental compositions of only the surficial materials are given in this report; the data on analyses of the plant samples are held in files of the U.S. Geological Survey.

ACKNOWLEDGMENTS

This study was made possible by the cooperation of many persons in the U.S. Geological Survey. We thank D. F. Davidson, A. T. Miesch, J. J. Connor, R. J. Ebens, and A. T. Myers for their interest in, and continued support of, this study. The sampling plan was suggested by H. L. Cannon, who also contributed analytical data from her project areas and samples from her travel routes. Others of the Geological Survey who collected samples, and to whom we express gratitude, are: J. M. Bowles, F. A. Branson, R. A. Cadigan, F. C. Canney, F. W. Cater, Jr., M. A. Chaffey, Todd Church, J. J. Connor, Dwight Crowder, R. J. Ebens, J. A. Erdman, G. L. Feder, G. B. Gott, W. R. Griffitts, T. P. Hill, E. K. Jenne, M. I. Kaufman, J. R. Keith, Frank Kleinhampl, A. T. Miesch, R. F. Miller, R. C. Pearson, E. V. Post, Douglas Richman, R. C. Severson, James Scott, D. A. Seeland, M. H. Staatz, T. A. Steven, M. H. Strobell, V. E. Swanson, R. R. Tidball, H. A. Tourtelot, J. D. Vine, and R. W. White. We thank the following members of the U.S. Department of Agriculture Soil Conservation Service for providing soil samples from areas in Minnesota: D. D. Barron, C. R. Carlson, D. E. DeMartelaire, R. R. Lewis, Charles Sutton, and Paul Nyberg.

We acknowledge the analytical support provided by the following U.S. Geological Survey chemists: Lowell Artis, Philip Aruscavage, A. J. Bartel, S. D. Bott, L. A. Bradley, J. W. Budinsky, Alice Caemmerer, P. Cahill, E. Y. Campbell, G. W. Chloe, Don Col E. F. Cooley, N. M. Conklin, W. B. Crandell, Maur Devalliere, P. L. D. Elmore, E. J. Finlay, John Gardner, J. L. Glenn, T. F. Harms, R. G. Haven R. H. Heidel, M. B. Hinkle, Claude Huffman, Jr., B. Jenkins, R. J. Knight, B. W. Lanthorn, L. M. La K. W. Leong, J. B. McHugh, J. D. Mensik, V. M. Me ritt, H. T. Millard, Jr., Wayne Mountjoy, H. Nakagawa, H. G. Neiman, Uteana Oda, C. S. E. Pap R. L. Rahill, V. E. Shaw, G. D. Shipley, Hezekia Smith, A. J. Sutton, Jr., J. A. Thomas, Barbara Tobi J. E. Troxel, J. H. Turner, and G. H. VanSickle.

We were assisted in computer programming for th data by the following persons of the U.S. Geologic Survey: W. A. Buehrer, G. I. Evenden, J. B. Fif Allen Popiel, M. R. Roberts, W. C. Schomburg, G. Selner, R. C. Terrazas, George VanTrump, Jr., an R. R. Wahl.

REVIEW OF LITERATURE

The literature on the chemical analysis of soils an other surficial materials in the United States is exten sive and deals largely with specific agricultural prob lems of regional interest. Many of the papers were writ ten by soil scientists and chemists associated with Stat agricultural experiment stations and colleges of agricul ture, and most reports considered only elements that were known to be nutritive or toxic to plants or ani mals.

Chemists with the U.S. Department of Agriculture prepared most early reports of element abundance in soils for large areas of the United States. (See Robinson, 1914; Robinson and others, 1917). The 1938 yearbook of agriculture was devoted to reports on soils of the United States; in this book, McMurtrey and Robinson (1938) discussed the importance and abundance of trace elements in soils. Amounts of the major elements in soil samples from a few soil profiles distributed throughout the United States were compiled by the soil scientist C. F. Marbut (1935) to illustrate characteristics of soil units.

The use of soil analysis in geochemical prospecting began in this country in the 1940's, and many reports were published on the element amounts in soils from areas where mineral deposits were known or suspected to occur. Most of these reports included only a few elements in soils from small areas. This early geochemical work was discussed by Webb (1953) and by Hawkes (1957). In succeeding years, as soil analyses became an accepted method of prospecting and as analytical

methods were improved, many elements in soils were analyzed; still, the areas studied were commonly small.

An estimate of the amounts of elements in average, or normal, soils is useful in appraising the amounts of elements in a soil sample as related to agricultural, mineral prospecting, environmental quality, and health and disease investigations. Swaine (1955) gave an extensive bibliography of trace-element reports on soils of the world, and he also summarized reports of the average amounts of elements as given by several investigators. The most comprehensive list of average amounts of rare and dispersed elements in soils is that of Vinogradov (1959), who reported the analytical results of extensive studies of soils in the Union of Soviet Socialist Republics, as well as analyses of soils from other countries. He did not state the basis upon which he established the average values; however, these values are presumably the arithmetic means of element amounts in samples from throughout the world. In their discussions of the principles of geochemistry, Goldschmidt (1954) and Rankama and Sahama (1955) reported the amounts of various elements present in soils and in other surficial materials, Hawks and Webb (1962) and, more recently, Brooks (1972), Siegal (1974), Levinson (1974), and Rose and others (1979) gave average amounts of certain elements in soils as useful guides in mineral exploration.

A report on the chemical characteristics of soils was edited by Bear (1964). In this book, the chapter on chemical composition of soils by Jackson (1964) and the chapter on trace elements in soils by Mitchell (1964) gave the ranges in values or the average amounts of some soil elements.

Regional geochemical studies conducted by scientists of the U.S. Geological Survey within the past two decades have been largely directed to the establishment of baseline abundances of elements in surficial materials, including soils. Most of the earlier work investigated these materials that occurred in their natural condition, having little or no alterations that related to human activities, with the objective of establishing normal element concentrations in the materials by which anomalous concentrations, both natural or man induced, could be judged. Some of these studies were conducted in cooperation with medical investigators who were searching for possible relationships of epidemiological patterns to characteristics of the environment. In one study, the geochemical characteristics of both natural and cultivated soils were determined in two areas of Georgia that had contrasting rates of cardiovascular diseases (Shacklette and others, 1970). In an extensive geochemical study of Missouri, also conducted cooperatively with medical researchers, both cultivated and natural soils were sampled. The results were presented for the State as a whole, and for physiographic regions or other subdivisions and smaller areas, as follows: Erdman and others (1976a, 1976b); Tidball (1976, 1983a, 1983b); and Ebens and others (1973). The results of these studies, and of other regional geochemical investigations, were summarized and tabulated by Connor and Shacklette (1975).

Recent regional studies of soil geochemistry by the U.S. Geological Survey related to the development of energy resources in the western part of the United States, including North Dakota, South Dakota, Montana, Wyoming, Colorado, Utah, and New Mexico. These studies established regional geochemical baselines for soils, both in undisturbed areas and in areas that had been altered by mining and related activities. Some of these studies considered the elements in soils both as total concentrations and as concentrations that were available to plants of the region. The results of these studies were published in annual progress reports (U.S. Geological Survey, 1974, 1975, 1976, 1977, and 1978). The data on soils, as well as on other natural materials, in these reports were summarized and tabulated by Ebens and Shacklette (1981). In a study of the elements in fruits and vegetables from 11 areas of commercial production in the United States, and in the soils on which this produce grew, soils were analyzed for 39 elements, as reported by Boerngen and Shacklette (1980) and Shacklette (1980).

The average amounts of elements in soils and other surficial materials of the United States, as determined in the present study, are given in table 1, with the average values or ranges in values that were reported by Vinogradov (1959), Rose and others (1979), Jackson (1964), Mitchell (1964), and Brooks (1972). The averages from the present study given in table 1 are the arithmetic means. Although the averages were computed by the methods described by Miesch (1967), the values obtained are directly comparable with the arithmetic means derived by common computational procedures.

COLLECTION AND ANALYSIS OF GEOCHEMICAL DATA

SAMPLING PLAN

The sampling plan was designed with the emphasis on practicality, in keeping with the expenditures of time and funds available, and its variance from an ideal plan has been recognized from the beginning. Because the collection of most samples was, by necessity, incidental to other duties of the samplers, the instructions for sampling were simplified as much as possible, so that sampling methods would be consistent within the wide range of kinds of sites to be sampled. The samples were

TABLE 1.—*Average or median contents, and range in contents, reported for elements in soils and other surficial materials*

[Data are in parts per million; each average represents arithmetic mean; leaders (—) in figure columns indicate no data available. A, average; M, median. <, less than; >, greater than]

Element	This report		Rose, and others (1979) (elements useful in geochemical prospecting)	Vinogradov (1959) (presumably, averages from worldwide sampling)	Jackson (1964)	Mitchell (1964)	Brooks (1972)
	Average	Range			"Typical",[1] average, or range in values	Range in contents in Scottish surface soils	Average or range
Al	72,000	700 - >10,000	—	71,300	10,000 - 60,000	—	—
As	7.2	<0.1 - 97	7.5 (M)	5	—	—	5
B	33	<20 - 300	29 (M)	10	30	—	10
Ba	580	10 - 5,000	300 (M)	—	—	400 - 3,000	500
Be	.92	<1 - 15	0.5 - 4	6	—	<5 - 5	6
Br	.85	<0.5 - 11	—	5	—	—	—
C, total	25,000	600 - 370,000	—	20,000	—	—	—
Ca	24,000	100 - 320,000	—	13,700	7,000	—	—
Ce	75	<150 - 300	—	—	—	—	—
Co	9.1	<3 - 70	10 (M)	8	—	<2 - 80	10
Cr	54	1 - 2,000	6.3 (M)	200	—	5 - 3,000	200
Cu	25	<1 - 700	15 (M)	20	20	<10 - 100	20
F	430	<10 - 3,700	300 (M)	200	—	—	—
Fe	26,000	100 - >100,000	21,000 (M)	38,000	7,000 - 42,000	—	10,000 - 50,000
Ga	17	<5 - 70	—	30	—	15 - 70	20
Ge	1.2	<0.1 - 2.5	—	1	—	—	5
Hg	.09	<0.01 - 4.6	0.056 (M)	—	—	—	.01
I	1.2	<0.5 - 9.6	—	—	—	—	—
K	15,000	50 - 63,000	11,000 (M)	13,600	400 - 28,000	—	—
La	37	<30 - 200	—	—	—	<30 - 200	—
Li	24	<5 - 140	6.2 (M)	30	—	—	30
Mg	9,000	50 - >100,000	—	6,300	<6,000	—	—
Mn	550	<2 - 7,000	320 (M)	850	—	200 - 3,000	850
Mo	.97	<3 - 15	2.5 (A)	2	—	<1 - 5	2.5
Na	12,000	<500 - 100,000	—	6,300	—	—	—
Nb	11	<10 - 100	15 (A)	—	—	—	15
Nd	46	<70 - 300	—	—	—	—	—
Ni	19	<5 - 700	17 (M)	40	—	10 - 800	40
P	430	<20 - 6,800	300 (M)	800	500	—	—
Pb	19	<10 - 700	17 (M)	—	—	<20 - 80	10
Rb	67	<20 - 210	35 (M)	100	—	—	—
S, total	1,600	<800 - 48,000	100 - 2,000	850	—	—	—
Sb	.66	<1 - 8.8	2 (A)	—	—	—	.5
Sc	8.9	<5 - 50	—	7	—	<3 - 15	—
Se	.39	<0.1 - 4.3	0.31 (M)	.001	—	—	.5
Si	310,000	16,000 - 450,000	—	330,000	—	—	—
Sn	1.3	<0.1 - 10	10 (A)	—	—	—	10
Sr	240	<5 - 3,000	67 (M)	300	—	60 - 700	300
Ti	2,900	70 - 20,000	—	4,600	1,200 - 6,000	—	—
Th	9.4	2.2 - 31	—	—	—	—	13
U	2.7	0.29 - 11	1 (A)	—	—	—	1
V	80	<7 - 500	57 (M)	100	—	20 - 250	100
Y	25	<10 - 200	—	50	—	25 - 100	—
Yb	3.1	<1 - 50	—	—	—	—	—
Zn	60	<5 - 2,900	36 (M)	50	—	—	50
Zr	230	<20 - 2,000	270 (M)	300	—	200 - >1,000	—

[1]Author's usage; generally used to indicate the most commonly occurring value.

collected by U.S. Geological Survey personnel along their routes of travel to areas of other types of field studies or within their project areas.

The locations of the routes that were sampled depended on both the network of roads that existed and the destinations of the samplers. Sampling intensity was kept at a minimum by selecting only one sampling site every 80 km (about 50 miles; selected for convenience because vehicle odometers were calibrated in miles) along the routes. The specific sampling sites were selected, insofar as possible, that had surficial materials that were very little altered from their natural condition and that supported native plants suitable for sampling. In practice, this site selection necessitated sampling away from roadcuts and fills. In some areas, only cultivated fields and plants were available for sampling.

Contamination of the sampling sites by vehicular emissions was seemingly insignificant, even though many sites were within 100 m or less of the roads. Col-

lecting samples at about 20 cm depth, rather than at the upper soil horizons, may have avoided the effects of surface contamination on the samples. However, we had no adequate way of measuring any contamination that may have occurred. (See Cannon and Bowles, 1962.) Many of the sampled routes had only light vehicular traffic, and some were new interstate highways. Routes through congested areas generally were not sampled; therefore, no gross contamination of the samples was expected.

The study areas that were sampled follow: Wisconsin and parts of contiguous States, southeastern Missouri, Georgia, and Kentucky, sampled by Shacklette; Kentucky, sampled by J. J. Connor and R. R. Tidball; Nevada, New Mexico, and Maryland, sampled by H. L. Cannon; various locations in Arizona, Colorado, Montana, New Mexico, Utah, and Wyoming, sampled by F. A. Branson and R. F. Miller; Missouri, sampled by Shacklette, J. A. Erdman, J. R. Keith, and R. R. Tidball; and various locations in Colorado, Idaho, Montana, South Dakota, Utah, and Wyoming, sampled by A. T. Miesch and J. J. Connor. Sampling techniques used in these areas varied according to the primary objectives of the studies being conducted, but generally these techniques were closely similar to the methods used in sampling along the roads.

In general, the sampling within study areas was more intensive than that along the travel routes. To make the sampling intensity of the two sampling programs more nearly equal, only the samples from selected sites in the study areas were used for this report. The selected sites were approximately 80 km apart. Where two or more samples were collected from one site, they were assigned numbers, and one of these samples was randomly chosen for evaluation in this study.

SAMPLING MEDIA

The material sampled at most sites could be termed "soil" because it was a mixture of comminuted rock and organic matter, it supported ordinary land plants, and it doubtless contained a rich microbiota. Some of the sampled deposits, however, were not soils as defined above, but were other kinds of regoliths. The regoliths included desert sands, sand dunes, some loess deposits, and beach and alluvial deposits that contained little or no visible organic matter. In some places the distinctions between soils and other regoliths are vague because the materials of the deposits are transitional between the two. Samples were collected from a few deposits consisting mostly of organic materials that would ordinarily be classified as peat, rather than soil.

To unify sampling techniques, the samplers were asked to collect the samples at a depth of approximately 20 cm below the surface of the deposits. This depth was chosen as our estimate of a depth below the plow zone that would include parts of the zone of illuviation in most well-developed zonal soils, and as a convenient depth for sampling other surficial materials. Where the thickness of the material was less than 20 cm, as in shallow soils over bedrock or in lithosols over large rock fragments, samples were taken of the material that lay just above the rock deposits. About 0.25 liter of this material was collected, put in a kraft paper envelope, and shipped to the U.S. Geological Survey laboratories in Denver, Colo.

CHEMICAL-ANALYSIS PROCEDURES

The soil samples were oven dried in the laboratory and then sifted through a 2-mm sieve. If the soil material would not pass this sieve, the sample was pulverized in a ceramic mill before seiving. Finally, the sifted, minus 2-mm fraction of the sample was used for analysis.

The methods of analysis used for some elements were changed during the course of this study, as new techniques and instruments became available. For most elements, the results published in the first report (Shacklette, Hamilton, and others, 1971) were obtained by use of a semiquantitative six-step emission spectrographic method (Meyers and others, 1961). The methods used for other elements were: EDTA titration for calcium; colorimetric (Ward and others, 1963) for phosphorus and zinc; and flame photometry for potassium. Many of the elements analyzed in the 355 samples collected in phase two of the study were also analyzed by the emission spectrographic method (Neiman, 1976). Other methods were used for the following elements: flame atomic absorption (Huffman and Dinnin, 1976) for mercury, lithium, magnesium, sodium, rubidium, and zinc; flameless atomic absorption (Vaughn, 1967) for mercury; X-ray fluorescence spectrometry (Wahlberg, 1976) for calcium, germanium, iron, potassium, selenium, silver, sulfur, and titanium; combustion (Huffman and Dinnin, 1976) for total carbon; and neutron activation (Millard, 1975, 1976) for thorium and uranium.

DATA PRESENTATION

Summary data for 46 elements are reported in tables 1 and 2. In table 1, the element concentrations found in samples of soil and other surficial materials of this study are compared with those in soils reported in other studies. Arithmetic means are used for the data of this study to make them more readily compared with the data generally reported in the literature. These arithmetic means were derived from the estimated geometric means by using a technique described by Miesch (1967), which is based on methods devised by Cohen (1959) and Sichel (1952). The arithmetic means in table

1, unlike the geometric means shown in table 2, are estimates of geochemical abundance (Miesch, 1967). Arithmetic means are always larger than corresponding geometric means (Miesch, 1967, p. B1) and are estimates of the fractional part of a single specimen that consists of the element of concern rather than of the typical concentration of the element in a suite of samples.

Concentrations of 46 elements in samples of this study are presented in table 2, which gives the determination ratios, geometric-mean concentrations and deviations, and observed ranges in concentrations. The analytical data for most elements as received from the laboratories were transformed into logarithms because of the tendency for elements in natural materials, particularly the trace elements, to have positively skewed

TABLE 2.—*Mean concentrations, deviations, and ranges of elements in samples of soils and other surficial materials in the conterminous United States*

[Means and ranges are reported in parts per million (μg/g), and means and deviations are geometric except as indicated. Ratio, number of samples in which the element was found in measurable concentrations to number of samples analyzed. <, less than; >, greater than]

Element	Conterminous United States			Western United States (west of 96th meridian)					Eastern United States (east of 96th meridian)				
	Mean	Deviation	Estimated arithmetic mean	Ratio	Mean	Deviation	Observed range	Estimated arithmetic mean	Ratio	Mean	Deviation	Observed range	Estimated arithmetic mean
Al, percent	4.7	2.48	7.2	661:770	5.8	2.00	0.5 - >10	7.4	450:477	3.3	2.87	0.7 - >10	5.7
As	5.2	2.23	7.2	728:730	5.5	1.98	<0.10 - 97	7.0	521:527	4.8	2.56	<0.1 - 73	7.4
B	26	1.97	33	506:778	23	1.99	<20 - 300	29	425:541	31	1.88	<20 - 150	38
Ba	440	2.14	580	778:778	580	1.72	70 - 5,000	670	541:541	290	2.35	10 - 1,500	420
Be	.63	2.38	.92	310:778	.68	2.30	<1 - 15	.97	169:525	.55	2.53	<1 - 7	.85
Br	.56	2.50	.85	113:220	.52	2.74	<0.5 - 11	.86	78:128	.62	2.18	<0.5 - 5.3	.85
C, percent	1.6	2.57	2.5	250:250	1.7	2.37	0.16 - 10	2.5	162:162	1.5	2.88	0.06 - 37	2.6
Ca, percent	.92	4.00	2.4	777:777	1.8	3.05	0.06 - 32	3.3	514:514	.34	3.08	0.01 - 28	.63
Ce	63	1.78	75	81:683	65	1.71	<150 - 300	75	70:489	63	1.85	<150 - 300	76
Co	6.7	2.19	9.1	698:778	7.1	1.97	<3 - 50	9.0	403:533	5.9	2.57	<0.3 - 70	9.2
Cr	37	2.37	54	778:778	41	2.19	3 - 2,000	56	541:541	33	2.60	1 - 1,000	52
Cu	17	2.44	25	778:778	21	2.07	2 - 300	27	523:533	13	2.80	<1 - 700	22
F	210	3.34	430	598:610	280	2.52	<10 - 1,900	440	390:435	130	4.19	<10 - 3,700	360
Fe, percent	1.8	2.38	2.6	776:777	2.1	1.95	0.1 - >10	2.6	539:540	1.4	2.87	0.01 - >10	2.5
Ga	13	2.03	17	767:776	16	1.68	<5 - 70	19	431:540	9.3	2.38	<5 - 70	14
Ge	1.2	1.37	1.2	224:224	1.2	1.32	0.58 - 2.5	1.2	130:131	1.1	1.45	<0.1 - 2.0	1.2
Hg	.058	2.52	.089	729:733	.046	2.33	<0.01 - 4.6	.065	534:534	.081	2.52	0.01 - 3.4	.12
I	.75	2.63	1.2	169:246	.79	2.55	<0.5 - 9.6	1.2	90:153	.68	2.81	<0.5 - 7.0	1.2
K, percent[1]	1.5	.79	None	777:777	1.8	.71	0.19 - 6.3	None	537:537	1.2	1.75	0.005 - 3.7	--
La	30	1.92	37	462:777	30	1.89	<30 - 200	37	294:516	29	1.98	<30 - 200	37
Li	20	1.85	24	731:731	22	1.58	5 - 130	25	479:527	17	2.16	<5 - 140	22
Mg, percent	.44	3.28	.90	777:778	.74	2.21	0.03 - >10	1.0	528:528	.21	3.55	0.005 - 5	.46
Mn	330	2.77	550	777:777	380	1.98	30 - 5,000	480	537:540	260	3.82	<2 - 7,000	640
Mo	.59	2.72	.97	57:774	.85	2.17	<3 - 7	1.1	32:524	.32	3.93	<3 - 15	.79
Na, percent	.59	3.27	1.2	744:744	.97	1.95	0.05 - 10	1.2	363:449	.25	4.55	<0.05 - 5	.78
Nb	9.3	1.75	11	418:771	8.7	1.82	<10 - 100	10	322:498	10	1.65	<10 - 50	12
Nd	40	1.68	46	120:538	36	1.76	<70 - 300	43	109:332	46	1.58	<70 - 300	51
Ni	13	2.31	19	747:778	15	2.10	<5 - 700	19	443:540	11	2.64	<5 - 700	18
P	260	2.67	430	524:524	320	2.33	40 - 4,500	460	380:382	200	2.95	<20 - 6,800	360
Pb	16	1.86	19	712:778	17	1.80	<10 - 700	20	422:541	14	1.95	<10 - 300	17
Rb	58	1.72	67	221:224	69	1.50	<20 - 210	74	107:131	43	1.94	<20 - 160	53
S, percent	.12	2.04	.16	34:224	.13	2.37	<0.08 - 4.8	.19	20:131	.10	1.34	<0.08 - 0.31	.11
Sb	.48	2.27	.67	35:223	.47	2.15	<1 - 2.6	.62	31:131	.52	2.38	<1 - 8.8	.76
Sc	7.5	1.82	8.9	685:778	8.2	1.74	<5 - 50	9.6	389:526	6.5	1.90	<5 - 30	8.0
Se	.26	2.46	.39	590:733	.23	2.43	<0.1 - 4.3	.34	449:534	.30	2.44	<0.1 - 3.9	.45
Si, percent[1]	31	6.48	None	250:250	30	5.70	15 - 44	None	156:156	34	6.64	1.7 - 45	--
Sn	.89	2.36	1.3	218:224	.90	2.11	<0.1 - 7.4	1.2	123:131	.86	2.81	<0.1 - 10	1.5
Sr	120	3.30	240	778:778	100	2.16	10 - 3,000	270	501:540	53	3.61	<5 - 700	120
Ti, percent	.24	1.89	.29	777:777	.22	1.78	0.05 - 2.0	.26	540:540	.28	2.00	0.007 - 1.5	.35
Th	8.6	1.53	9.4	195:195	9.1	1.49	2.4 - 31	9.8	102:102	7.7	1.58	2.2 - 23	8.6
U	2.3	1.73	2.7	224:224	2.5	1.45	0.68 - 7.9	2.7	130:130	2.1	2.12	0.29 - 11	2.7
V	58	2.25	80	778:778	70	1.95	7 - 500	88	516:541	43	2.51	<7 - 300	66
Y	21	1.78	25	759:778	22	1.66	<10 - 150	25	477:541	20	1.97	<10 - 200	25
Yb	2.6	1.79	3.1	754:764	2.6	1.63	<1 - 20	3.0	452:486	2.6	2.06	<1 - 50	3.3
Zn	48	1.95	60	766:766	55	1.79	10 - 2,100	65	473:482	40	2.11	<5 - 2,900	52
Zr	180	1.91	230	777:778	160	1.77	<20 - 1,500	190	539:541	220	2.01	<20 - 2,000	290

[1]Means are arithmetic, deviations are standard.

frequency distributions. For this reason, the geometric mean is the more proper measure of central tendency for these elements. The frequency distributions for potassium and silicon, on the other hand, are more nearly normal if the data are not transformed to logarithms and the mean is expressed as the arithmetic average.

In geochemical background studies, the magnitude of scatter to be expected around the mean is as important as the mean. In lognormal distributions, the geometric deviation measures this scatter, and this deviation may be used to estimate the range of variation expected for an element in the material being studied. About 68 percent of the samples in a randomly selected suite should fall within the limits M/D and $M \cdot D$, where M represents the geometric mean and D the geometric deviation. About 95 percent should fall between M/D^2 and $M \cdot D^2$, and about 99.7 percent between M/D^3 and $M \cdot D^3$.

The analytical data for some elements include values that are below, or above, the limits of numerical determination, and these values are expressed as less than (<) or greater than (>) a stated value. These data are said to be censored, and for these the mean was computed by using a technique described by Cohen (1959) and applied to geochemical studies by Miesch (1967). This technique requires an adjustment of the summary statistics computed for the noncensored part of the data. The censoring may be so severe in certain sets of data that a reliable adjustment cannot be made; with the data sets used in the present study, however, no such circumstances were encountered. The use of these procedures in censored data to quantify the central tendency may result in estimates of the mean that are lower than the limit of determination. For example, in table 2 the geometric-mean molybdenum concentration in soils from the Eastern United States is estimated to be 0.32 ppm, although the lower limit of determination of the analytical method that was used is 3 ppm. Use of this procedure permits inclusion of the censored values in the calculation of expected mean concentrations.

The determination ratios in table 2—that is, the ratio of the number of samples in which the element was found in measurable concentrations to the total number of samples—permit the number of censored values, if any, to be found that were used in calculating the mean. This number is found by subtracting the left value in the ratio from the right.

The distribution of the sampling sites and the concentrations of elements determined for samples from the sites are presented on maps of the conterminous United States (figs. 1–47). Figure 1 shows the locations of sites where four elements, bismuth, cadmium, praseodymium, and silver, were found in the samples. These elements were determined too uncommonly for reliable mean concentrations to be calculated. Each of the remaining maps (figs. 2–47) gives the locations where an element was found in a sample from a site and the concentration of the element, shown by a symbol that represents a class of values. By examining the tables of frequency for concentration values of the elements, we were able to divide the ranges of reported values for many elements into five classes so that approximately 20 percent of the values fell into each class. The limited range in values for some elements, however, prohibited the use of more than two or three classes to represent the total distribution. Symbols representing the classes were drawn on the maps by an automatic plotter that was guided by computer classification of the data, including the latitude and longitude of the sampling sites. A histogram on each map gives the frequency distribution of the analytical values, and the assignment of analytical values to each class as represented by symbols.

We were able to obtain analyses of 11 more elements for the 355 samples of phase two of this study than for the 963 samples of phase one because of improved analytical methods and services. These elements are antimony, bromine, carbon, germanium, iodine, rubidium, silicon, sulfur, thorium, tin, and uranium. The constraints of resources and time prohibited analysis of the 963 samples of the first phase for these additional elements. Results of analysis of the plant samples that were collected at all soil-sampling sites are not presented in this report.

Some elements were looked for in all samples but were not found. These elements, analyzed by the semiquantitative spectrographic method, and their approximate lower detection limits, in parts per million, are as follows: gold, 20; hafnium, 100; indium, 10; platinum, 30; palladium, 1; rhenium, 30; tantalum, 200; tellurium, 2,000; and thallium, 50. If lanthanum or cerium were found in a sample, the following elements, with their stated lower detection limits, were looked for in the same sample but were not found: dysprosium, 50; erbium, 50; gadolinium, 50; holmium, 20; lutetium, 30; terbium, 300; and thulium, 20.

DISCUSSION OF RESULTS

The data presented in this report may reveal evidence of regional variations in abundances of elements in soils or other regoliths; single values or small clusters of values on the maps may have little significance if considered alone. Apparent differences in values shown between certain sampling routes, such as some of those across the Great Plains and the North Central States where high values for cerium, cobalt, gallium, and lead predominate, suggest the possibility of systematic er-

rors in sampling or in laboratory analysis. Some gross patterns and some of lesser scale, nevertheless, are evident in the compositional variation of regoliths, as shown in figures 2–47.

The lower abundances of some elements (notably aluminum, barium, calcium, magnesium, potassium, sodium, and strontium) in regoliths of the Eastern United States, and the greater abundances of the heavy metals in the same materials of the Western United States indicate a regional pattern of the largest scale. This visual observation of the maps can be substantiated by examining the mean concentrations for these two regions given in table 2. The abundances of these elements differ markedly on either side of a line extending from western Minnesota southward through east-central Texas. This line is generally from the 96th to 97th meridian, and corresponds to the boundary proposed by Marbut (1935, p. 14), which divides soils of the United States into two major groups—the pedalfers that lie to the east, and the pedocals to the west. Marbut (1928) attributed the major differences in chemical and physical qualities of these two major groups to the effects of climate on soils. A line approximating the 96th meridian also separates the Orders, Suborders, and Great Groups of moist-to-wet soils in the Eastern United States from the same categories of dry soils that lie to the west, as mapped by the [U.S.] Soil Conservation Service (1969). As shown in table 2, soils of the Western United States have the highest mean values for all elements considered in this report except for antimony, boron, bromine, mercury, neodymium, selenium, titanium, and zirconium. The differences, however, probably are not significant for these latter elements, except for zirconium.

Superimposed upon this large-scale compositional variation pattern are several features of intermediate scale. Perhaps the most notable of these are the low concentrations of many elements in soils of the Atlantic Coastal Plain. Soils of the Pacific Northwest are high in concentrations of aluminum, cobalt, iron, scandium, and vanadium, but low in boron, and soils of the Rocky Mountain region tend to be high in copper, lead, and zinc.

Several small-scale patterns of compositional variation can be noted, among them the high mercury concentrations in surficial materials from the Gulf Coast of eastern Texas, Louisiana, Mississippi, Alabama, and northwest Florida, and a similar pattern on the Atlantic Coast in Connecticut, Massachusetts, and Maine. High phosphorus values occur in soils along a line extending west across Utah and Nevada to the coast of California, then south-east in California and Arizona. At the State level, Florida shows the most striking pattern by having low soil concentrations of most of the elements considered in this study.

The concentrations of certain elements do not show well-defined patterns of distribution, and the regional concentrations of some other elements cannot be evaluated because they were not present in detectable amounts in most of the samples, or because the sampling density was insufficient. The degree of confidence in regional patterns of element abundance is expected to be in direct proportion to the number of samples analyzed from the region. As the observed patterns become smaller, the probability increases that the characteristics that form the patterns are the results of chance.

Some features of element-abundance patterns probably reflect geologic characteristics of the areas that the soils overlie. Samples from most of the regoliths overlying basic volcanic rocks of Washington and Oregon contained higher than average concentrations of iron and other elements, as mentioned earlier. A few soil samples with high phosphorus content are associated with phosphate deposits in Florida, and a single sample in Michigan with high copper content is known to be of soil that occurs over a copper deposit.

These data do not provide obvious evidences of north-south trends in elemental compositions that might be expected to relate to differences in temperature regimes under which the surficial materials developed. There is, moreover, no consistent evidence of significant differences in element abundances between glaciated and nonglaciated areas (the general area of continental glaciation includes the northern tier of States from Montana to Maine and south in places to about lat 40°N.; see fig. 1).

The world averages of abundance for some elements in soils, as given by Vinogradov (1959) and by others (table 1), do not correspond to the averages of abundance for these elements in the soils of the United States, according to the data presented in this report. The world averages are too low for the concentrations of boron, calcium, cerium, lead, magnesium, potassium, and sodium in United States soils and other surficial materials, and too high for beryllium, chromium, gallium, manganese, nickel, phosphorus, titanium, vanadium, and yttrium.

The stability of values for concentrations of most elements seems to be satisfactory because the addition of analytical values for 355 samples of phase two of the study to values for 963 samples of the first phase did not significantly change the geometric means and deviations of element abundance that were reported earlier (Shacklette, Boerngen, and Turner, 1971; Shacklette, Hamilton, and others, 1971; Shacklette and others,

1973, 1974). Although additional sampling of the same type as reported here might give a clearer picture of small-to-intermediate element-abundance patterns, mean values reported herein most likely would not change significantly.

REFERENCES CITED

Bear, F. E., ed., 1964, Chemistry of the soil [2d ed.]: New York, Reinhold Publishing Corp., 515 p.

Boerngen, J. G., and Shacklette, H. T., 1980, Chemical analyses of fruits, vegetables, and their associated soils from areas of commercial production in the conterminous United States: U.S. Geological Survey Open-File Report 80–84, 134 p.

———1981, Chemical analysis of soils and other surficial materials of the conterminous United States: U.S. Geological Survey Open-File Report 81–197, 143 p.

Brooks, R. R., 1972, Geobotany and biogeochemistry in mineral exploration: New York, Harper and Row, 290 p.

Cannon, H. L., and Bowles, J. M., 1962, Contamination of vegetation by tetraethyl lead: Science, v. 137, no. 3532, p. 765–766.

Cohen, A. C., Jr., 1959, Simplified estimators for the normal distribution when samples are singly censored or truncated: Technometrics, v. 1, no. 3, p. 217–237.

Connor, J. J., and Shacklette, H. T., 1975, Background geochemistry of some rocks, soils, plants, and vegetables in the conterminous United States, *with sections on* Field studies by R. J. Ebens, J. A. Erdman, A. T. Miesch, R. R. Tidball, and H. A. Tourtelot: U.S. Geological Survey Professional Paper 574–F, 168 p.

Ebens, R. J., Erdman, J. A., Feder, G. L., Case, A. A., and Selby, L. A., 1973, Geochemical anomalies of a claypit area, Callaway County, Missouri, and related metabolic imbalance in beef cattle: U.S. Geological Survey Professional Paper 807, 24 p.

Ebens, R. J., and Shacklette, H. T., 1981, Geochemistry of some rocks, mine spoils, stream sediments, soils, plants, and waters in the western energy region of the conterminous United States, *with sections on* Field studies by B. M. Anderson, J. G. Boerngen, J. J. Connor, W. E. Dean, J. A. Erdman, G. L. Feder, L. P. Gough, J. R. Herring, T. K. Hinkley, J. R. Keith, R. W. Klusman, J. M. McNeal, C. D. Ringrose, R. C. Severson, and R. R. Tidball: U.S. Geological Survey Professional Paper 1237, 173 p.

Erdman, J. A., Shacklette, H. T., and Keith, J. R., 1976a, Elemental composition of selected native plants and associated soils from major vegetation-type areas in Missouri: U.S. Geological Survey Professional Paper 954-C, p. C1–C87.

———1976b, Elemental composition of corn grains, soybean seeds, pasture grasses, and associated soils from selected areas in Missouri: U.S. Geological Survey Professional Paper 954–D, p. D1–D23.

Goldschmidt, V. M., 1954, Geochemistry: Oxford, Clarendon Press, 730 p.

Hawkes, H. E., 1957, Principles of geochemical prospecting: U.S. Geological Survey Bulletin 1000–F, p. 225–355.

Hawkes, H. E., and Webb, J. S., 1962, Geochemistry in mineral exploration: New York, N. Y., and Evanston, Ill., Harper and Row, 415 p.

Huffman, Claude, Jr., and Dinnin, J. I., 1976, Analysis of rocks and soil by atomic absorption spectrometry and other methods, *in* Miesch, A. T., Geochemical survey of Missouri—Methods of sampling, laboratory analysis, and statistical reduction of data: U.S. Geological Survey Professional Paper 954–A, p. 12–14.

Jackson, M. L., 1964, Chemical composition of soils, *in* Bear, F. E., ed., Chemistry of the soil [2d ed.]: New York, Reinhold Publishing Corp., p. 71–141.

Levinson, A. A., 1974, Introduction to exploration geochemistry: Calgary, Applied Publishing, Ltd., 612 p.

Marbut, C. F., 1928, Classification, nomenclature, and mapping of soils in the United States—The American point of view: Soil Science, v. 25, p. 61–70.

———1935, Soils of the United States, pt. 3 *of* Atlas of American agriculture: Washington, D.C., U.S. Government Printing Office, 98 p.

McMurtrey, J. E., Jr., and Robinson, W. O., 1938, Neglected soil constituents that affect plant and animal development, *in* Soils and men—Yearbook of Agriculture 1938: Washington, D.C., U.S. Government Printing Office, p. 807–829.

Miesch, A. T., 1967, Methods of computation for estimating geochemical abundance: U.S. Geological Survey Professional Paper 574-B, 15 p.

Millard, H. T., Jr., 1975, Determination of uranium and thorium in rocks and soils by the delayed neutron technique, *in* U.S. Geological Survey, Geochemical survey of the western coal region, second annual progress report, July 1975: U.S. Geological Survey Open-File Report 75–436, p. 79–81.

———1976, Determination of uranium and thorium in U.S.G.S. standard rocks by the delayed neutron technique, *in* Flanagan, F. J., ed. and compiler, Description and analyses of eight new U.S.G.S. rock standards: U.S. Geological Survey Professional Paper 840, p. 61–65.

Mitchell, R. L., 1964, Trace elements in soils, *in* Bear, F. E., ed., Chemistry of the soil [2d ed.]: New York, Reinhold Publishing Corp., p. 320–368.

Myers, A. T., Havens, R. G., and Dunton, P. J., 1961, A spectrochemical method for the semiquantitative analysis of rocks, minerals, and ores: U.S. Geological Survey Bulletin 1084–I, p. 207–229.

Neiman, H. G., 1976, Analysis of rocks, soils, and plant ashes by emission spectroscopy, *in* Miesch, A. T., Geochemical survey of Missouri—Methods of sampling, laboratory analysis, and statistical reduction of data: U.S. Geological Survey Professional Paper 594–A, p. 14–15.

Rankama, K. K., and Sahama, T. G., 1955, Geochemistry: Chicago, Chicago University Press, 912 p.

Robinson, W. O., 1914, The inorganic composition of some important American soils: U.S. Department of Agriculture Bulletin 122, 27 p.

Robinson, W. O., Steinkoenig, L. A., and Fry, W. H., 1917, Variation in the chemical composition of soils: U.S. Department of Agriculture Bulletin 551, 16 p.

Rose, A. W., Hawkes, H. E., and Webb, J. S., 1979, Geochemistry in mineral exploration [2d ed.]: London, Academic Press, 658 p.

Shacklette, H. T., 1980, Elements in fruits and vegetables from areas of commercial production in the conterminous United States: U.S. Geological Survey Professional Paper 1178, 149 p.

Shacklette, H. T., Boerngen, J. G., Cahill, J. P., and Rahill, R. L., 1973, Lithium in surficial materials of the conterminous United States and partial data on cadmium: U.S. Geological Survey Circular 673, 8 p.

Shacklette, H. T., Boerngen, J. G., and Keith, J. R., 1974, Selenium, fluorine, and arsenic in surficial materials of the conterminous United States: U.S. Geological Survey Circular 692, 14 p.

Shacklette, H. T., Boerngen, J. G., and Turner, R. L., 1971, Mercury in the environment—Surficial materials of the conterminous

United States: U.S. Geological Survey Circular 644, 5 p.

Shacklette, H. T., Hamilton, J. C., Boerngen, J. G., and Bowles, J. M., 1971, Elemental composition of surficial materials in the conterminous United States: U.S. Geological Survey Professional Paper 574–D, 71 p.

Shacklette, H. T., Sauer, H. I., and Miesch, A. T., 1970, Geochemical environments and cardiovascular mortality rates in Georgia: U.S. Geological Survey Professional Paper 574–C, 39 p.

Sichel, H. S., 1952, New methods in the statistical evaluation of mine sampling data: Institute of Mining and Metallurgy Transactions, v. 61, p. 261–288.

Siegel, F. R., 1974, Applied geochemistry: New York, John Wiley and Sons, 353 p.

Swain, D. J., 1955, The trace-element content of soils: England Commonwealth Agricultural Bureau, Commonwealth Bureau of Soil Science Technical Communication 48, 157 p.

Tidball, R. R., 1976, Chemical variation of soils in Missouri associated with selected levels of the Soil Classification System: U.S. Geological Survey Professional Paper 954–B, 16 p.

———1983a, Geography of soil geochemistry of Missouri agricultural soils, *in* Geochemical survey of Missouri: U.S. Geological Survey Professional Paper 954–H, in press.

———1983b, Geochemical classification by factor analysis of Missouri agricultural soils, *in* Geochemical survey of Missouri: U.S. Geological Survey Professional Paper 954–I, in press.

U.S. Geological Survey, 1974, Geochemical survey of the western coal regions, first annual progress report, July 1974: U.S. Geological Survey Open-File Report 74–250, 38 p.

———1975, Geochemical survey of the western coal regions, second annual progress report, July 1975: U.S. Geological Survey Open-File Report 75–436, 132 p.

———1976, Geochemical survey of the western energy regions, third annual progress report, July 1976: U.S. Geological Survey Open-File Report 76–729, 138 p. + appendix, 44 p.

———1977, Geochemical survey of the western energy regions, fourth annual progress report, July 1977: U.S. Geological Survey Open-File Report 77–872, 207 p.

———1978, Geochemical survey of the western energy regions, fifth annual progress report, July 1978: U.S. Geological Survey Open-File Report 78–1105, 194 p.

[U.S.] Soil Conservation Service, 1969, Distribution of principal kinds of soils—Orders, Suborders, and Great Groups, *in* National Atlas of the United States of America: U.S. Geological Survey, Sheet 86, 2 p.

Vaughn, W. W., 1967, A simple mercury vapor detector for geochemical prospecting: U.S. Geological Survey Circular 540, 8 p.

Vinogradov, A. P., 1959, The geochemistry of rare and dispersed chemical elements in soils [2d ed., revised and enlarged]: New York, Consultants Bureau Enterprises, 209 p.

Wahlberg, J. S., 1976, Analysis of rocks and soils by X-ray fluorescence, *in* Miesch, A. T., Geochemical survey of Missouri—Methods of sampling, laboratory analysis, and statistical reduction of data: U.S. Geological Survey Professional Paper 954–A, p. 11–12.

Ward, F. N., Lakin, H. W., Canney, F. C., and others, 1963, Analytical methods used in geochemical exploration by the U.S. Geological Survey: U.S. Geological Survey Bulletin 1152, 100 p.

Webb, J. S., 1953, A review of American progress in geochemical prospecting and recommendations for future British work in this field: Institute of Mining and Metallurgy Transactions, v. 62, pt. 7, p. 321–348.

ATTACHMENT C

Statistical Analysis Output

1. Unpaired t test with Welch Correction (As, Cd, & Pb)

2. Non-parametric Mann-Whitney Test (Ba & Cr)

Arsenic Background vs Arsenic in Vadose Zone on 04/07/2010

Col. title	As-Bkgd	As-VZ
Mean	2.1668125	1.461375
Standard deviation (SD)	0.8384	0.4196
Sample size (N)	16	16
Std. error of mean(SEM)	0.2096	0.1049
Lower 95% conf. limit	1.720	1.238
Upper 95% conf. limit	2.613	1.685
Minimum	0.8390	0.8450
Median (50th percentile	2.065	1.560
Maximum	3.650	2.070
Normality test KS	0.1405	0.1711
Normality test P value	>0.10	>0.10
Passed normality test?	Yes	Yes

COMMENTS:

The background mean exceeds the vadose zone mean.

The maximum background concentration exceeds the maximum vadose zone concentration.

Arsenic Background vs Arsenic in Vadose Zone on 04/07/2010

Unpaired t test with Welch correction

Do the means of As-Bkgd and As-VZ differ significantly?

P value

The two-tailed P value is 0.0064, considered very significant.
Welch correction applied. This test does not assume equal variances.

Welch's approximate t = 3.010 with 22 degrees of freedom.

95% confidence interval

Mean difference = -0.7054 (Mean of As-VZ minus mean of As-Bkgd)
The 95% confidence interval of the difference: -1.191 to -0.2194

Assumption test: Are the data sampled from Gaussian distributions?

The t test assumes that the data are sampled from populations that follow Gaussian distributions. This assumption is tested using the method Kolmogorov and Smirnov:

Group	KS	P Value	Passed normality test?
As-Bkgd	0.1405	>0.10	Yes
As-VZ	0.1711	>0.10	Yes

Summary of Data

Parameter:	As-Bkgd	As-VZ
Mean:	2.167	1.461
# of points:	16	16
Std deviation:	0.8384	0.4196
Std error:	0.2096	0.1049
Minimum:	0.8390	0.8450
Maximum:	3.650	2.070
Median:	2.065	1.560
Lower 95% CI:	1.720	1.238
Upper 95% CI:	2.613	1.685

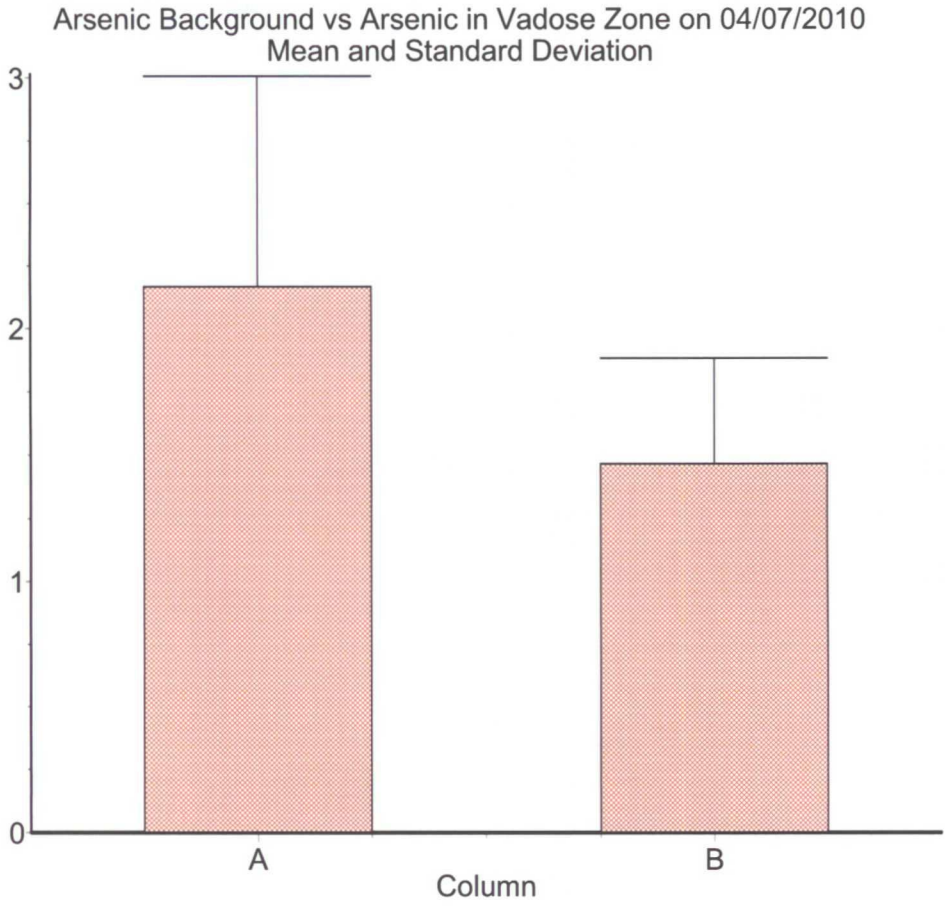
* * *

COMMENTS:

Although the P value suggests a significant difference between the background mean and vadose zone mean, the background mean exceeds the vadose zone mean.

Also, the maximum background concentration exceeds the maximum vadose zone concentration.

Results of this analysis indicate there is no threat of arsenic migrating downward through the vadose zone.


Arsenic Background vs Arsenic in Vadose Zone on 04/07/2010
Mean and Standard Deviation
3
2
1
0
A
B
Column

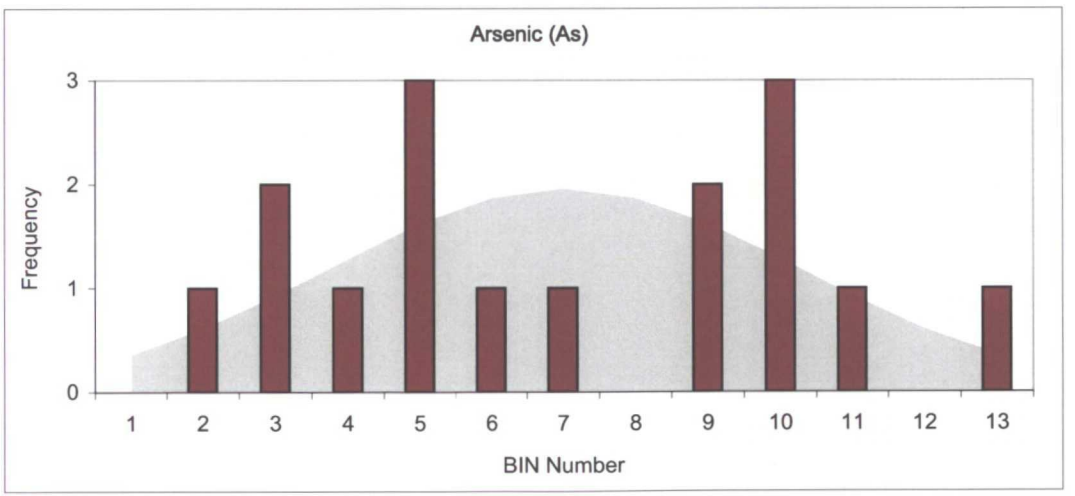
Comparison of Arsenic Background Concentration Observations to a Normal Distribution

mean :	2.17	
sd :	0.84	
Cell #	n	Background Conc. (mg/L)
7B	1	3.65
1A	2	3.23
1B	3	3.05
1C	4	2.24
2A	5	0.839
2B	6	1.72
2C	7	2.84
10A	8	1.63
10B	9	1.24
10C	10	1.43
11A	11	1.53
11B	12	1.23
11C	13	2.67
12A	14	2.90
12B	15	2.58
12C	16	1.89

Bin Size: 0.257958 | St Devs: 2 | n: 16

	Bin		Bin Range			Freq	Cum P	P	Exp Shape
	8		Infinity	< x <=	0.49	0	2.3%		
	7	1	0.49	< x <=	0.75	0	4.5%	2.25%	0.36
	6	2	0.75	< x <=	1.01	1	8.3%	3.78%	0.60
	5	3	1.01	< x <=	1.26	2	14.1%	5.77%	0.92
	4	4	1.26	< x <=	1.52	1	22.1%	8.01%	1.28
	3	5	1.52	< x <=	1.78	3	32.2%	10.13%	1.62
	2	6	1.78	< x <=	2.04	1	43.9%	11.67%	1.87
Mean	1	7	2.04	< x <=	2.30	1	56.1%	12.23%	1.96
	2	8	2.30	< x <=	2.55	0	67.8%	11.67%	1.87
	3	9	2.55	< x <=	2.81	2	77.9%	10.13%	1.62
	4	10	2.81	< x <=	3.07	3	85.9%	8.01%	1.28
	5	11	3.07	< x <=	3.33	1	91.7%	5.77%	0.92
	6	12	3.33	< x <=	3.59	0	95.5%	3.78%	0.60
	7	13	3.59	< x <=	3.84	1	97.7%	2.25%	0.36
	8		3.84	< x <=	Infinity	0	100.0%		
						16		95.45%	15.27

Observations within 2 StdDev : 16



Comparison of known Arsenic Background Concentration Observations to a Normal Distribution

16 of 16 observations are within 2 standard deviation(s)

Cadmium Background vs Cadmium in Vadose Zone on 04/07/2010

Col. title	Cd-Bkgd	Cd-VZ
Mean	0.1811111111	0.26425
Standard deviation (SD)	0.06698	0.06938
Sample size (N)	9	16
Std. error of mean(SEM)	0.02233	0.01734
Lower 95% conf. limit	0.1296	0.2273
Upper 95% conf. limit	0.2326	0.3012
Minimum	0.1130	0.1510
Median (50th percentile	0.1760	0.2635
Maximum	0.3410	0.3910
Normality test KS	0.2665	0.09459
Normality test P value	0.0648	>0.10
Passed normality test?	Yes	Yes

Comments:

The data set for background samples is limited to only 9 samples because 7 non-detect samples could not be included in this analysis.

Cadmium Background vs Cadmium in Vadose Zone on 04/07/2010

Unpaired t test

Do the means of Cd-Bkgd and Cd-VZ differ significantly?

P value
The two-tailed P value is 0.0079, considered very significant.

t = 2.911 with 23 degrees of freedom.

95% confidence interval
Mean difference = 0.08314 (Mean of Cd-VZ minus mean of Cd-Bkgd)
The 95% confidence interval of the difference: 0.02405 to 0.1422

Assumption test: Are the standard deviations equal?
The t test assumes that the columns come from populations with equal SDs. The following calculations test that assumption.

F = 1.073
The P value is 0.9623.
This test suggests that the difference between the two SDs is not significant.

Assumption test: Are the data sampled from Gaussian distributions?
The t test assumes that the data are sampled from populations that follow Gaussian distributions. This assumption is tested using the method Kolmogorov and Smirnov:

Group	KS	P Value	Passed normality test?
Cd-Bkgd	0.2665	0.0648	Yes
Cd-VZ	0.09459	>0.10	Yes

Summary of Data

Parameter:	Cd-Bkgd	Cd-VZ
Mean:	0.1811	0.2643
# of points:	9	16
Std deviation:	0.06698	0.06938
Std error:	0.02233	0.01734
Minimum:	0.1130	0.1510
Maximum:	0.3410	0.3910
Median:	0.1760	0.2635
Lower 95% CI:	0.1296	0.2273
Upper 95% CI:	0.2326	0.3012

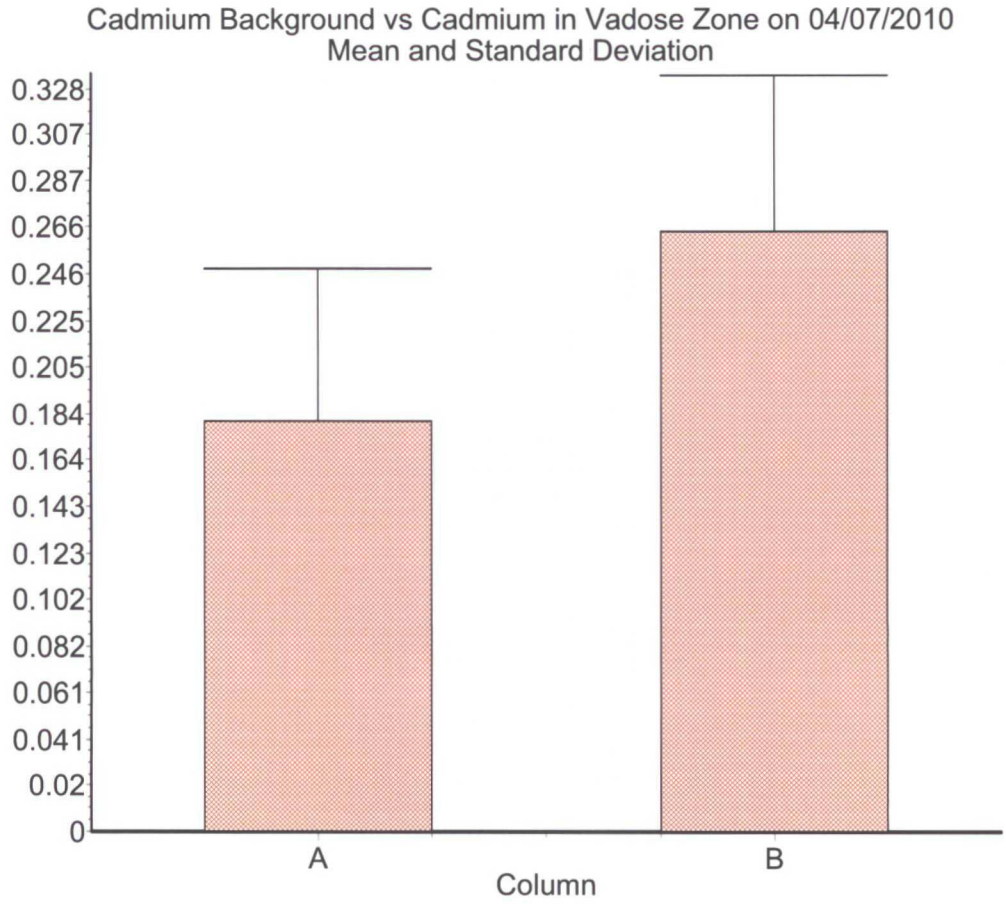
* * *

Comments:

Note that the data set for background samples is limited to only 9 samples because 7 non-detect samples could not be included in this analysis. A small data set allows for Type I errors and/or the possibility of chance (random error) to reject the null hypothesis.

It is also important to note that there is a small range of cadmium concentrations in both the background and VZ data sets, with a minimum 0.113 mg/kg value compared to a maximum of 0.391 mg/kg). Also, this small range of values represents only 1.1 to 3.9 times the laboratory reporting limit of 0.1 mg/kg.

Unless a larger data set can be included, other (non-statistical) techniques for evaluating this data should be performed to determine if migration to vadose zone has occurred.

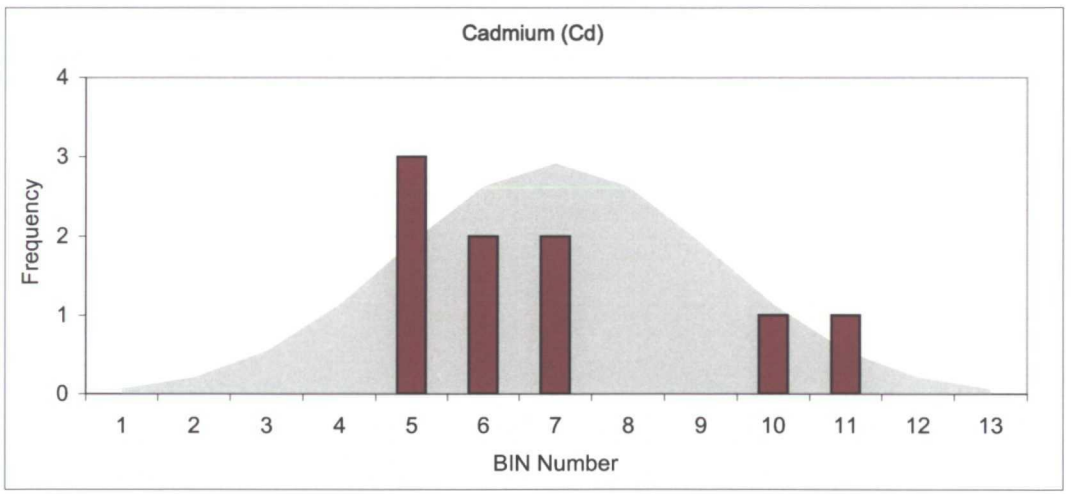

Cadmium Background vs Cadmium in Vadose Zone on 04/07/2010
Mean and Standard Deviation
0.328
0.307
0.287
0.266
0.246
0.225
0.205
0.184
0.164
0.143
0.123
0.102
0.082
0.061
0.041
0.02
0
A
B
Column

Comparison of Cadmium Background Concentration Observations to a Normal Distribution

	mean :	0.18
	sd :	0.09

Cell #	n	Background Conc. (mg/L)
7B	1	0.341
1A	2	0.196
1B	3	0.178
1C	4	0.142
2C	5	0.092
11C	6	0.109
12A	7	0.130
12B	8	0.100
12C	9	0.300
	10	
	11	
	12	
	13	
	14	
	15	
	16	

			Bin Size		St Devs		n		
			0.041151		3		16		
	Bin		Bin Range			Freq	Cum P	P	Exp Shape
	8	Infinity	< x <=	-0.09		0	0.1%		
	7	1	-0.09	< x <=	-0.05	0	0.6%	0.42%	0.07
	6	2	-0.05	< x <=	-0.01	0	1.9%	1.33%	0.21
	5	3	-0.01	< x <=	0.03	0	5.3%	3.42%	0.55
	4	4	0.03	< x <=	0.07	0	12.4%	7.12%	1.14
	3	5	0.07	< x <=	0.11	3	24.4%	12.01%	1.92
	2	6	0.11	< x <=	0.16	2	40.9%	16.44%	2.63
Mean	1	7	0.16	< x <=	0.20	2	59.1%	18.25%	2.92
	2	8	0.20	< x <=	0.24	0	75.6%	16.44%	2.63
	3	9	0.24	< x <=	0.28	0	87.6%	12.01%	1.92
	4	10	0.28	< x <=	0.32	1	94.7%	7.12%	1.14
	5	11	0.32	< x <=	0.36	1	98.1%	3.42%	0.55
	6	12	0.36	< x <=	0.40	0	99.4%	1.33%	0.21
	7	13	0.40	< x <=	0.44	0	99.9%	0.42%	0.07
	8		0.44	< x <=	Infinity	0	100.0%		
						9		99.73%	15.96
			Observations within 3 StdDev :			9			



Comparison of Cadmium Background Concentration Observations to a Normal Distribution

9 of 9 observations are within 3 standard deviation(s)

Lead Background vs Lead in Vadose Zone on 04/07/2010

Col. title	Pb-Bkgd	Pb-VZ
Mean	3.9375	4.88
Standard deviation (SD)	1.633	1.567
Sample size (N)	16	16
Std. error of mean (SEM)	0.4082	0.3918
Lower 95% conf. limit	3.068	4.045
Upper 95% conf. limit	4.807	5.715
Minimum	0.5000	2.770
Median (50th percentile	3.565	4.850
Maximum	6.840	7.450
Normality test KS	0.1901	0.1348
Normality test P value	>0.10	>0.10
Passed normality test?	Yes	Yes

Lead Background vs Lead in Vadose Zone on 04/07/2010

Unpaired t test with Welch correction

Do the means of Pb-Bkgd and Pb-VZ differ significantly?

P value

The two-tailed P value is 0.1065, considered not significant.
Welch correction applied. This test does not assume equal variances.

Welch's approximate t = 1.666 with 29 degrees of freedom.

95% confidence interval

Mean difference = 0.9425 (Mean of Pb-VZ minus mean of Pb-Bkgd)
The 95% confidence interval of the difference: -0.2147 to 2.100

Assumption test: Are the data sampled from Gaussian distributions?

The t test assumes that the data are sampled from populations that follow Gaussian distributions. This assumption is tested using the method Kolmogorov and Smirnov:

Group	KS	P Value	Passed normality test?
Pb-Bkgd	0.1901	>0.10	Yes
Pb-VZ	0.1348	>0.10	Yes

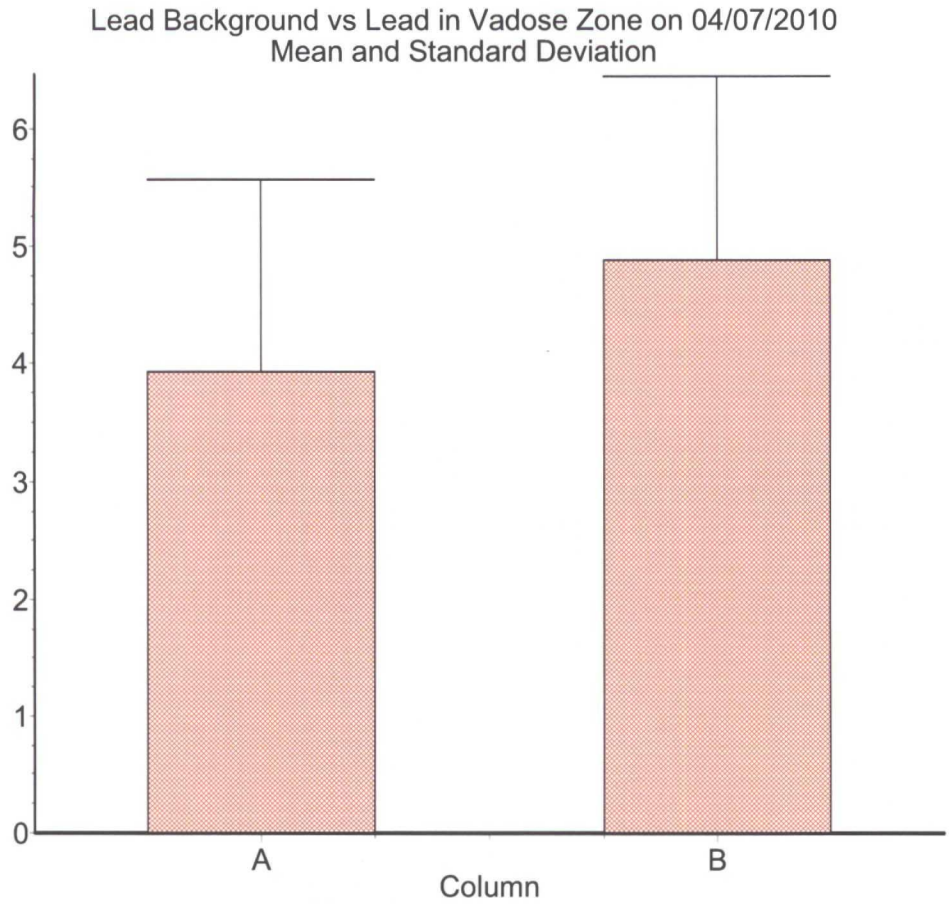
Summary of Data

Parameter:	Pb-Bkgd	Pb-VZ
Mean:	3.938	4.880
# of points:	16	16
Std deviation:	1.633	1.567
Std error:	0.4082	0.3918
Minimum:	0.5000	2.770
Maximum:	6.840	7.450
Median:	3.565	4.850
Lower 95% CI:	3.068	4.045
Upper 95% CI:	4.807	5.715

* * *

COMMENTS:

The P value indicates no significant difference between the background mean and vadose zone mean; therefore, results of this analysis indicate there is no evidence of lead migrating downward through the vadose zone.


Lead Background vs Lead in Vadose Zone on 04/07/2010
Mean and Standard Deviation
6
5
4
3
2
1
0
A
B
Column

Comparison of Lead Background Concentration Observations to a Normal Distribution

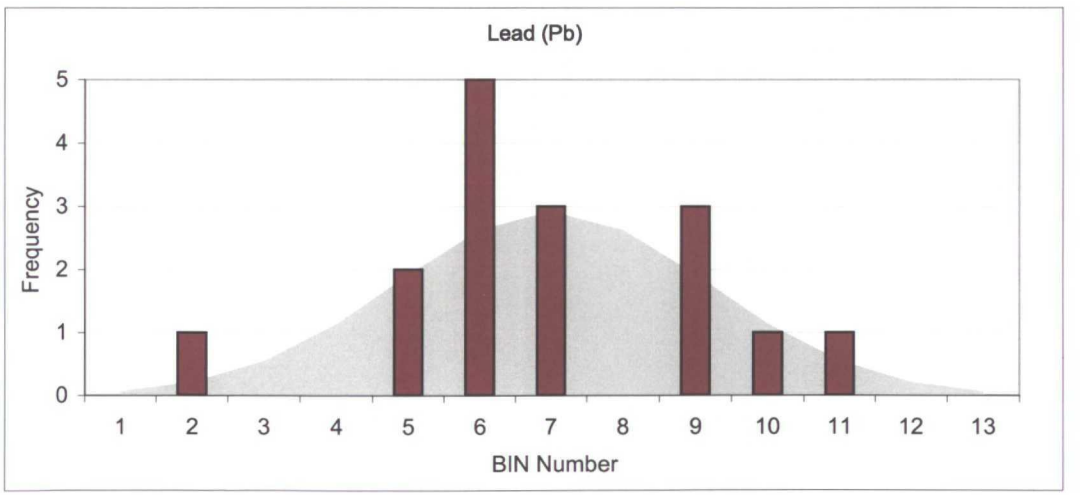
	Background
mean :	3.94
sd :	1.63

	Bin Size	St Devs	n
	0.75359	3	16

Cell #	n	Conc. (mg/L)
7B	1	0.50
1A	2	6.84
1B	3	6.30
1C	4	5.13
2A	5	2.39
2B	6	3.67
2C	7	5.77
10A	8	4.09
10B	9	3.05
10C	10	3.36
11A	11	3.46
11B	12	3.53
11C	13	2.62
12A	14	5.61
12B	15	3.08
12C	16	3.60

	Bin		Bin Range			Freq	Cum P	P	Exp Shape
	8		Infinity	< x <=	-0.96	0	0.1%		
	7	1	-0.96	< x <=	-0.21	0	0.6%	0.42%	0.07
	6	2	-0.21	< x <=	0.55	1	1.9%	1.33%	0.21
	5	3	0.55	< x <=	1.30	0	5.3%	3.42%	0.55
	4	4	1.30	< x <=	2.05	0	12.4%	7.12%	1.14
	3	5	2.05	< x <=	2.81	2	24.4%	12.01%	1.92
	2	6	2.81	< x <=	3.56	5	40.9%	16.44%	2.63
Mean	1	7	3.56	< x <=	4.31	3	59.1%	18.25%	2.92
	2	8	4.31	< x <=	5.07	0	75.6%	16.44%	2.63
	3	9	5.07	< x <=	5.82	3	87.6%	12.01%	1.92
	4	10	5.82	< x <=	6.58	1	94.7%	7.12%	1.14
	5	11	6.58	< x <=	7.33	1	98.1%	3.42%	0.55
	6	12	7.33	< x <=	8.08	0	99.4%	1.33%	0.21
	7	13	8.08	< x <=	8.84	0	99.9%	0.42%	0.07
	8		8.84	< x <=	Infinity	0	100.0%		
						16		99.73%	15.96

Observations within 3 StdDev : 16



Comparison of Lead Background Concentration Observations to a Normal Distribution
16 of 16 observations are within 3 standard deviation(s)

Barium Background vs Barium in Vadose Zone on 04/07/2010

Col. title	Ba-Bkgd	Ba-VZ
Mean	95.58125	34.676125
Standard deviation (SD)	136.06	20.566
Sample size (N)	16	16
Std. error of mean(SEM)	34.015	5.141
Lower 95% conf. limit	23.096	23.720
Upper 95% conf. limit	168.07	45.632
Minimum	15.400	0.9880
Median (50th percentile	47.600	37.250
Maximum	507.00	63.300
Normality test KS	0.4083	0.1447
Normality test P value	<0.0001	>0.10
Passed normality test?	No	Yes

COMMENTS:

The background mean and median are greater than the vadose zone mean and median.

Also, the background maximum exceeds the vadose zone maximum.

Barium Background vs Barium in Vadose Zone on 04/07/2010

Mann-Whitney Test

Do the medians of Ba-Bkgd and Ba-VZ differ significantly?

The two-tailed P value is 0.2504, considered not significant.
The P value is an estimate based on a normal approximation.
The 'exact' method would not be exact, due to tied ranks.

Calculation details

Mann-Whitney U-statistic = 97.000
U' = 159.00
Sum of ranks in Ba-Bkgd = 295.00. Sum of ranks in Ba-VZ = 233.00.

Summary of Data

Parameter:	Ba-Bkgd	Ba-VZ
Mean:	95.581	34.676
# of points:	16	16
Std deviation:	136.06	20.566
Std error:	34.015	5.141
Minimum:	15.400	0.9880
Maximum:	507.00	63.300
Median:	47.600	37.250
Lower 95% CI:	23.096	23.720
Upper 95% CI:	168.07	45.632

* * *

COMMENTS:

The P value indicates no significant difference between the background mean and vadose zone mean.

The background mean and median are greater than the vadose zone mean and median.

Also, the background maximum exceeds the vadose zone maximum.

Results of this analysis indicate there is no evidence of lead migrating downward through the vadose zone.

Comparison of Barium Background Concentration Observations to a Normal Distribution

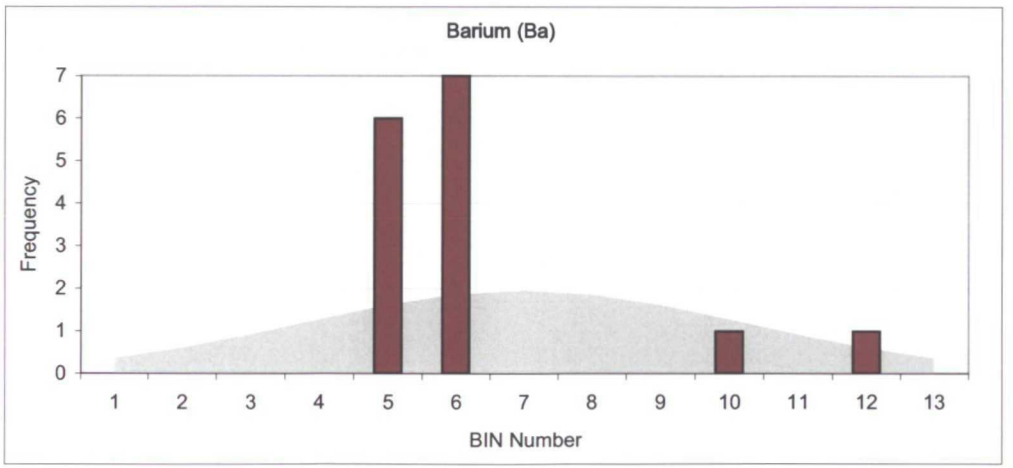
	mean :	95.58
	sd :	136.06

Cell #	n	Background Conc. (mg/L)
7B	1	507
1A	2	55.4
1B	3	48.4
1C	4	46.8
2A	5	15.4
2B	6	26
2C	7	51.4
10A	8	34.1
10B	9	23
10C	10	23.5
11A	11	27.1
11B	12	21.8
11C	13	300
12A	14	50.8
12B	15	236
12C	16	62.6

Bin Size: 41.86446 | St Devs: 2 | n: 16

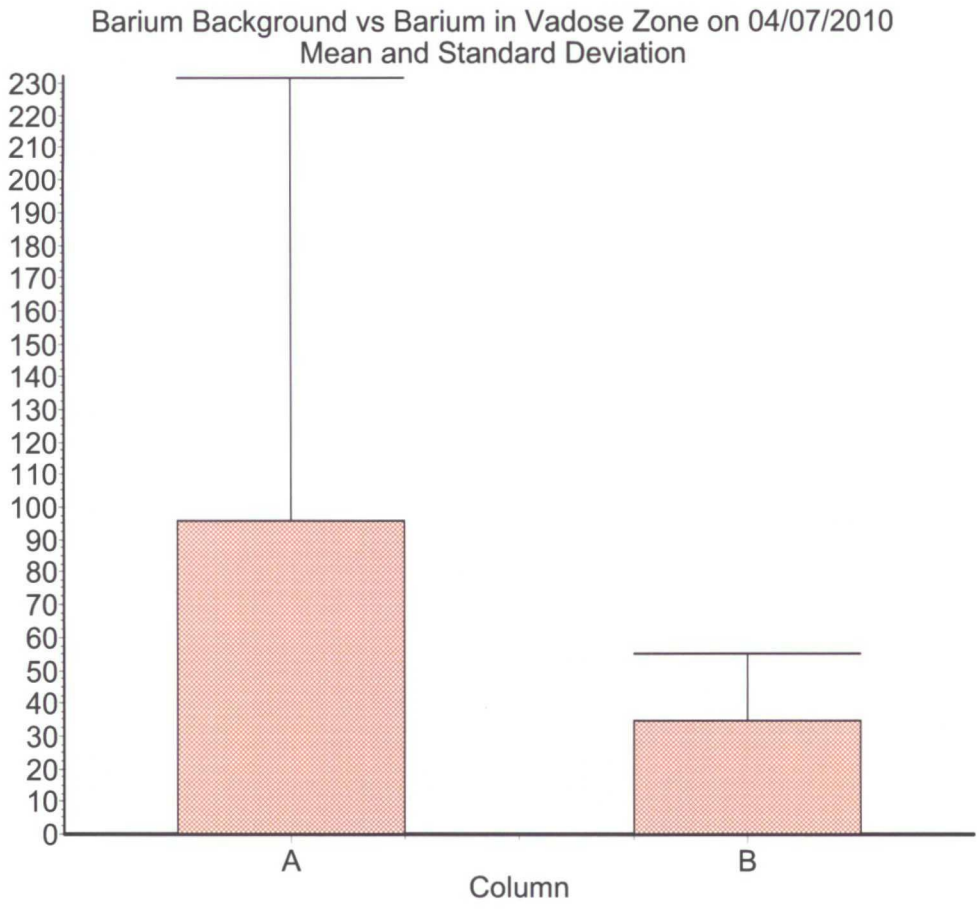
	Bin		Bin Range			Freq	Cum P	P	Exp Shape
	8		Infinity	< x <=	-176.54	0	2.3%		
	7	1	-176.54	< x <=	-134.67	0	4.5%	2.25%	0.36
	6	2	-134.67	< x <=	-92.81	0	8.3%	3.78%	0.60
	5	3	-92.81	< x <=	-50.94	0	14.1%	5.77%	0.92
	4	4	-50.94	< x <=	-9.08	0	22.1%	8.01%	1.28
	3	5	-9.08	< x <=	32.78	6	32.2%	10.13%	1.62
	2	6	32.78	< x <=	74.65	7	43.9%	11.67%	1.87
Mean	1	7	74.65	< x <=	116.51	0	56.1%	12.23%	1.96
	2	8	116.51	< x <=	158.38	0	67.8%	11.67%	1.87
	3	9	158.38	< x <=	200.24	0	77.9%	10.13%	1.62
	4	10	200.24	< x <=	242.11	1	85.9%	8.01%	1.28
	5	11	242.11	< x <=	283.97	0	91.7%	5.77%	0.92
	6	12	283.97	< x <=	325.84	1	95.5%	3.78%	0.60
	7	13	325.84	< x <=	367.70	0	97.7%	2.25%	0.36
	8		367.70	< x <=	Infinity	1	100.0%		
						16		95.45%	15.27

Observations within 2 StdDev : 15



Comparison of Barium Background Concentration Observations to a Normal Distribution

15 of 16 observations are within 2 standard deviation(s)


Barium Background vs Barium in Vadose Zone on 04/07/2010
Mean and Standard Deviation
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
A
B
Column

Chromium Background vs Chromium in Vadose Zone on 04/07/2010

Col. title	Cr-Bkgd	Cr-VZ
Mean	7.153125	5.846875
Standard deviation (SD)	3.106	1.638
Sample size (N)	16	16
Std. error of mean(SEM)	0.7765	0.4096
Lower 95% conf. limit	5.498	4.974
Upper 95% conf. limit	8.808	6.720
Minimum	3.010	3.790
Median (50th percentile	5.910	5.705
Maximum	13.400	8.780
Normality test KS	0.2645	0.1620
Normality test P value	0.0039	>0.10
Passed normality test?	No	Yes

COMMENTS:

Background mean exceeds VZ mean

Background maximum exceeds VZ maximum

Background data set does not exhibit a normal distribution

Chromium Background vs Chromium in Vadose Zone on 04/07/2010

Mann-Whitney Test

Do the medians of Cr-Bkgd and Cr-VZ differ significantly?

The two-tailed P value is 0.3414, considered not significant.
The P value is exact.

Calculation details

Mann-Whitney U-statistic = 102.00
U' = 154.00
Sum of ranks in Cr-Bkgd = 290.00. Sum of ranks in Cr-VZ = 238.00.

Summary of Data

Parameter:	Cr-Bkgd	Cr-VZ
Mean:	7.153	5.847
# of points:	16	16
Std deviation:	3.106	1.638
Std error:	0.7765	0.4096
Minimum:	3.010	3.790
Maximum:	13.400	8.780
Median:	5.910	5.705
Lower 95% CI:	5.498	4.974
Upper 95% CI:	8.808	6.720

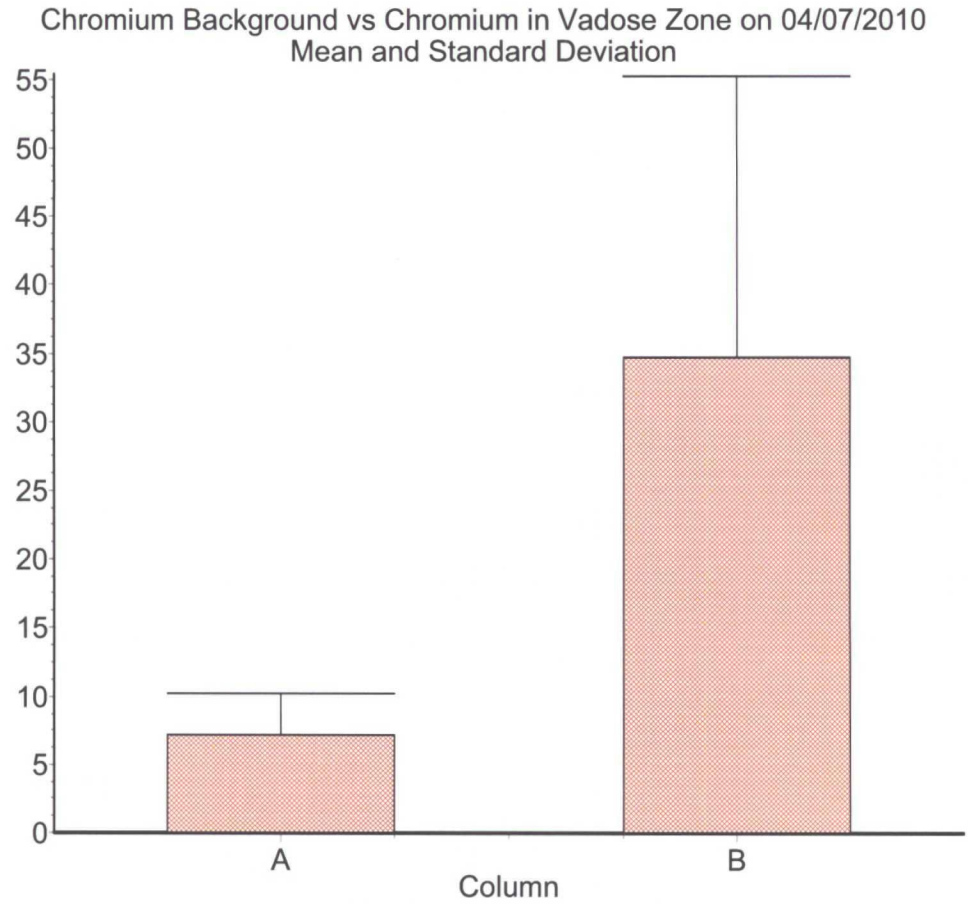
* * *

COMMENTS:

The P value suggests no significant difference between the background median and vadose zone median.

Note that the background median exceeds the vadose zone median. Also, the maximum background concentration exceeds the maximum vadose zone concentration.

Results of this analysis indicate there is no threat of chromium migrating downward through the vadose zone.


Chromium Background vs Chromium in Vadose Zone on 04/07/2010
Mean and Standard Deviation
55
50
45
40
35
30
25
20
15
10
5
0
A
B
Column

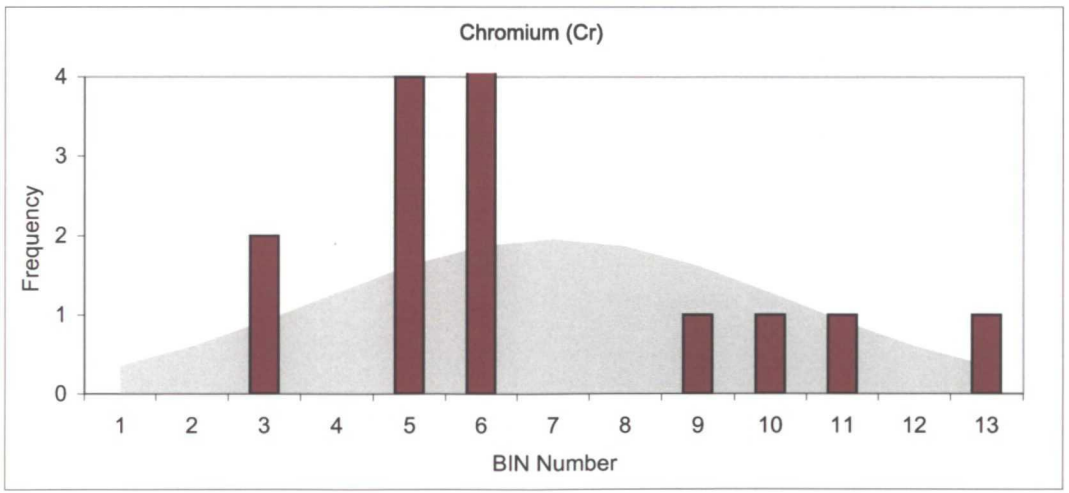
Comparison of Chromium Background Concentration Observations to a Normal Distribution

mean :	7.15	
sd :	3.11	
Cell #	n	Background Conc. (mg/L)
7B	1	3.01
1A	2	13.4
1B	3	12.5
1C	4	9.14
2A	5	3.77
2B	6	5.89
2C	7	9.64
10A	8	6.55
10B	9	5.24
10C	10	5.31
11A	11	5.93
11B	12	4.98
11C	13	5.47
12A	14	11.4
12B	15	5.76
12C	16	6.43

Bin Size: 0.956401 | St Devs: 2 | n: 16

		Bin		Bin Range		Freq	Cum P	P	Exp Shape
	8		Infinity	< x <=	0.93	0	2.3%		
	7	1	0.93	< x <=	1.89	0	4.5%	2.25%	0.36
	6	2	1.89	< x <=	2.85	0	8.3%	3.78%	0.60
	5	3	2.85	< x <=	3.80	2	14.1%	5.77%	0.92
	4	4	3.80	< x <=	4.76	0	22.1%	8.01%	1.28
	3	5	4.76	< x <=	5.72	4	32.2%	10.13%	1.62
	2	6	5.72	< x <=	6.67	5	43.9%	11.67%	1.87
Mean	1	7	6.67	< x <=	7.63	0	56.1%	12.23%	1.96
	2	8	7.63	< x <=	8.59	0	67.8%	11.67%	1.87
	3	9	8.59	< x <=	9.54	1	77.9%	10.13%	1.62
	4	10	9.54	< x <=	10.50	1	85.9%	8.01%	1.28
	5	11	10.50	< x <=	11.46	1	91.7%	5.77%	0.92
	6	12	11.46	< x <=	12.41	0	95.5%	3.78%	0.60
	7	13	12.41	< x <=	13.37	1	97.7%	2.25%	0.36
	8		13.37	< x <=	Infinity	1	100.0%		
						16		95.45%	15.27

Observations within 2 StdDev : 15



Comparison of Chromium Background Concentration Observations to a Normal Distribution

15 of 16 observations are within 2 standard deviation(s)

ATTACHMENT D

GraphPad **InStat**® Documentation

Version 3.0

The InStat guide to choosing and interpreting statistical tests

Harvey Motulsky

Program design, manual and help screens:	Dr. Harvey J. Motulsky Paige Searle
Programming:	Mike Platt John Pilkington Harvey Motulsky

InStat and GraphPad Prism are registered trademarks of GraphPad Software, Inc.

How to cite GraphPad InStat

When citing analyses performed by the program, include the name of the analysis, and InStat version number (including the second number after the decimal point). Use this example as a guide: "One-way ANOVA with Dunnett's post test was performed using GraphPad InStat version 3.05 for Windows 95, GraphPad Software, San Diego California USA, www.graphpad.com".

To find the full version number, pull down the Help menu (Windows), or InStat menu (Mac OS X), or a Apple menu (Mac OS 8-9, and choose About GraphPad InStat.)

If you want to cite this manual rather than the program itself, use this example as a guide: "GraphPad Software, InStat guide to choosing and interpreting statistical tests, 1998, GraphPad Software, Inc., San Diego California USA, www.graphpad.com". It makes sense to include the web address, since this manual is available on-line, but not in libraries.

System requirements

The Windows version requires Windows 95 or higher, 4Mb RAM, 3Mb free hard disk space. The Macintosh version requires OS 8.6 or higher (including OS X) and 4Mb free hard disk space. InStat 3.0 Mac is a native OS X (carbon) application. If you run InStat under Mac system 8.6-9.2, you must have CarbonLib (version 1.5 or later) installed on your system. You can find CarbonLib at www.graphpad.com.

Contents

Welcome to InStat

The InStat approach

GraphPad InStat is designed to help the experimental or clinical scientist analyze small amounts of data. Although InStat can do some data manipulation and selection, it is not designed to manage a large database with many variables. InStat works best when you have a single question in mind. Enter the data to answer that question, and InStat guides you to pick the right test to answer it:

- The first step – even before entering or importing data – is to tell InStat what kind of data you wish to enter. InStat will then present you with a data table for that kind of data.
- The next step is to enter data. You can type in numbers, paste from the clipboard, or import a text file.
- InStat then asks you several questions to choose a test. On-line help (or this manual) can help you answer those questions.
- Finally InStat presents the results, avoiding jargon when possible. On-line help, and this manual, can help you interpret the values.

This manual provides a comprehensive explanation of all of InStat's features. In addition, this guide will to help you review statistical principles, pick an appropriate test, and interpret the results.

What InStat does

InStat calculates these statistical tests:

Category	Tests that InStat performs
Column statistics	Mean, median, 95% CI, SD, SEM. Also tests whether the distribution conforms to a Gaussian distribution using the Kolmogorov-Smirnov test.
Group comparisons	Paired and unpaired t tests; Mann-Whitney and Wilcoxon nonparametric tests. Ordinary and repeated measures ANOVA followed by Bonferroni, Tukey, Student-Newman-Keuls or Dunnett post tests. Kruskal-Wallis or Friedman nonparametric tests followed by Dunn post test.
Contingency tables	Chi-square test (with or without Yates' correction). Fisher's exact test. Calculate 95% confidence interval for the difference of two proportions, relative risk, odds ratio, sensitivity or specificity. Chi-square test for trend.
Linear regression and correlation	Linear regression, optionally forcing the line through a defined point. Determine new points along the standard curve. Pearson linear correlation and Spearman nonparametric correlation.
Multiple regression	Determine the best linear equation that fits Y to two or more X variables.

InStat is not for everyone. It performs basic tests easily, but does not handle advanced statistical tests. For example, InStat does not perform two-way (or higher) ANOVA, logistic regression, the Mantel-Haenszel test (to analyze a stack of contingency tables), stepwise multiple regression, analyses of survival curves, analysis of covariance, factor or cluster analysis, polynomial regression or nonlinear regression.

Please note that our scientific graphics and analysis program, GraphPad Prism, can perform polynomial and nonlinear regression, analyze survival curves and perform two-way ANOVA. For more information, contact GraphPad Software or visit our web page at www.graphpad.com. Do you have the current version?

Like all software companies, GraphPad occasionally issues minor updates to Prism. If you are having trouble with InStat, check that you are running the current release.

The full version number is not on the manual cover or the CD label. You have to run the program and find out which version it is. Drop the Help menu (Windows), Apple menu (Mac OS8-9) or Prism menu (Mac OS X) and choose About InStat. Windows versions have two digits after the decimal point (i.e. 3.05). Mac versions have a single digit after the decimal followed by a letter (i.e. 3.0a).

Go to the Support page at www.graphpad.com to find out what version is most current. Download and install the updater if your version is not the most current. Updates (interim versions of GraphPad software containing bug fixes or minor improvements) are free to owners of the corresponding major releases. In contrast, upgrades (a new version with many new features) must be purchased.

How to start

There are three ways to proceed:

- Learn to use InStat systematically by carefully reading "Tutorial: The InStat approach" on page 21, and then browsing "Using InStat" on page 109.
- Review the principles of statistics before using the program by reading this manual from start to finish.
- Simply plunge in! Start using InStat, and consult the manual or help screens when you have questions. The InStat Guide (page 109) will help you learn the program quickly. You can complete your first analysis in just a few minutes.

Like any tool, data analysis programs can be misused. InStat won't be helpful if you designed the experiment badly, entered incorrect data or picked an inappropriate analysis. Heed the first rule of computers: *Garbage in, garbage out.*

Introduction to statistical principles

When do you need statistical calculations?

When analyzing data, your goal is simple: You wish to make the strongest possible conclusion from limited amounts of data. To do this, you need to overcome two problems:

- Important differences can be obscured by biological variability and experimental imprecision. This makes it hard to distinguish real differences from random variability.
- The human brain excels at finding patterns, even from random data. Our natural inclination (especially with our own data) is to conclude that differences are real, and to minimize the contribution of random variability. Statistical rigor prevents you from making this mistake.

Statistical analyses are most useful when observed differences are small compared to experimental imprecision and biological variability. If you only care about large differences, heed these aphorisms:

If you need statistics to analyze your experiment, then you've done the wrong experiment.

If your data speak for themselves, don't interrupt!

But in many fields, scientists care about small differences and are faced with large amounts of variability. Statistical methods are necessary to draw valid conclusions from these data.

The key concept: Sampling from a population

Sampling from a population

The basic idea of statistics is simple: you want to extrapolate from the data you have collected to make general conclusions.

To do this, statisticians have developed methods based on this simple model: Assume that all your data are randomly sampled from an infinitely large population. Analyze this sample to make inferences about the population.

In some fields of science – for example, quality control – you really do collect random samples from a large (if not infinite) population. In other fields, you encounter two problems:

The first problem is that you don't really have a random sample. It is rare for a scientist to randomly select subjects from a population. More often you just did an experiment a few times and want to extrapolate to the more general situation. But you can define the population to be the results of a

hypothetical experiment done many times (or a single experiment performed with an infinite sample size).

The second problem is that you generally want to make conclusions that extrapolate beyond the population. The statistical inferences only apply to the population your samples were obtained from. Let's say you perform an experiment in the lab three times. All the experiments used the same cell preparation, the same buffers, and the same equipment. Statistical inferences let you make conclusions about what would happen if you repeated the experiment many more times with that same cell preparation, those same buffers, and the same equipment. You probably want to extrapolate further to what would happen if someone else repeated the experiment with a different source of cells, freshly made buffer and different instruments. Statistics can't help with this further extrapolation. You can use scientific judgment and common sense to make inferences that go beyond statistics. Statistical logic is only part of data interpretation.

Even though scientific research is not really based on drawing random samples from populations, the statistical tests based on this logic have proven to be very useful in analyzing scientific data. This table shows how the terms *sample* and *population* apply in various kinds of experiments.

Situation	Sample	Population
Quality control	The items you tested.	The entire batch of items produced.
Political polls	The voters you polled.	All voters.
Clinical studies	Subset of patients who attended Tuesday morning clinic in August.	All similar patients.
Laboratory research	The data you actually collected.	All the data you could have collected if you had repeated the experiment many times the same way.

The need for independent samples

It is not enough that your data are sampled from a population. Statistical tests are also based on the assumption that each subject (or each experimental unit) was sampled independently of the rest. The concept of independence is hard to grasp. Consider these three situations.

- You are measuring blood pressure in animals. You have five animals in each group, and measure the blood pressure three times in each animal. You do not have 15 independent measurements, because the triplicate measurements in one animal are likely to be closer to each other than to measurements from the other animals. You should average the three measurements in each animal. Now you have five mean values that are independent of each other.

- You have done a laboratory experiment three times, each time in triplicate. You do not have nine independent values, as an error in

preparing the reagents for one experiment could affect all three triplicates. If you average the triplicates, you do have three independent mean values.

- You are doing a clinical study, and recruit ten patients from an inner-city hospital and ten more patients from a suburban clinic. You have not independently sampled 20 subjects from one population. The data from the ten inner-city patients may be closer to each other than to the data from the suburban patients. You have sampled from two populations, and need to account for this in your analysis.

Data are independent when any random factor that causes a value to be too high or too low affects only that one value. If a random factor (that you didn't account for in the analysis of the data) can affect more than one, but not all, of the values, then the data are not independent.

How statistics can extrapolate from sample to population

Statisticians have devised three basic approaches to use data from samples to make conclusions about populations:

The first method is to assume that the populations follow a special distribution, known as the Gaussian (bell shaped) distribution. Once you assume that a population is distributed in that manner, statistical tests let you make inferences about the mean (and other properties) of the population. Most commonly used statistical tests assume that the population is Gaussian.

The second method is to convert all values to ranks, and look at the distribution of ranks. This is the principle behind most commonly used nonparametric tests.

The third method is known as resampling. This is best seen by an example. Assume you have a single sample of five values, and want to know how close that sample mean is likely to be from the true population mean. Write each value on a card and place them in a hat. Create many pseudo samples by drawing a card from the hat, then return it. You can generate many samples of N=5 this way. Since you can draw the same value more than once, the samples won't all be the same. The distribution of the means of these pseudo samples gives you information about how well you know the population mean. The idea of resampling is hard to grasp. To learn about this approach to statistics, read the instructional material available at www.resampling.com. InStat does not perform any tests based on resampling.

Confidence intervals

Statistical calculations produce two kinds of results that help you make inferences about the population by analyzing the samples. Confidence intervals are explained here, and P values are explained in the next section.

Confidence interval of a mean

The mean you calculate from a sample is unlikely to equal the population mean. The size of the discrepancy depends on the size and variability of the sample. If your sample is small and variable, the sample mean may be quite far from the population mean. If your sample is large with little scatter, the sample mean will probably be very close to the population mean. Statistical calculations combine sample size and variability (standard deviation) to generate a confidence interval (CI) for the population mean. You can calculate intervals for any desired degree of confidence, but 95% confidence intervals are used most commonly. If you assume that your sample is randomly selected from some population (that follows a Gaussian distribution, see "What is the Gaussian distribution?" on page 17), you can be 95% sure that the confidence interval includes the population mean. More precisely, if you generate many 95% CI from many data sets, you expect the CI to include the true population mean in 95% of the cases and not to include the true mean value in the other 5%. Since you don't know the population mean, you'll never know when this happens.

Confidence intervals in other situations

Statisticians have derived methods to generate confidence intervals for almost any situation. For example when comparing groups, you can calculate the 95% confidence interval for the difference between the population means. Interpretation is straightforward. If you accept the assumptions, there is a 95% chance that the interval you calculate includes the true difference between population means.

Similarly, methods exist to compute a 95% confidence interval for the relative risk, the best-fit slope of linear regression, and almost any other statistical parameter.

P values

What is a P value?

Assume that you've collected data from two samples, and the means are different. You want to know whether the data were sampled from populations with different means. Observing different sample means is not enough to persuade you to conclude that the populations have different means. It is possible that the populations have the same mean, and the difference you observed is a coincidence of random sampling. There is no way you can ever be sure whether the difference you observed reflects a true difference or a coincidence of random sampling. All you can do is calculate the probabilities.

The P value answers this question: If the populations really did have the same mean, what is the probability of observing such a large difference (or larger) between sample means in an experiment of this size?

The P value is a probability, with a value ranging from zero to one. If the P value is small, you'll conclude that the difference is quite unlikely to be

caused by random sampling. You'll conclude instead that the populations have different means.

What is a null hypothesis?

When statisticians refer to P values, they use the term null hypothesis. The null hypothesis simply states that there is no difference between the groups. Using that term, you can define the P value to be the probability of observing a difference as large or larger than you observed if the null hypothesis were true.

Common misinterpretation of a P value

Many people misunderstand P values. If the P value is 0.03, that means that there is a 3% chance of observing a difference as large as you observed even if the two population means are identical (the null hypothesis is true). It is tempting to conclude, therefore, that there is a 97% chance that the difference you observed reflects a real difference between populations and a 3% chance that the difference is due to chance. Wrong. What you can say is that random sampling from identical populations would lead to a difference smaller than you observed in 97% of experiments and larger than you observed in 3% of experiments.

The P value is a fraction, but what it is a fraction of? The P value is the fraction of all possible results obtained under the null hypothesis where the difference is as large or larger than you observed. That is NOT the same as the fraction of all experiments that yield a certain P value where the null hypothesis is true. To determine that fraction, you need to use Bayesian reasoning – beyond the scope of InStat.

One- vs. two-tail P values

When comparing two groups, you must distinguish between one- and two-tail P values.

Start with the null hypothesis that the two populations really are the same and that the observed discrepancy between sample means is due to chance.

Note: This example is for an unpaired t test that compares the means of two groups. The same ideas can be applied to other statistical tests.

The two-tail P value answers this question: Assuming the null hypothesis is true, what is the chance that randomly selected samples would have means as far apart (or further) as you observed in this experiment with either group having the larger mean?

To interpret a one-tail P value, you must predict which group will have the larger mean before collecting any data. The one-tail P value answers this question: Assuming the null hypothesis is true, what is the chance that randomly selected samples would have means as far apart (or further) as observed in this experiment with the specified group having the larger mean?

A one-tail P value is appropriate only when previous data, physical limitations or common sense tell you that a difference, if any, can only go in one direction. The issue is not whether you expect a difference to exist – that is what you are trying to find out with the experiment. The issue is whether you should interpret increases and decreases the same.

You should only choose a one-tail P value when two things are true. First, you must have predicted which group will have the larger mean (or proportion) before you collected any data. That's easy, but the second criterion is harder. If the other group ends up with the larger mean – even if it is quite a bit larger -- then you must attribute that difference to chance.

It is usually best to use a two-tail P value for these reasons:

- The relationship between P values and confidence intervals is easier to understand with two-tail P values.
- Some tests compare three or more groups, which makes the concept of tails inappropriate (more precisely, the P values have many tails). A two-tail P value is more consistent with the P values reported by these tests.
- Choosing a one-tail P value can pose a dilemma. What would you do if you chose to use a one-tail P value, observed a large difference between means, but the "wrong" group had the larger mean? In other words, the observed difference was in the opposite direction to your experimental hypothesis. To be rigorous, you must conclude that the difference is due to chance, no matter how large the difference is. You must say that the difference is not statistically significant. But most people would be tempted to switch to a two-tail P value or to reverse the direction of the experimental hypothesis. You avoid this situation by always using two-tail P values.

Hypothesis testing and statistical significance

Statistical hypothesis testing

The P value is a fraction. In many situations, the best thing to do is report that fraction to summarize your results ("P=0.0234"). If you do this, you can totally avoid using the term "statistically significant", which is often misinterpreted.

In other situations, you'll want to make a decision based on a single comparison. In these situations, follow the steps of statistical hypothesis testing.

- Set a threshold P value before you do the experiment. Ideally, you should set this value based on the relative consequences of missing a true difference or falsely finding a difference. In fact, the threshold value (called α) is traditionally almost always set to 0.05.

- Define the null hypothesis. If you are comparing two means, the null hypothesis is that the two populations have the same mean.
- Do the appropriate statistical test to compute the P value.
- Compare the P value to the preset threshold value.
- If the P value is less than the threshold, state that you "reject the null hypothesis" and that the difference is "statistically significant".
- If the P value is greater than the threshold, state that you "do not reject the null hypothesis" and that the difference is "not statistically significant". You cannot conclude that the null hypothesis is true. All you can do is conclude that you don't have sufficient evidence to reject the null hypothesis.

Statistical significance

The term *significant* is seductive, and it is easy to misinterpret it. A result is said to be *statistically significant* when the result would be surprising if the populations were really identical.

It is easy to read far too much into the word *significant* because the statistical use of the word has a meaning entirely distinct from its usual meaning. Just because a difference is *statistically significant* does not mean that it is important or interesting. And a result that is not *statistically significant* (in the first experiment) may turn out to be very important.

If a result is statistically significant, there are two possible explanations:

- The populations are identical, so there really is no difference. By chance, you obtained larger values in one group and smaller values in the other. Finding a statistically significant result when the populations are identical is called making a Type I error. If you define statistically significant to mean "P<0.05", then you'll make a Type I error in 5% of experiments where there really is no difference.
- The populations really are different, so your conclusion is correct.

Beware of multiple comparisons

A result is said to be statistically significant when it would occur rarely under the null hypothesis. Therefore you conclude that the null hypothesis is unlikely to be true. But if you perform enough tests, statistically significant results will occur often (even if the null hypotheses are all true).

For example, assume you perform ten independent statistical tests and the null hypotheses are all true. The probability is 5% that any particular test will have a P value less then 0.05. But by performing ten tests, there is a very high chance that at least one of those comparisons will have a P value less than 0.05. The probability is about 40% (to calculate this, first calculate the probability of getting ten consecutive P values greater than

0.05, which is 0.95^{10}, or about 60%; so the chance that at least one of the P values is less than 0.05 is 100% - 60% or 40%).

The multiple comparison problem means that you cannot interpret a small P value without knowing how many comparisons were made. There are three practical implications:

- When comparing three or more groups, you should not perform a series of t tests. Instead, use one-way ANOVA followed by posttests (which take into account all the comparisons).

- Beware of data mining. If you look at many variables, in many subgroups, using many analyses, you are sure to find some small P values. But these are likely to occur by chance. Data exploration can be fun, and can lead to interesting ideas or hypotheses. But you'll need to test the hypotheses with a focused experiment using new data.

- All analyses should be planned and all planned analyses should be reported. It is not fair to include in your papers the analyses that give small P values while excluding those that gave large P values.

The Gaussian distribution and testing for normality

What is the Gaussian distribution?

When many independent random factors act in an additive manner to create variability, data will follow a bell-shaped distribution called the Gaussian distribution. This distribution is also called a Normal distribution (don't confuse this use of the word "normal" with its usual meaning). The Gaussian distribution has some special mathematical properties that form the basis of many statistical tests. Although no data follows that mathematical ideal, many kinds of data follow a distribution that is approximately Gaussian.

What's so special about the Gaussian distribution?

The Gaussian distribution plays a central role in statistics because of a mathematical relationship known as the Central Limit Theorem. To understand this theorem, follow this imaginary experiment.

1. Create a population with a known distribution (which does not have to be Gaussian).
2. Randomly pick many samples from that population. Tabulate the means of these samples.
3. Draw a histogram of the frequency distribution of the means.

The central limit theorem says that if your samples are large enough, the distribution of means will follow a Gaussian distribution even if the population is not Gaussian. Since most statistical tests (such as the t test and ANOVA) are concerned only about differences between means, the Central Limit Theorem lets these tests work well even when the populations are not Gaussian. The catch is that the samples have to be reasonably large. How large is that? It depends on how far the population distribution differs from a Gaussian distribution.

To learn more about why the ideal Gaussian distribution is so useful, read about the Central Limit Theorem in any statistics text.

Nonparametric tests

The t test and ANOVA, as well as other statistical tests, assume that you have sampled data from populations that follow a Gaussian bell-shaped distribution. Biological data never follow a Gaussian distribution precisely, because a Gaussian distribution extends infinitely in both directions, so includes both infinitely low negative numbers and infinitely high positive numbers! But many kinds of biological data follow a bell-shaped

distribution that is approximately Gaussian. Because ANOVA, t tests and other statistical tests work well even if the distribution is only approximately Gaussian (especially with large samples), these tests are used routinely in many fields of science.

An alternative approach does not assume that data follow a Gaussian distribution. In this approach, values are ranked from low to high and the analyses are based on the distribution of ranks. These tests, called *nonparametric* tests, are appealing because they make fewer assumptions about the distribution of the data. But there is a drawback. Nonparametric tests are less powerful than the parametric tests that assume Gaussian distributions. This means that P values tend to be higher, making it harder to detect real differences as being statistically significant. If the samples are large the difference in power is minor. With small samples, nonparametric tests have little power to detect differences.

You may find it difficult to decide when to select nonparametric tests. You should definitely choose a nonparametric test in these situations:

- The outcome variable is a rank or score with fewer than a dozen or so categories (i.e. Apgar score). Clearly the population cannot be Gaussian in these cases.

- A few values are off scale, too high or too low to measure. Even if the population is Gaussian, it is impossible to analyze these data with a t test or ANOVA. Using a nonparametric test with these data is easy. Assign values too low to measure an arbitrary low value, and values too high to measure an arbitrary high value. Since the nonparametric tests only consider the relative ranks of the values, it won't matter that you didn't know a few values exactly.

- You are sure that the population is far from Gaussian. Before choosing a nonparametric test, consider transforming the data (i.e. logarithms, reciprocals). Sometimes a simple transformation will convert nongaussian data to a Gaussian distribution. See "Transforming data to create a Gaussian distribution" on page 19.

In many situations, perhaps most, you will find it difficult to decide whether to select nonparametric tests. Remember that the Gaussian assumption is about the distribution of the overall population of values, not just the sample you have obtained in this particular experiment. Look at the scatter of data from previous experiments that measured the same variable. Also consider the source of the scatter. When variability is due to the sum of numerous independent sources, with no one source dominating, you expect a Gaussian distribution.

InStat performs normality testing in an attempt to determine whether data were sampled from a Gaussian distribution, but normality testing is less useful than you might hope (see "Testing for normality" on page 19). Normality testing doesn't help if you have fewer than a few dozen (or so) values.

Your decision to choose a parametric or nonparametric test matters the most when samples are small for reasons summarized here:

	Large samples (> 100 or so)	Small samples (<12 or so)
Parametric tests	Robust. P value will be nearly correct even if population is fairly far from Gaussian.	Not robust. If the population is not Gaussian, the P value may be misleading.
Nonparametric test	Powerful. If the population is Gaussian, the P value will be nearly identical to the P value you would have obtained from parametric test. With large sample sizes, nonparametric tests are almost as powerful as parametric tests.	Not powerful. If the population is Gaussian, the P value will be higher than the P value obtained from a t test. With very small samples, it may be impossible for the P value to ever be less than 0.05, no matter how the values differ.
Normality test	Useful. Use a normality test to determine whether the data are sampled from a Gaussian population.	Not very useful. Little power to discriminate between Gaussian and nongaussian populations. Small samples simply don't contain enough information to let you make inferences about the shape of the distribution in the entire population.

Transforming data to create a Gaussian distribution

If your data do not follow a Gaussian (normal) distribution, you may be able to transform the values to create a Gaussian distribution. If you know the distribution of your population, transforming the values to create a Gaussian distribution is a good thing to do, as it lets you use statistical tests based on the Gaussian distribution.

This table shows some common normalizing transformations:

Type of data and distribution	Normalizing transformation
Count (C comes from Poisson distribution)	Square root of C
Proportion (P comes from binomial distribution)	Arcsine of square root of P
Measurement (M comes from lognormal distribution)	Log(M)
Time or duration (D)	1/D

Testing for normality

InStat tests for deviations from Gaussian distribution. Since the Gaussian distribution is also called the Normal distribution, the test is called a normality test. InStat tests for normality using the Kolmogorov-Smirnov test. The KS statistic (which some other programs call D) quantifies the discrepancy between the distribution of your data and an ideal Gaussian

distribution – a larger value denotes a larger discrepancy. It is not informative by itself, but is used to compute a P value.

InStat uses the method of Kolmogorov and Smirnov to calculate KS. However, the method originally published by those investigators cannot be used to calculate the P value because their method assumes that you know the mean and SD of the overall population (perhaps from prior work). When analyzing data, you rarely know the overall population mean and SD. You only know the mean and SD of your sample. To compute the P value, therefore, InStat uses the Dallal and Wilkinson approximation to Lilliefors' method (Am. Statistician, 40:294-296, 1986). Since that method is only accurate with small P values, InStat simply reports "P>0.10" for large P values.

The P value from the normality test answers this question: If you randomly sample from a Gaussian population, what is the probability of obtaining a sample that deviates as much from a Gaussian distribution (or more so) as this sample does. More precisely, the P value answers this question: If the population was really Gaussian, what is the chance that a randomly selected sample of this size would have a KS distance as large, or larger, as observed?

By looking at the distribution of a small sample of data, it is hard to tell if the values came from a Gaussian distribution or not. Running a formal test does not make it easier. The tests simply have little power to discriminate between Gaussian and nongaussian populations with small sample sizes. How small? If you have fewer than five values, InStat doesn't even attempt to test for normality. But the test doesn't really have much power to detect deviations from Gaussian distribution unless you have several dozen values.

Your interpretation of a normality test depends on the P value and the sample size.

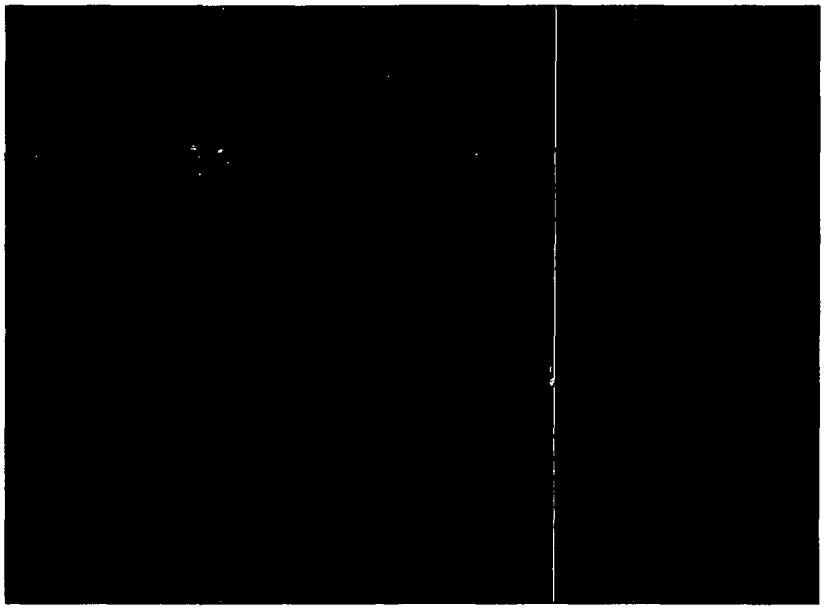
P value	Sample size	Conclusion
Small	Any	The data failed the normality test. You can conclude that the population is unlikely to be Gaussian.
Large	Large	The data passed the normality test. You can conclude that the population is likely to be Gaussian, or nearly so. How large does the sample have to be? There is no firm answer, but one rule-of-thumb is that the normality tests are only useful when your sample size is a few dozen or more.
Large	Small	You will be tempted to conclude that the population is Gaussian. Don't do that. A large P value just means that the data are not inconsistent with a Gaussian population. That doesn't exclude the possibility of a nongaussian population. Small sample sizes simply don't provide enough data to discriminate between Gaussian and nongaussian distributions. You can't conclude much about the distribution of a population if your sample contains fewer than a dozen values.

Tutorial: The InStat approach

After installing InStat, the easiest way to learn InStat is to follow a simple example. In this example, we'll perform an unpaired t test. It will take just a few minutes. The screen shots are for Windows, but the Mac is very similar.

Step 1. Choose data format

Launch InStat by double clicking on its icon. You'll see this screen:

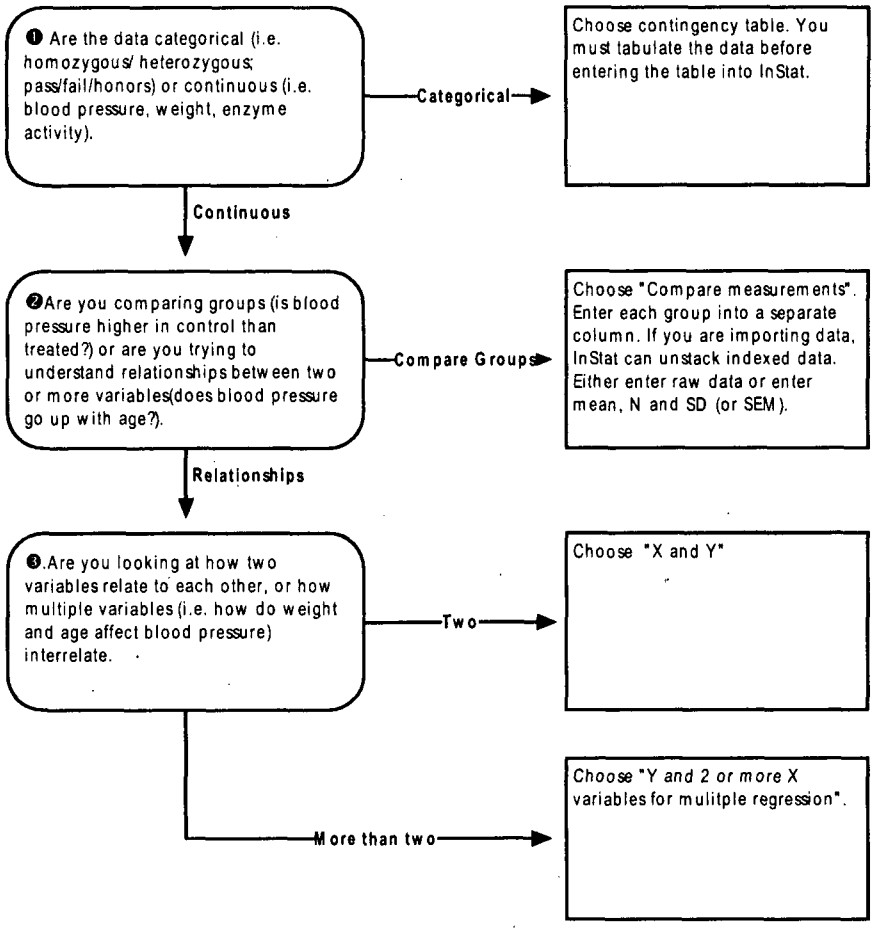


You may see the InStat Guide superimposed on this screen. While following this written tutorial, you may wish to turn off the Guide window (uncheck the box "Keep showing the InStat Guide", then press Close). The Guide is always on in the demo version. In the full version of the program, you decide when to show the Guide. Bring it back by selecting InStat Guide from the Help menu.

Before you can enter data, you first have to tell InStat what kind of data table you need. This important step makes InStat unique. Once you've chosen the right kind of data table for your experiment, InStat will be able to guide you to choose an appropriate statistical test.

InStat offers three goals on the top left of the screen, with more choices below. Based on your choices, you'll be able to perform different tests as shown on the right.

The three goals are distinct, and you shouldn't have a problem telling InStat what kind of data you have. Follow the logic of this flowchart:

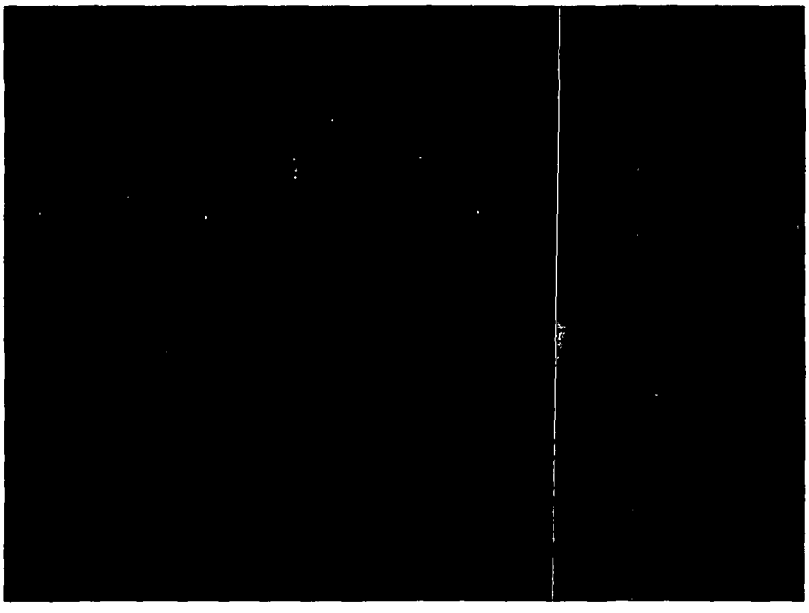


Choose "Compare means (or medians)" and "Raw data". Then click the arrow button in the lower right of the screen to move to the next step.

Step 2. Enter data

Enter the values shown here.

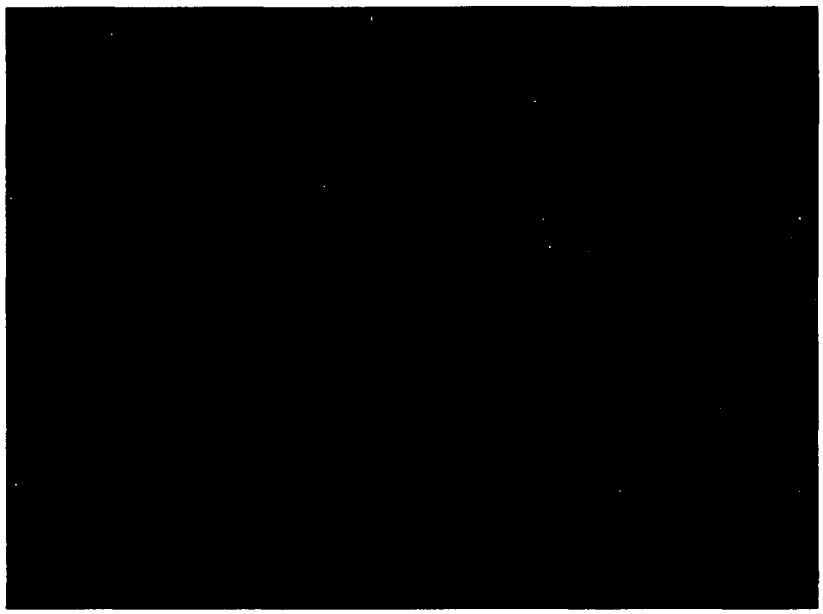
Group A	Group B
23	32
25	29
26	27
31	30
23	33



Press the buttons at the lower left of the window to learn how to arrange your data (important with InStat) or how to import data (including stacked or indexed data). As you move from step to step, these buttons will provide help on different topics.

Click the blue right arrow button (lower right of window) to go to the next step.

Step 3. Summary statistics

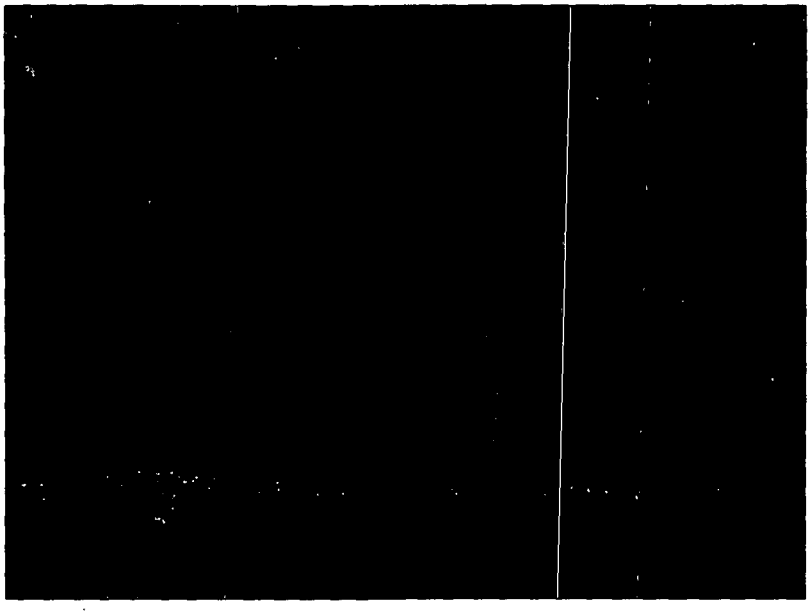


The summary statistics screen shows the mean, SD, SEM, confidence interval, etc. for each column. You can also enter data here if you have calculated the mean and SD (or SEM) in another program.

Click "Explain the results" for a definition of the statistical terms and a discussion of how they are used.

Go to the next step.

Step 4. Select a statistical test



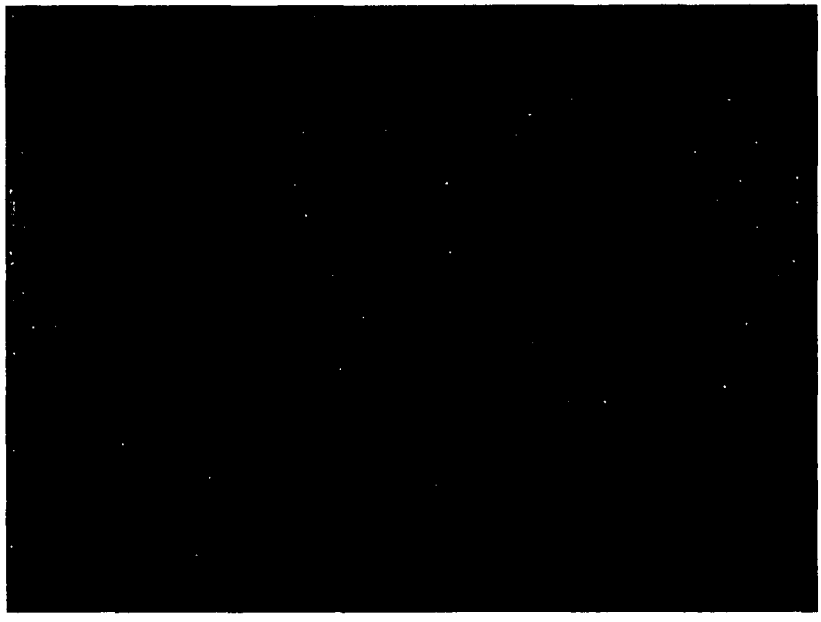
For this example, InStat presents questions necessary to choose an analysis to compare two columns of data. You'd see different choices if you entered a different number of columns of data, or if you created a different kind of data table.

Select an unpaired test, assuming the populations are Gaussian with equal standard deviations, and a two-tail P value.

If you are unsure of the choices, InStat can help you understand these questions. Press "Help me choose" for guidance.

Go to the next step.

Step 5. View the results



InStat presents the results using as little statistical jargon as possible. Of course you can print the results or export them to another program.

Press the "Checklist" button to confirm that you picked an appropriate test and to understand the results.

You don't have to follow InStat's steps in order. Use one of the six step buttons (lower right) to jump from step to step.

Step 6. On your own

Press the last step button to see a notebook quality graph, suitable for getting the sense of your data and to spot errors in data entry. You cannot change or edit the graph, but can print it or copy it to the clipboard.

You don't have to follow the steps in order. Click the data table button to go back to the data and change one or more of the values. Now click the results step button ("P=") to view the results. Note that InStat instantly recomputed the results to correspond with the new data.

An InStat file consists of one data table and one analysis. Click "What's next" to learn how to manage multiple analyses.

Descriptive statistics

Column statistics

There are many ways to describe the distribution of a group of values. After you enter data for column comparisons, InStat next presents a table of descriptive statistics for each column.

Descriptive statistics

Statistic	Definition
Mean	The mean is the average of all the values in the column.
Standard deviation	The standard deviation (SD) quantifies variability or scatter among the values in a column. If the data follow a bell-shaped Gaussian distribution, then 68% of the values lie within one SD of the mean (on either side) and 95% of the values lie within two SD of the mean. The SD is expressed in the same units as your data. InStat calculates the "sample SD" (which uses a denominator of N-1), not the "population SD" with a denominator of N. InStat does not report the variance. If you want to know the variance, simply square the standard deviation. Variance is expressed in the units of your data squared.
Standard error of the mean	The standard error of the mean (SEM) is a measure of the likely discrepancy between the mean calculated from your data and the true population mean (which you can't know without an infinite amount of data). The SEM is calculated as the SD divided by the square root of sample size. With large samples, therefore, the SEM is always small. By itself, the SEM is difficult to interpret. It is easier to interpret the 95% confidence interval, which is calculated from the SEM.
Confidence interval	The mean you calculate from your sample of data points depends on which values you happened to sample. Therefore, the mean you calculate is unlikely to equal the true population mean exactly. The size of the likely discrepancy depends on the variability of the values (expressed as the SD) and the sample size. Combine those together to calculate a 95% confidence interval (95% CI), which is a range of values. If the population is Gaussian (or nearly so), you can be 95% sure that this interval contains the true population mean. More precisely, if you generate many 95% CI from many data sets, you expect the CI to include the true population mean in 95% of the cases and not to include the true mean value in the other 5%. Since you don't know the population mean, you'll never know when this happens.

Median	The median is the 50th percentile. Half the values are larger than the median, and half are lower. If there are an even number of values, the median is defined as the average of the two middle values.
Normality test	For each column, InStat reports the results of the normality test. If the P value is low, you can conclude that it is unlikely that the data were sampled from a Gaussian population. See "Testing for normality" on page 19.

SD vs. SEM

Many scientists are confused about the difference between the standard deviation (SD) and standard error of the mean (SEM).

The SD quantifies scatter — how much the values vary from one another.

The SEM quantifies how accurately you know the true population mean. The SEM gets smaller as your samples get larger, simply because the mean of a large sample is likely to be closer to the true mean than is the mean of a small sample.

The SD does not change predictably as you acquire more data. The SD quantifies the scatter of the data, and increasing the size of the sample does not increase the scatter. The SD might go up or it might go down. You can't predict. On average, the SD will stay the same as sample size gets larger.

If the scatter is caused by biological variability, your readers may want to see the variation. In this case, report the SD rather than the SEM. Better, show a graph of all data points, or perhaps report the largest and smallest value — there is no reason to only report the mean and SD.

If you are using an *in vitro* system with no biological variability, the scatter can only result from experimental imprecision. Since you don't really care about the scatter, the SD is less useful here. Instead, report the SEM to give your readers a sense of how well you have determined the mean.

Mean vs. median

The mean is the average. The median is the middle value. Half the values are higher than the median, and half are lower.

The median is a more robust measure of central tendency. Changing a single value won't change the median very much. In contrast, the value of the mean can be strongly affected by a single value that is very low or very high.

Entering averaged data into InStat

If you have already analyzed your data with another program, you may not need to enter every value into InStat. Instead, enter the mean, sample size (N) and either standard deviation (SD) or standard error of the mean (SEM) for each column. On the first step, choose that you want to enter mean with sample size and SD (or SEM). InStat won't let you go to the data table. Enter the data directly on the column statistics page.

Paired, repeated measures, and nonparametric tests require raw data, and cannot be performed if you enter averaged data.

You can also enter raw data into some columns and averaged data into others. Format the data table for raw data. After entering raw data into some columns, go to the column statistics step. You'll see the mean, SD, etc. for the data you have entered. In blank column(s) enter the mean, SD and N.

One sample tests

Introduction to one sample tests

The one sample t test (and nonparametric Wilcoxon test) tests whether the mean (median) of a sample differs significantly from a value set by theory.

Choosing the one-sample t test or Wilcoxon test

If you entered a single column of data, InStat will present the choices for comparing one column of data to a hypothetical mean or median.

If you entered more columns, InStat will present the choices for comparing two columns or comparing three or more columns. If this happens, click the button "select other columns" that appears over all the choices. Uncheck all but one of the columns, and InStat will present the choices for analyzing one column of data.

The one-sample t test and Wilcoxon rank sum test determine whether the values in a single column differ significantly from a hypothetical value.

You need to make three choices:

Parametric or nonparametric?

InStat can compare the mean with the hypothetical value using a one-sample t test, or compare the median with the hypothetical value using the nonparametric Wilcoxon signed rank test. Choose the one-sample t test if it is reasonable to assume that the population follows a Gaussian distribution. Otherwise choose the Wilcoxon nonparametric test, realizing that the test has less power. See "Nonparametric tests" on page 17.

One- or two-tailed P value?

If in doubt, choose a two-tail P value. See "One- vs. two-tail P values" on page 13.

What is the hypothetical value?

Enter the hypothetical mean or median, often 0, 1, or 100. The hypothetical value comes from theory, from other kinds of experiments, or from common sense (for example, if data expressed as percent of control you may want to test whether the mean differs significantly from 100).

The results of a one-sample t test

Checklist. Is a one-sample t test the right test for these data?

Before accepting the results of any statistical test, first think carefully about whether you chose an appropriate test. Before accepting results from a one-sample t test, ask yourself these questions:

Is the population distributed according to a Gaussian distribution?

The one sample t test assumes that you have sampled your data from a population that follows a Gaussian distribution. While this assumption is not too important with large samples, it is important with small sample sizes. InStat tests for violations of this assumption, but normality tests have limited utility. See "Testing for normality" on page 19. If your data do not come from a Gaussian distribution, you have three options. Your best option is to transform the values to make the distribution more Gaussian (see "Transforming data to create a Gaussian distribution" on page 19). Another choice is to use the Wilcoxon rank sum nonparametric test instead of the t test. A final option is to use the t test anyway, knowing that the t test is fairly robust to violations of a Gaussian distribution with large samples.

Are the "errors" independent?

The term "error" refers to the difference between each value and the group mean. The results of a t test only make sense when the scatter is random – that whatever factor caused a value to be too high or too low affects only that one value. There is no way for InStat to test this assumption. See "The need for independent samples" on page 10.

Are you interested only in the means?

The one sample t test compares the *mean* of a group with a hypothetical mean. Even if the P value is tiny– clear evidence that the population mean differs from the hypothetical mean – the distribution of values may straddle the hypothetical mean with a substantial number of values on either side.

If you chose a one-tail P value, did you predict correctly?

If you chose a one-tail P value, you should have predicted whether the mean of your data would be larger than or smaller than the hypothetical mean. InStat does not ask you to record this prediction, but assumes that it is correct. If your prediction was wrong, then ignore the P value reported by InStat and state that P>0.50. See "One- vs. two-tail P values" on page 13.

How to think about results from the one-sample t test

The one-sample t test compares the mean of one column of numbers to a theoretical mean.

Look first at the P value, which answers this question: If the data were sampled from a Gaussian population with a mean equal to the hypothetical value you entered, what is the chance of randomly selecting N data points and finding a mean as far (or further) from the hypothetical value as observed here?

"Statistically significant" is not the same as "scientifically important". Before interpreting the P value or confidence interval, you should think about the size of the difference you are looking for. How large a difference (between the population mean and the hypothetical mean) would you consider to be scientifically important? How small a difference would you consider to be scientifically trivial? Use scientific judgment and common sense to answer these questions. Statistical calculations cannot help, as the answers depend on the context of the experiment.

You will interpret the results differently depending on whether the P value is small or large.

If the P value is small

If the P value is small, then it is unlikely that the discrepancy you observed between sample mean and hypothetical mean is due to a coincidence of random sampling. You can reject the idea that the difference is a

coincidence, and conclude instead that the population has a mean different than the hypothetical value you entered. The difference is statistically significant. But is it scientifically significant? The confidence interval helps you decide.

Your data are affected by random scatter, so the true difference between population mean and hypothetical mean is probably not the same as the difference observed in this experiment. There is no way to know what that true difference is. InStat presents the uncertainty as a 95% confidence interval. You can be 95% sure that this interval contains the true difference between the overall (population) mean and the hypothetical value you entered.

To interpret the results in a scientific context, look at both ends of the confidence interval and ask whether they represent a discrepancy that would be scientifically important or scientifically trivial.

Lower confidence limit	Upper confidence limit	Conclusion
Trivial	Trivial	Although the true difference is not zero (since the P value is low) the true difference is tiny and uninteresting. The data have a mean distinct from the hypothetical value, but the discrepancy is too small to be scientifically interesting.
Trivial	Important	Since the confidence interval ranges from a difference that you think is biologically trivial to one you think would be important, you can't reach a strong conclusion from your data. You can conclude that the data has a mean distinct from the hypothetical value you entered, but don't know whether that difference is scientifically trivial or important. You'll need more data to obtain a clear conclusion.
Important	Important	Since even the low end of the confidence interval represents a difference large enough to be considered biologically important, you can conclude that the data have a mean distinct from the hypothetical value, and the discrepancy is large enough to be scientifically relevant.

If the P value is large

If the P value is large, the data do not give you any reason to conclude that the overall mean differs from the hypothetical value you entered. This is not the same as saying that the true mean equals the hypothetical value. You just don't have evidence of a difference.

How large could the true difference really be? Because of random variation, the difference between the hypothetical mean and the group mean in this experiment is unlikely to equal the true difference between population mean and hypothetical mean. There is no way to know what that true difference is. InStat presents the uncertainty as a 95% confidence interval. You can be 95% sure that this interval contains the true difference between overall (population) mean of the data and the hypothetical mean you entered. When the P value is larger than 0.05, the 95% confidence interval will start with a negative number (the hypothetical mean is larger than the actual mean) and go up to a positive number (the actual mean is larger than the hypothetical mean).

To interpret the results in a scientific context, look at both ends of the confidence interval and ask whether they represent differences that would be scientifically important or scientifically trivial.

Lower confidence limit	Upper confidence limit	Conclusion
Trivial	Trivial	You can reach a crisp conclusion. Either the data has a mean equal to the hypothetical mean or they differ by a trivial amount.
Trivial	Large	You can't reach a strong conclusion. The data are consistent with a mean slightly smaller than the hypothetical mean, equal to the hypothetical mean, or larger than the hypothetical mean, perhaps large enough to be scientifically important. To reach a clear conclusion, you need to repeat the experiment with more subjects.
Large	Trivial	You can't reach a strong conclusion. The data are consistent with a mean smaller than the hypothetical mean (perhaps enough smaller to be scientifically important), equal to the hypothetical mean, or slightly larger than the hypothetical mean. You can't make a clear conclusion without repeating the experiment with more subjects.

The results of a one-sample t test, line by line

Result	Explanation
P value	The P value that answers this question: If the data were sampled from a Gaussian population with a mean equal to the hypothetical value you entered, what is the chance of randomly selecting N data points and finding a mean as far (or further) from the hypothetical value as observed here?
t ratio	InStat calculates the t ratio from this equation: t=(Sample Mean – Hypothetical Mean)/SEM

95% confidence interval	InStat calculates the 95% confidence interval for the difference between the mean calculated from your sample and the hypothetical (theoretical) mean you entered. You can be 95% sure that the interval contains the true difference.
Normality test	The one sample t test assumes that your data were sampled from a population that is distributed according to a Gaussian distribution. The normality test attempts to test this assumption. If the P value is low, conclude that the population is unlikely to be Gaussian. Either transform your data to make the distribution Gaussian, or choose the nonparametric Wilcoxon test. See "Testing for normality" on page 19.

The results of a Wilcoxon test

Checklist. Is the Wilcoxon rank sum test the right test for these data?

Before interpreting the results of any statistical test, first think carefully about whether you have chosen an appropriate test. Before accepting results from a Wilcoxon test, ask yourself these questions (InStat cannot help you answer them):

Are the "errors" independent?
The term "error" refers to the difference between each value and the group median. The results of a Wilcoxon test only make sense when the scatter is random – that any factor that causes a value to be too high or too low affects only that one value. There is no way for InStat to test this assumption. See "The need for independent samples" on page 10.

Are the data clearly sampled from a nongaussian population?
By selecting a nonparametric test, you have avoided assuming that the data were sampled from a Gaussian distribution. But there are drawbacks to using a nonparametric test. If the populations really are Gaussian, the nonparametric tests have less power (are less likely to give you a small P value), especially with small sample sizes. Furthermore, InStat (along with most other programs) does not calculate confidence intervals when calculating nonparametric tests. If the distribution is clearly not bell-shaped, consider transforming the values (perhaps logs or reciprocals) to create a Gaussian distribution and then using a t test.

Are the data distributed symmetrically?
The Wilcoxon test does not assume that the data are sampled from a Gaussian distribution. However it does assume that the data are distributed symmetrically around their median.

If you chose a one-tail P value, did you predict correctly?

If you chose a one-tail P value, you should have predicted which group would have the larger median before collecting any data. InStat does not ask you to record this prediction, but assumes that it is correct. If your prediction was wrong, then ignore the P value reported by InStat and state that P>0.50. See "One- vs. two-tail P values" on page 13.

Approach to interpreting the results of a Wilcoxon signed rank test

The Wilcoxon signed rank test is a nonparametric test that compares the median of one column of numbers to a theoretical median.

Look first at the P value, which answers this question: If the data were sampled from a population with a median equal to the hypothetical value you entered, what is the chance of randomly selecting N data points and finding a median as far (or further) from the hypothetical value as observed here?

If the P value is small, you can reject the idea that the difference is a coincidence, and conclude instead that the population has a median distinct from the hypothetical value you entered.

If the P value is large, the data do not give you any reason to conclude that the overall median differs from the hypothetical median. This is not the same as saying that the medians are the same. You just have no evidence that they differ. If you have small samples, the Wilcoxon test has little power. In fact, if you have five or fewer values, the Wilcoxon test will always give a P value greater than 0.05 no matter how far the sample median is from the hypothetical median.

How the Wilcoxon rank sum test works

InStat follows these steps:

1. Calculate how far each value is from the hypothetical value.
2. Ignore values that exactly equal the hypothetical value. Call the number of remaining values N.
3. Rank these distances, paying no attention to whether the values are higher or lower than the hypothetical value.
4. For each value that is lower than the hypothetical value, multiply the rank by negative 1.
5. Sum the positive ranks. InStat reports this value.
6. Sum the negative ranks. InStat also reports this value.
7. Add the two sums together. This is the sum of signed ranks, which InStat reports as W.

If the data really were sampled from a population with the hypothetical mean, you'd expect W to be near zero. If W (the sum of signed ranks) is far

from zero, the P value will be small. The P value answers this question: Assume that you randomly sample N values from a population with the hypothetical median. What is the chance that W will be as far from zero (or further) as you observed?

Comparing two groups (t tests etc.)

Introduction to t tests

Use the t test, and corresponding nonparametric tests, to test whether the mean (or median) of a variable differs between two groups. For example, compare whether systolic blood pressure differs between a control and treated group, between men and women, or any other two groups.

Don't confuse t tests with correlation and regression. The t test compares one variable (perhaps blood pressure) between two groups. Use correlation and regression to see how two variables (perhaps blood pressure and heart rate) vary together.

Also don't confuse t tests with ANOVA. The t tests (and related nonparametric tests) compare exactly two groups. ANOVA (and related nonparametric tests) compare three or more groups.

Finally don't confuse a t test with analyses of a contingency table (Fishers or chi-square test). Use a t test to compare a continuous variable (i.e. blood pressure, weight or enzyme activity). Analyze a contingency table when comparing a categorical variable (i.e. pass vs. fail, viable vs. not viable).

Entering t test data into InStat

Enter each group into its own column. InStat compares the means (or medians) to ask whether the observed differences are likely to be due to coincidence.

Enter either raw data (enter each value) or averaged data (enter mean, N and SD or SEM). If you enter averaged data, InStat will not offer nonparametric or paired tests, which require raw data.

When entering raw data, simply leave a blank spot in the table to denote missing values. If you enter averaged data, you must enter the mean, N and SD (or SEM) for each column. It is okay if N differs among columns, but you must enter mean, N and SD (or SEM) for each column; you can't leave any of those values blank.

Do not enter indexed data

InStat expects you to enter data in a format that is natural to many scientists. For example, to compare the blood pressure of a group of men and a group of women with InStat, enter the men's blood pressure in one column and the women's blood pressure in another.

Some other statistics programs expect you to arrange data differently, putting all of the data into one column and using another column to define group. For the blood pressure example, you would enter all the blood pressure values (for both groups) in one column. In another column you

would enter a code or index (perhaps 1 for men and 2 for women). Don't arrange data like this when using InStat. If you have data files arranged like this (sometimes called indexed or stacked), InStat can import them, automatically rearranging the values. See "Importing indexed data" on page 110.

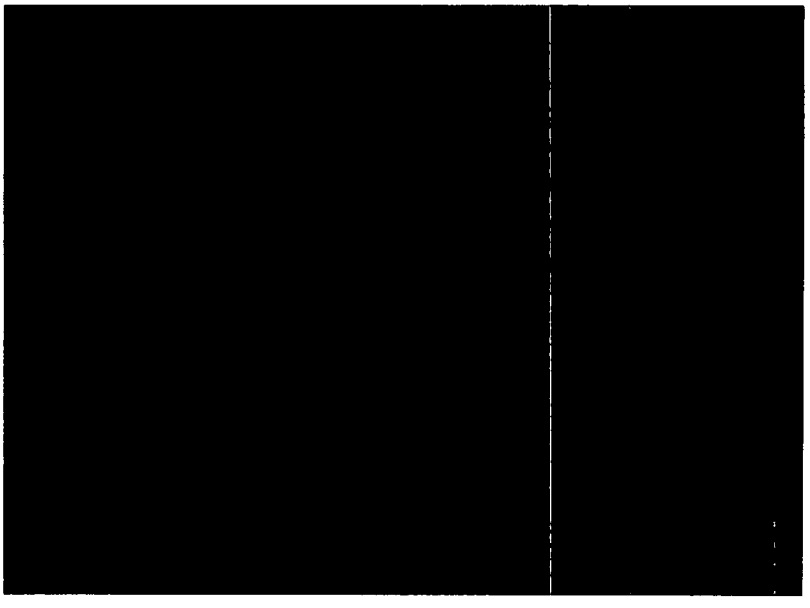
Consider transforming the data

Before comparing columns, consider whether you should first transform the values. The t test assumes that your data are sampled from a population that follows a Gaussian distribution. If your data do not follow a Gaussian (normal) distribution, you may be able to transform the values to create a Gaussian distribution. See "Transforming data to create a Gaussian distribution" on page 19.

If you know the distribution of your population, transforming the values to create a Gaussian distribution is a good thing to do, as it lets you use a t test, which has more power than a nonparametric test.

If you plan to use a nonparametric test, transforming the data will make no difference.

Choosing a test to compare two columns



InStat can perform paired and unpaired t tests, and the nonparametric Mann-Whitney and Wilcoxon tests. To choose between these tests, you must answer four questions:

Are the data paired?

Choose a paired test when the experiment follows one of these designs:

- You measure a variable before and after an intervention in each subject.
- You recruit subjects as pairs, matched for variables such as age, ethnic group or disease severity. One of the pair gets one treatment; the other gets an alternative treatment.
- You run a laboratory experiment several times, each time with a control and treated preparation handled in parallel.
- You measure a variable in twins, or child/parent pairs.

More generally, you should select a paired test whenever you expect a value in one group to be closer to a *particular* value in the other group than to a *randomly selected* value in the other group.

Ideally, you should decide about pairing before collecting data. Certainly the matching should not be based on the variable you are comparing. If you are comparing blood pressures in two groups, it is okay to match based on age or zip code, but it is not okay to match based on blood pressure.

Parametric or nonparametric test?

The t test, like many statistical tests, assumes that your data are sampled from a population that follows a Gaussian bell-shaped distribution. Alternative tests, known as nonparametric tests, make fewer assumptions about the distribution of the data, but are less powerful (especially with small samples). Choosing between parametric and nonparametric tests can be difficult. See "Nonparametric tests" on page 17. The results of a normality test can be helpful, but not always as helpful as you'd hope. See "Testing for normality" on page 19

Assume equal variances?

The unpaired t test assumes that the data are sampled from two populations with the same variance (and thus the same standard deviation). Use a modification of the t test (developed by Welch) when you are unwilling to make that assumption. This choice is only available for the unpaired t test. Use Welch's t test rarely, when you have a good reason. It is not commonly used.

One- or two-tail P value?

Choose a one-tailed P value only if:

- You predicted which group would have the larger mean before you collected any data.
- If the other group turned out to have the larger mean, you would have attributed that difference to coincidence, even if the means are very far apart.

Since those conditions are rarely met, two-tail P values are usually more appropriate. See "One- vs. two-tail P values" on page 13.

Summary of tests to compare two columns

Based on your answers...		...InStat chooses a test
Not paired	Gaussian distribution, equal SDs	Unpaired t test
Not paired	Gaussian distribution, different SDs	Welch's t test
Paired	Gaussian distribution of differences	Paired t test
Not paired	Not Gaussian	Mann-Whitney test
Paired	Not Gaussian	Wilcoxon test

The results of an unpaired t test

Checklist. Is an unpaired t test the right test for these data?

Before accepting the results of any statistical test, first think carefully about whether you chose an appropriate test. Before accepting results from an unpaired t test, ask yourself these questions:

Questions that InStat can help you answer

Are the populations distributed according to a Gaussian distribution?

The unpaired t test assumes that you have sampled your data from populations that follow a Gaussian distribution. While this assumption is not too important with large samples, it is important with small sample sizes (especially with unequal sample sizes). InStat tests for violations of this assumption, but normality tests have limited utility. See "Testing for normality" on page 19. If your data do not come from Gaussian distributions, you have three options. Your best option is to transform the values to make the distributions more Gaussian (see "Transforming data to create a Gaussian distribution" on page 19). Another choice is to use the Mann-Whitney nonparametric test instead of the t test. A final option is to use the t test anyway, knowing that the t test is fairly robust to violations of a Gaussian distribution with large samples.

Do the two populations have the same standard deviation?

The unpaired t test assumes that the two populations have the same standard deviation (and thus the same variance).

InStat tests for equality of variance with an F test. The P value from this test answers this question: If the two populations really have the same variance, what is the chance that you'd randomly select samples whose ratio of variances is as far from 1.0 (or further) as observed in your experiment. A small P value suggests that the variances are different.

Don't base your conclusion solely on the F test. Also think about data from other similar experiments. If you have plenty of previous data that convinces you that the variances are really equal, ignore the F test (unless the P value is really tiny) and interpret the t test results as usual.

In some contexts, finding that populations have different variances may be as important as finding different means. See "F test to compare variances" on page 46.

Questions about experimental design

Are the data unpaired?

The unpaired t test works by comparing the difference between means with the pooled standard deviations of the two groups. If the data are paired or matched, then you should choose a paired t test. If the pairing is effective in controlling for experimental variability, the paired t test will be more powerful than the unpaired test.

Are the "errors" independent?

The term "error" refers to the difference between each value and the group mean. The results of a t test only make sense when the scatter is random – that whatever factor caused a value to be too high or too low affects only that one value. There is no way for InStat to test this assumption. You must think about the experimental design. For example, the errors are not independent if you have six values in each group, but these were obtained from two animals in each group (in triplicate). In this case, some factor may cause all triplicates from one animal to be high or low. See "The need for independent samples" on page 10.

Are you comparing exactly two groups?

Use the t test only to compare two groups. To compare three or more groups, use one-way Analysis of Variance followed by post tests. It is not appropriate to perform several t tests, comparing two groups at a time. Making multiple comparisons increases the chance of finding a statistically significant difference by chance and makes it difficult to interpret P values and statements of statistical significance.

Do both columns contain data?

If you want to compare a single set of experimental data with a theoretical value (perhaps 100%) don't fill a column with that theoretical value and perform a t test. Instead, use a one-sample t test. See "Choosing the one-sample t test or Wilcoxon test" on page 30.

Do you really want to compare means?
The unpaired t test compares the means of two groups. It is possible to have a tiny P value – clear evidence that the population means are different – even if the two distributions overlap considerably. In some situations – for example, assessing the usefulness of a diagnostic test – you may be more interested in the overlap of the distributions than in differences between means.

If you chose a one-tail P value, did you predict correctly?
f you chose a one-tail P value, you should have predicted which group would have the larger mean before collecting any data. InStat does not ask you to record this prediction, but assumes that it is correct. If your prediction was wrong, then ignore the P value reported by InStat and state that P>0.50. See "One- vs. two-tail P values" on page 13.

How to think about results from an unpaired t test

The unpaired t test compares the means of two groups, assuming that data are sampled from Gaussian populations. The most important results are the P value and the confidence interval.

The P value answers this question: If the populations really have the same mean, what is the chance that random sampling would result in means as far apart (or more so) as observed in this experiment?

"Statistically significant" is not the same as "scientifically important". Before interpreting the P value or confidence interval, you should think about the size of the difference you are looking for. How large a difference would you consider to be scientifically important? How small a difference would you consider to be scientifically trivial? Use scientific judgment and common sense to answer these questions. Statistical calculations cannot help, as the answers depend on the context of the experiment.

You will interpret the results differently depending on whether the P value is small or large.

If the P value is small

If the P value is small, then it is unlikely that the difference you observed is due to a coincidence of random sampling. You can reject the idea that the difference is a coincidence, and conclude instead that the populations have different means. The difference is statistically significant. But is it scientifically significant? The confidence interval helps you decide.

Because of random variation, the difference between the group means in this experiment is unlikely to equal the true difference between population means. There is no way to know what that true difference is. InStat presents the uncertainty as a 95% confidence interval. You can be 95% sure that this interval contains the true difference between the two means.

To interpret the results in a scientific context, look at both ends of the confidence interval and ask whether they represent a difference between means that would be scientifically important or scientifically trivial.

Lower confidence limit	Upper confidence limit	Conclusion
Trivial difference	Trivial difference	Although the true difference is not zero (since the P value is low) the true difference between means is tiny and uninteresting. The treatment had an effect, but a small one.
Trivial difference	Important difference	Since the confidence interval ranges from a difference that you think are biologically trivial to one you think would be important, you can't reach a strong conclusion from your data. You can conclude that the means are different, but you don't know whether the size of that difference is scientifically trivial or important. You'll need more data to obtain a clear conclusion.
Important difference	Important difference	Since even the low end of the confidence interval represents a difference large enough to be considered biologically important, you can conclude that there is a difference between treatment means and that the difference is large enough to be scientifically relevant.

If the P value is large

If the P value is large, the data do not give you any reason to conclude that the overall means differ. Even if the true means were equal, you would not be surprised to find means this far apart just by coincidence. This is not the same as saying that the true means are the same. You just don't have evidence that they differ.

How large could the true difference really be? Because of random variation, the difference between the group means in this experiment is unlikely to equal the true difference between population means. There is no way to know what that true difference is. InStat presents the uncertainty as a 95% confidence interval. You can be 95% sure that this interval contains the true difference between the two means. When the P value is larger than 0.05, the 95% confidence interval will start with a negative number (representing a decrease) and go up to a positive number (representing an increase).

To interpret the results in a scientific context, look at both ends of the confidence interval and ask whether they represent a difference between means that would be scientifically important or scientifically trivial.

Lower confidence limit	Upper confidence limit	Conclusion
Trivial decrease	Trivial increase	You can reach a crisp conclusion. Either the means really are the same or they differ by a trivial amount. At most, the true difference between means is tiny and uninteresting.
Trivial decrease	Large increase	You can't reach a strong conclusion. The data are consistent with the treatment causing a trivial decrease, no change, or a large increase. To reach a clear conclusion, you need to repeat the experiment with more subjects.
Large decrease	Trivial increase	You can't reach a strong conclusion. The data are consistent with a trivial increase, no change, or a decrease that may be large enough to be important. You can't make a clear conclusion without repeating the experiment with more subjects.

The results of an unpaired t test, line by line.

P value

The P value answers this question: If the populations really have the same mean, what is the chance that random sampling would result in means as far apart (or more so) as observed in this experiment? More precisely, the P value answers this question: If the populations really had the same mean, what is the chance of obtaining a t ratio as far from zero (or more so) than you obtained in this experiment.

If you chose a one-tail P value, you must have predicted which group would have the larger mean before collecting any data. InStat does not ask you to record this prediction, but assumes that it is correct. If your prediction was wrong, then ignore the P value reported by InStat and state that P>0.50.

See "P values" on page 12.

t ratio

The t ratio is an intermediate calculation of the t test. InStat first computes a t ratio, and then uses it to determine the P value.

InStat calculates the t ratio by dividing the difference between sample means by the standard error of the difference, calculated by pooling the SEMs of the two groups. If the difference is large compared to the SE of the difference, then the t ratio is also large (or is a large negative number), and the P value is small.

For the standard t test, the number of degrees of freedom (df) equals the total sample size minus 2. Welch's t test calculates df from a complicated equation. InStat calculates the P value from t and df.

CI for difference between means

Because of random variation, the difference between the group means in this experiment is unlikely to equal the true difference between population means. The size of the discrepancy depends on the scatter of your samples and the number of values in your sample. InStat reports the uncertainty as the 95% confidence interval of the mean. If you accept the assumptions of the analysis, you can be 95% sure that the confidence interval includes the true difference between group means.

The confidence interval is centered on the difference between the sample means. It extends in each direction by a distance calculated from the standard error of the difference (computed from the two SEM values) multiplied by a critical value from the t distribution for 95% confidence and corresponding to the number of degrees of freedom in this experiment. With large samples, this multiplier equals 1.96. With smaller samples, the multiplier is larger.

F test to compare variances

InStat tests whether the variances of the two groups are the same by calculating F, which equals the larger variance divided by the smaller variance. Remember that the variance equals the standard deviation squared. The degrees of freedom for the numerator and denominator equal the sample sizes minus 1. From F and the two df values, InStat computes a P value that answers this question: If the two populations really have the same variance, what is the chance that you'd randomly select samples and end up with F as large (or larger) as observed in your experiment.

If possible, don't base your conclusion just on this one F test. Also consider data from other experiments in the series, if possible. If you conclude that the two populations have different variances, you have three choices:

- Conclude that the two populations are different – the treatment had an effect. In many experimental contexts, the finding of different variances is as important as the finding of different means. If the variances are truly different, then the populations are different regardless of what the t test concludes about differences between the means. This may be the most important conclusion from the experiment.

- Transform the data to equalize the variances, then rerun the t test. Often you'll find that converting values to their reciprocals or logarithms will equalize the variances and make the distributions more Gaussian. See "Transforming data to create a Gaussian distribution" on page 19.

- Rerun the t test without assuming equal variances using Welch's modified t test.

Normality test

The t test assumes that data are sampled from Gaussian populations. This assumption is tested with a normality test. See "Testing for normality" on page 19.

The results of a paired t test

Checklist. Is the paired t test the right test for these data?

Before accepting the results of any statistical test, first think carefully about whether you chose an appropriate test. Before accepting results from a paired t test, ask yourself these questions:

Questions that InStat can help you answer

Are the differences distributed according to a Gaussian distribution?

The paired t test assumes that you have sampled your pairs of values from a population of pairs where the difference between pairs follows a Gaussian distribution. While this assumption is not too important with large samples, it is important with small sample sizes. InStat tests for violations of this assumption, but normality tests have limited utility. If your data do not come from Gaussian distributions, you have two options. Your best option is to transform the values to make the distributions more Gaussian (see "Transforming data to create a Gaussian distribution" on page 19. Another choice is to use the Wilcoxon nonparametric test instead of the t test.

Was the pairing effective?

The pairing should be part of the experimental design and not something you do after collecting data. InStat tests the effectiveness of pairing by calculating the Pearson correlation coefficient, r, and a corresponding P value. See "Correlation coefficient" on page 91. If r is positive and P is small, the two groups are significantly correlated. This justifies the use of a paired test.

If this P value is large (say larger than 0.05), you should question whether it made sense to use a paired test. Your choice of whether to use a paired test or not should not be based on this one P value, but also on the experimental design and the results you have seen in other similar experiments.

Questions about experimental design

Are the pairs independent?

The results of a paired t test only make sense when the pairs are independent – that whatever factor caused a difference (between paired values) to be too high or too low affects only that one pair. There is no way for InStat to test this assumption. You must think about the

experimental design. For example, the errors are not independent if you have six pairs of values, but these were obtained from three animals, with duplicate measurements in each animal. In this case, some factor may cause the after-before differences from one animal to be high or low. This factor would affect two of the pairs, so they are not independent. See "The need for independent samples" on page 10.

Are you comparing exactly two groups?

Use the t test only to compare two groups. To compare three or more matched groups, use repeated measures one-way Analysis of Variance followed by post tests. It is not appropriate to perform several t tests, comparing two groups at a time.

Do you care about differences or ratios?

The paired t test analyzes the differences between pairs. With some experiments, you may observe a very large variability among the differences. The differences are larger when the control value is larger. With these data, you'll get more consistent results if you look at the ratio (treated/control) rather than the difference (treated – control). It turns out that analyses of ratios are problematic. The problem is that the ratio is intrinsically asymmetric – all decreases are expressed as ratios between zero and one; all increases are expressed as ratios greater than 1.0. Instead it makes more sense to look at the logarithm of ratios. If you have paired data and think that it makes more sense to look at ratios rather than differences, follow these steps. First transform both columns to logarithms. Then perform a paired t test. Note that the difference between logarithms (that InStat analyzes in this case) equals the log of the ratio.

If you chose a one-tail P value, did you predict correctly?

If you chose a one-tail P value, you should have predicted which group would have the larger mean before collecting data. InStat does not ask you to record this prediction, but assumes that it is correct. If your prediction was wrong, then ignore the reported P value and state that P>0.50. See "One- vs. two-tail P values" on page 13.

How to think about results of a paired t test

The paired t test compares two paired groups to make inferences about the size of the average treatment effect (average difference between the paired measurements). The most important results are the P value and the confidence interval.

The P value answers this question: If the treatment really had no effect, what is the chance that random sampling would result in an average effect as far from zero (or more so) as observed in this experiment?

"Statistically significant" is not the same as "scientifically important". Before interpreting the P value or confidence interval, you should think about the size of the treatment effect you are looking for. How large a difference would you consider to be scientifically important? How small a

difference would you consider to be scientifically trivial? Use scientific judgment and common sense to answer these questions. Statistical calculations cannot help, as the answers depend on the context of the experiment.

You will interpret the results differently depending on whether the P value is small or large.

If the P value is small

If the P value is small, then it is unlikely that the treatment effect you observed is due to a coincidence of random sampling. You can reject the idea that the treatment does nothing, and conclude instead that the treatment had an effect. The treatment effect is statistically significant. But is it scientifically significant? The confidence interval helps you decide.

Random scatter affects your data, so the true average treatment effect is probably not the same as the average of the differences observed in this experiment. There is no way to know what that true effect is. InStat presents the uncertainty as a 95% confidence interval. You can be 95% sure that this interval contains the true treatment effect (the true mean of the differences between paired values).

To interpret the results in a scientific context, look at both ends of the confidence interval and ask whether they represent a difference between means that would be scientifically important or scientifically trivial.

Lower confidence limit	Upper confidence limit	Conclusion
Trivial difference	Trivial difference	Although the true effect is not zero (since the P value is low) it is tiny and uninteresting. The treatment had an effect, but a small one.
Trivial difference	Important difference	Since the confidence interval ranges from a difference that you think are biologically trivial to one you think would be important, you can't reach a strong conclusion from your data. You can conclude that the treatment had an effect, but you don't know whether it is scientifically trivial or important. You'll need more data to obtain a clear conclusion.
Important difference	Important difference	Since even the low end of the confidence interval represents a treatment effect large enough to be considered biologically important, you can conclude that there the treatment had an effect large enough to be scientifically relevant.

If the P value is large

If the P value is large, the data do not give you any reason to conclude that the treatment had an effect. This is not the same as saying that the treatment had no effect. You just don't have evidence of an effect.

How large could the true treatment effect really be? The average difference between pairs in this experiment is unlikely to equal the true average difference between pairs (because of random variability). There is no way to know what that true difference is. InStat presents the uncertainty as a 95% confidence interval. You can be 95% sure that this interval contains the true treatment effect. When the P value is larger than 0.05, the 95% confidence interval will start with a negative number (representing a decrease) and go up to a positive number (representing an increase).

To interpret the results in a scientific context, look at both ends of the confidence interval and ask whether they represent a difference between means that would be scientifically important or scientifically trivial.

Lower confidence limit	Upper confidence limit	Conclusion
Trivial decrease	Trivial increase	You can reach a crisp conclusion. Either the treatment has no effect or a tiny one.
Trivial decrease	Large increase	You can't reach a strong conclusion. The data are consistent with the treatment causing a trivial decrease, no change, or a large increase. To reach a clear conclusion, you need to repeat the experiment with more subjects.
Large decrease	Trivial increase	You can't reach a strong conclusion. The data are consistent with a trivial increase, no change, or a decrease that may be large enough to be important. You can't make a clear conclusion without repeating the experiment with more subjects.

The results of a paired t test, line by line.

The paired t test compares two paired groups. It calculates the difference between each set of pairs, and analyzes that list of differences based on the assumption that the differences in the entire population follow a Gaussian distribution.

P value

The P value answers this question: If the treatment is really ineffective so the mean difference is really zero in the overall population, what is the chance that random sampling would result in a mean difference as far from zero (or further) as observed in this experiment?

If you chose a one-tail P value, you must have predicted which group would have the larger mean before collecting any data. InStat does not ask you to record this prediction, but assumes that it is correct. If your prediction was wrong, then ignore the P value reported by InStat and state that P>0.50.

See "P values" on page 12.

t ratio

First InStat calculates the difference between each set of pairs, keeping track of sign. If the value in column B is larger, then the difference is positive. If the value in column A is larger, then the difference is negative. The t ratio for a paired t test is the mean of these differences divided by the standard error of the differences. If the t ratio is large (or is a large negative number), the P value will be small.

CI for difference between means

InStat reports the 95% confidence interval for the mean treatment effect. If you accept the assumptions of the analysis, you can be 95% sure that the confidence interval includes the true mean difference between pairs.

Test for adequate pairing

The whole point of using a paired test is to control for experimental variability. Some factors you don't control in the experiment will affect the before and the after measurements equally, so will not affect the difference between before and after. By analyzing only the differences, therefore, a paired test corrects for those sources of scatter.

If pairing is effective, you expect the before and after measurements to vary together. InStat quantifies this by calculating the Pearson correlation coefficient, r. From r, InStat calculates a P value that answers this question: If the two groups really are not correlated at all, what is the chance that randomly selected subjects would have a correlation coefficient as large (or larger) as observed in your experiment? The P value has one-tail, as you are not interested in the possibility of observing a strong negative correlation.

If the pairing was effective, r will be positive and the P value will be small. This means that the two groups are significantly correlated, so it made sense to choose a paired test.

If the P value is large (say larger than 0.05), you should question whether it made sense to use a paired test. Your choice of whether to use a paired test or not should not be based on this one P value, but also on the experimental design and the results you have seen in other similar experiments.

If r is negative, it means that the pairing was counterproductive! You expect the values of the pairs to move together – if one is higher, so is the other. Here the opposite is true – if one has a higher value, the other has a lower value. Most likely this is just a matter of chance. If r is close to -1, you should review your experimental design, as this is a very unusual result.

Normality test

The paired t test assumes that you have sampled your pairs of values from a population of pairs where the difference between pairs follows a Gaussian distribution. While this assumption is not too important with large samples, it is important with small sample sizes. See "Testing for normality" on page 19.

The results of a Mann-Whitney test

Checklist. Is the Mann-Whitney test the right test for these data?

Before interpreting the results of any statistical test, first think carefully about whether you have chosen an appropriate test. Before accepting results from a Mann-Whitney test, ask yourself these questions (InStat cannot help you answer them):

Are the "errors" independent?

The term "error" refers to the difference between each value and the group median. The results of a Mann-Whitney test only make sense when the scatter is random – that whatever factor caused a value to be too high or too low affects only that one value. There is no way for InStat to test this assumption. You must think about the experimental design. For example, the errors are not independent if you have six values in each group, but these were obtained from two animals in each group (in triplicate). In this case, some factor may cause all triplicates from one animal to be high or low. See "The need for independent samples" on page 10.

Are the data unpaired?

The Mann-Whitney test works by ranking all the values from low to high, and comparing the mean rank in the two groups. If the data are paired or matched, then you should choose a Wilcoxon test instead.

Are you comparing exactly two groups?

Use the Mann-Whitney test only to compare two groups. To compare three or more groups, use the Kruskall-Wallis test followed by post tests. It is not appropriate to perform several Mann-Whitney (or t) tests, comparing two groups at a time.

Are the shapes of the two distributions identical?

The Mann-Whitney test does not assume that the populations follow Gaussian distributions. But it does assume that the shape of the two distributions is identical. The medians may differ – that is what you are testing for – but the test assumes that the shape of the two distributions is identical. If two groups have very different

distributions, transforming the data may make the distributions more similar.

Do you really want to compare medians?

The Mann-Whitney test compares the medians of two groups. It is possible to have a tiny P value – clear evidence that the population medians are different – even if the two distributions overlap considerably.

If you chose a one-tail P value, did you predict correctly?

If you chose a one-tail P value, you should have predicted which group would have the larger median before collecting any data. InStat does not ask you to record this prediction, but assumes that it is correct. If your prediction was wrong, then ignore the P value reported by InStat and state that P>0.50. See "One- vs. two-tail P values" on page 13.

Are the data sampled from nongaussian populations?

By selecting a nonparametric test, you have avoided assuming that the data were sampled from Gaussian distributions. But there are drawbacks to using a nonparametric test. If the populations really are Gaussian, the nonparametric tests have less power (are less likely to give you a small P value), especially with small sample sizes. Furthermore, InStat (along with most other programs) does not calculate confidence intervals when calculating nonparametric tests. If the distribution is clearly not bell-shaped, consider transforming the values to create a Gaussian distribution and then using a t test (see "Transforming data to create a Gaussian distribution" on page 19).

How to think about the results of a Mann-Whitney test

The Mann-Whitney test is a nonparametric test to compare two unpaired groups. The key result is a P value that answers this question: If the populations really have the same median, what is the chance that random sampling would result in medians as far apart (or more so) as observed in this experiment?

If the P value is small, you can reject the idea that the difference is a coincidence, and conclude instead that the populations have different medians.

If the P value is large, the data do not give you any reason to conclude that the overall medians differ. This is not the same as saying that the medians are the same. You just have no evidence that they differ. If you have small samples, the Mann-Whitney test has little power. In fact, if the total sample size is seven or less, the Mann-Whitney test will always give a P value greater than 0.05 no matter how the groups differ.

How the Mann-Whitney test works

The Mann-Whitney test, also called the rank sum test, is a nonparametric test that compares two unpaired groups. To perform the Mann-Whitney test, InStat first ranks all the values from low to high, paying no attention to which group each value belongs. If two values are the same, then they both get the average of the two ranks for which they tie. The smallest number gets a rank of 1. The largest number gets a rank of N, where N is the total number of values in the two groups. InStat then sums the ranks in each group, and reports the two sums. If the sums of the ranks are very different, the P value will be small.

The P value answers this question: If the populations really have the same median, what is the chance that random sampling would result in a sum of ranks as far apart (or more so) as observed in this experiment?

If your samples are small, InStat calculates an exact P value. If your samples are large, it approximates the P value from a Gaussian approximation. The term Gaussian has to do with the distribution of sum of ranks, and does not imply that your data need to follow a Gaussian distribution. The approximation is quite accurate with large samples.

The results of a Wilcoxon test

Checklist. Is the Wilcoxon test the right test for these data?

Before interpreting the results of any statistical test, first think carefully about whether you have chosen an appropriate test. Before accepting results from a Wilcoxon matched pairs test, ask yourself these questions:

Are the pairs independent?

The results of a Wilcoxon test only make sense when the pairs are independent – that whatever factor caused a difference (between paired values) to be too high or too low affects only that one pair. There is no way for InStat to test this assumption. You must think about the experimental design. For example, the errors are not independent if you have six pairs of values, but these were obtained from three animals, with duplicate measurements in each animal. In this case, some factor may cause the after-before differences from one animal to be high or low. This factor would affect two of the pairs (but not the other four), so they are not independent. See "The need for independent samples" on page 10.Are the pairs independent?

Is the pairing effective?

The whole point of using a paired test is to control for experimental variability. Some factors you don't control in the experiment will affect the before and the after measurements equally, so will not affect the difference between before and after. By analyzing only the differences, therefore, a paired test controls for some of the sources of scatter.

The pairing should be part of the experimental design and not something you do after collecting data. InStat tests the effectiveness of pairing by calculating the Spearman correlation coefficient, r_s, and a corresponding P value. See "Results of correlation" on page 90. If r_s is positive and P is small, the two groups are significantly correlated. This justifies the use of a paired test.

If the P value is large (say larger than 0.05), you should question whether it made sense to use a paired test. Your choice of whether to use a paired test or not should not be based solely on this one P value, but also on the experimental design and the results you have seen in other similar experiments.

Are you comparing exactly two groups?

Use the Wilcoxon test only to compare two groups. To compare three or more matched groups, use the Friedman test followed by post tests. It is not appropriate to perform several Wilcoxon tests, comparing two groups at a time.

If you chose a one-tail P value, did you predict correctly?

If you chose a one-tail P value, you should have predicted which group would have the larger median before collecting any data. InStat does not ask you to record this prediction, but assumes that it is correct. If your prediction was wrong, then ignore the P value reported by InStat and state that P>0.50. See "One- vs. two-tail P values" on page 13.

Are the data clearly sampled from nongaussian populations?

By selecting a nonparametric test, you have avoided assuming that the data were sampled from Gaussian distributions. But there are drawbacks to using a nonparametric test. If the populations really are Gaussian, the nonparametric tests have less power (are less likely to give you a small P value), especially with small sample sizes. Furthermore, InStat (along with most other programs) does not calculate confidence intervals when calculating nonparametric tests. If the distribution is clearly not bell-shaped, consider transforming the values (perhaps logs or reciprocals) to create a Gaussian distribution and then using a t test. See "Transforming data to create a Gaussian distribution" on page 19.

Are the differences distributed symmetrically?

The Wilcoxon test first computes the difference between the two values in each row, and analyzes only the list of differences. The Wilcoxon test does not assume that those differences are sampled from a Gaussian distribution. However it does assume that the differences are distributed symmetrically around their median.

How to think about the results of a Wilcoxon test

The Wilcoxon test is a nonparametric test to compare two paired groups. It is also called the Wilcoxon matched-pairs signed-ranks test.

The Wilcoxon test analyzes only the differences between the paired measurements for each subject. The P value answers this question: If the median difference really is zero overall, what is the chance that random sampling would result in a median difference as far from zero (or more so) as observed in this experiment?

If the P value is small, you can reject the idea that the difference is a coincidence, and conclude instead that the populations have different medians.

If the P value is large, the data do not give you any reason to conclude that the overall medians differ. This is not the same as saying that the means are the same. You just have no evidence that they differ. If you have small samples, the Wilcoxon test has little power to detect small differences.

How the Wilcoxon matched pairs test works

P value

The Wilcoxon test is a nonparametric test that compares two paired groups. It calculates the difference between each set of pairs, and analyzes that list of differences. The P value answers this question: If the median difference in the entire population is zero (the treatment is ineffective), what is the chance that random sampling would result in a median as far from zero (or further) as observed in this experiment?

In calculating the Wilcoxon test, InStat first computes the differences between each set of pairs. Then it ranks the absolute values of the differences from low to high. Finally, it sums the ranks of the differences where column A was higher (positive ranks) and the sum of the ranks where column B was higher (it calls these negative ranks), and reports these two sums. If the two sums of ranks are very different, the P value will be small. The P value answers this question: If the treatment really had no effect overall, what is the chance that random sampling would lead to a sum of ranks as far apart (or more so) as observed here?

If you chose a one-tail P value, you must have predicted which group would have the larger median before collecting any data. InStat does not ask you to record this prediction, but assumes that it is correct. If your prediction was wrong, then ignore the P value reported by InStat and state that $P>0.50$.

If your samples are small, InStat calculates an exact P value. If your samples are large, it calculates the P value from a Gaussian approximation. The term Gaussian has to do with the distribution of sum of ranks, and does not imply that your data need to follow a Gaussian distribution.

Test for effective pairing

The whole point of using a paired test is to control for experimental variability. Some factors you don't control in the experiment will affect the before and the after measurements equally, so will not affect the difference between before and after. By analyzing only the differences, therefore, a paired test corrects for these sources of scatter.

If pairing is effective, you expect the before and after measurements to vary together. InStat quantifies this by calculating the nonparametric Spearman correlation coefficient, r_s. From r_s, InStat calculates a P value that answers this question: If the two groups really are not correlated at all, what is the chance that randomly selected subjects would have a correlation coefficient as large (or larger) as observed in your experiment (the P value is one-tail, as you are not interested in the possibility of observing a strong negative correlation).

If the pairing was effective, r_s will be positive and the P value will be small. This means that the two groups are significantly correlated, so it made sense to choose a paired test.

If the P value is large (say larger than 0.05), you should question whether it made sense to use a paired test. Your choice of whether to use a paired test or not should not be based on this one P value, but also on the experimental design and the results you have seen in other similar experiments (assuming you have repeated the experiments several times).

If r_s is negative, it means that the pairing was counter productive! You expect the values of the pairs to move together – if one is higher, so is the other. Here the opposite is true – if one has a higher value, the other has a lower value. Most likely this is just a matter of chance. If r_s is close to -1, you should review your procedures, as the data are unusual.

Comparing three or more groups (one-way ANOVA, etc.)

Introduction to ANOVA

Use one-way analysis of variance (ANOVA), and corresponding nonparametric tests, to test whether the mean (or median) of a variable differs among three or more groups. For example, compare whether systolic blood pressure differs between a control group and two treatment groups, or among three (or more) age groups.

Rather than using one-way ANOVA, you might be tempted to use a series of t tests, comparing two groups each time. Don't do it. If you have three or more groups, use one-way ANOVA (perhaps followed by post tests) – don't use a series of t tests.

Don't confuse ANOVA with multiple regression. ANOVA test whether the mean (or median) of a single variable (perhaps blood pressure) differs among three or more groups. Multiple regression is used to find out how three or more variables (perhaps blood pressure, age and heart rate) vary together.

One way ANOVA compares three or more groups defined by a single factor. For example, you might compare control, with drug treatment with drug treatment plus antagonist. Or you might compare control with five different drug treatments.

Some experiments involve more than one factor. For example, you might compare the effects of three different drugs administered at two times. There are two factors in that experiment: drug treatment and time. These data need to be analyzed by two-way ANOVA, also called two factor ANOVA. InStat does not perform two-way ANOVA.

Entering ANOVA data into InStat

Enter each group into its own column. InStat compares the means (or medians) to ask whether the observed differences are likely to be due to coincidence.

Enter either raw data (enter each value) or averaged data (enter mean, N and SD or SEM). If you enter averaged data, InStat will not offer nonparametric or paired tests, which require raw data.

When entering raw data, simply leave a blank spot in the table to denote missing values. If you enter averaged data, you must enter the mean, N and SD (or SEM) for each column. It is okay if N differs among columns, but you must enter mean, N and SD (or SEM) for each column; you can't leave any of those values blank.

Do not enter indexed data

InStat expects you to enter data in a format that is natural to many scientists. For example, to compare the blood pressure of three groups with InStat, enter the men's blood pressure in one column and the women's blood pressure in another.

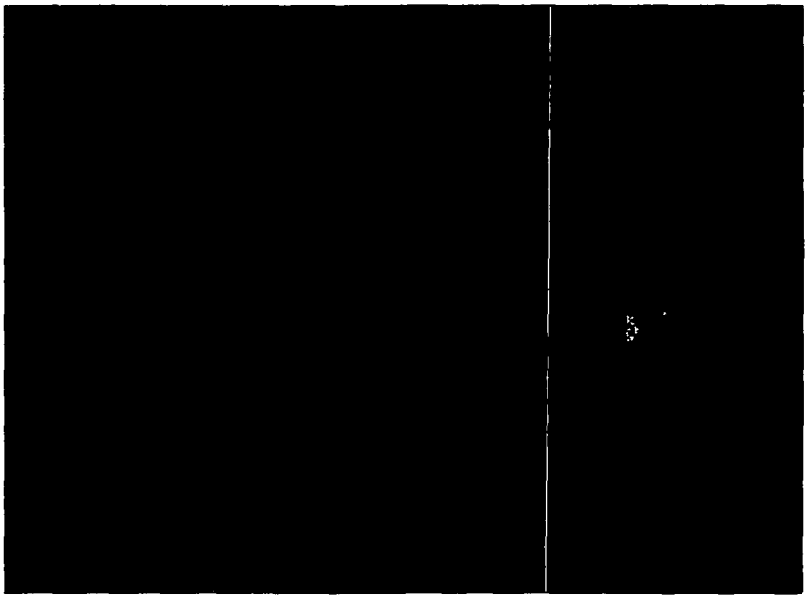
Some other statistics programs expect you to arrange data differently, putting all of the data into one column and using another column to define group. Don't arrange data like this when using InStat. If you have data files arranged like this (called indexed or stacked format), InStat can import them, automatically rearranging the values. See "Importing indexed data" on page 110.

Consider transforming the data

Before comparing columns, consider whether you should first transform the values. ANOVA assumes that your data are sampled from populations that follow Gaussian distributions. If your data do not follow a Gaussian (normal) distribution, you may be able to transform the values to create a Gaussian distribution. See "Transforming data to create a Gaussian distribution" on page 19.

If you know the distribution of your population, transforming the values to create a Gaussian distribution is a good thing to do, as it lets you use ANOVA, which has more power than a nonparametric test.

Choosing a one-way ANOVA analysis



InStat can perform ordinary one-way ANOVA, repeated measures ANOVA and the nonparametric tests of Kruskal-Wallis and Freidman. To choose among these tests, you must answer three questions:

Are the data matched?

You should choose a repeated measures test when the experiment used matched subjects. Here are some examples:

- You measure a variable in each subject before, during and after an intervention.
- You recruit subjects as matched sets. Each subject in the set has the same age, diagnosis and other relevant variables. One of the sets gets treatment A, another gets treatment B, another gets treatment C, etc.
- You run a laboratory experiment several times, each time with a control and several treated preparations handled in parallel.

The term *repeated measures* applies strictly only to the first example – you are giving treatments repeatedly to one subject. The other two examples are called *randomized block* experiments (each set of subjects is called a *block* and you randomly assign treatments within each block). The analyses are identical for repeated measures and randomized block experiments, and InStat always uses the term repeated measures.

Ideally, you should decide about matching before collecting data. Certainly the matching should not be based on the variable you are comparing. If you are comparing blood pressures in two groups, it is okay to match based on age or postal code, but it is not okay to match based on blood pressure.

Assume sampling from a Gaussian distribution?

The t test, like many statistical tests, assumes that your data are sampled from a population that follows a Gaussian bell-shaped distribution. Alternative tests, known as nonparametric tests, make fewer assumptions about the distribution of the data, but are less powerful (especially with small samples). Choosing between parametric and nonparametric tests can be difficult. See "Nonparametric tests" on page 17. The results of a normality test can be helpful, but not always as helpful as you'd hope. See "Testing for normality" on page 19.

Which post test?

If you are comparing three or more groups, you may pick a post test to compare pairs of group means. It is not appropriate to repeatedly use a t test to compare various pairs of columns (see "Beware of multiple comparisons" on page 15). InStat offers these choices of post test.

- No post test.
- Bonferroni. Compare selected pairs of columns.

- Bonferroni. Compare all pairs of columns.
- Tukey. Compare all pairs of columns.
- Student-Newman-Keuls. Compare all pairs of columns.
- Dunnett. Compare all vs. control.
- Test for linear trend between column mean and column number.

Select **Dunnett's** test if one column represents control data, and you wish to compare all other columns to that control column but not to each other.

Select the **test for linear trend**, if the columns are arranged in a natural order (i.e. dose or time) and you want to test whether there is a trend so that values increase (or decrease) as you move from left to right across columns.

Select the **Bonferroni test for selected pairs of columns** when you only wish to compare certain column pairs. You must select those pairs based on experimental design, and ideally should specify the pairs of interest before collecting any data. If you base your decision on the results (i.e. compare the smallest with the largest mean), then you have effectively compared all columns, and it is not appropriate to use the test for selected pairs.

Most often, you will want to compare all pairs of columns. InStat offers you three choices. The only advantage of the **Bonferroni** method is that it is easy to understand. Its disadvantage is that it is too conservative, leading to P values that are too high and confidence intervals that are too wide. This is a minor concern when you compare only a few columns, but is a major problem when you have many columns. Don't use the Bonferroni test with more than five groups.

Choosing between the **Tukey** and **Newman-Keuls** test is not straightforward, and there appears to be no real consensus among statisticians. The two methods are related, and the rationale for the differences is subtle. The methods are identical when comparing the largest group mean with the smallest. For other comparisons, the Newman-Keuls test yields lower P values. The problem is that it is difficult to articulate exactly what null hypotheses the P values test. For that reason, and because the Newman-Keuls test does not generate confidence intervals, we suggest selecting Tukey's test.

Summary of tests to compare three or more columns

Based on your answers...		...InStat chooses a test
Not matched	Gaussian distribution	Ordinary one-way ANOVA
Matched	Gaussian distribution	Repeated measures one-way ANOVA
Not matched	Not Gaussian	Kruskal-Wallis test
Matched	Not Gaussian	Friedman test

The results of one-way ANOVA

Checklist. Is one-way ANOVA the right test for these data?

Before accepting the results of any statistical test, first think carefully about whether you chose an appropriate test. Before accepting results from a one-way ANOVA, ask yourself these questions:

Questions that InStat can help you answer

Are the populations distributed according to a Gaussian distribution?

One-way ANOVA assumes that you have sampled your data from populations that follow a Gaussian distribution. While this assumption is not too important with large samples, it is important with small sample sizes (especially with unequal sample sizes). InStat tests for violations of this assumption, but normality tests have limited utility. See "Testing for normality" on page 19. If your data do not come from Gaussian distributions, you have three options. Your best option is to transform the values (perhaps logs or reciprocals) to make the distributions more Gaussian (see "Transforming data to create a Gaussian distribution" on page 19. Another choice is to use the Kruskal-Wallis nonparametric test instead of ANOVA. A final option is to use ANOVA anyway, knowing that it is fairly robust to violations of a Gaussian distribution with large samples.

Do the populations have the same standard deviation?

One-way ANOVA assumes that all the populations have the same standard deviation (and thus the same variance). This assumption is not very important when all the groups have the same (or almost the same) number of subjects, but is very important when sample sizes differ.

InStat tests for equality of variance with Bartlett's test. The P value from this test answers this question: If the populations really have the same variance, what is the chance that you'd randomly select samples whose variances are as different as observed in your experiment. A small P value suggests that the variances are different.

Don't base your conclusion solely on Bartlett's test. Also think about data from other similar experiments. If you have plenty of previous data that convinces you that the variances are really equal, ignore Bartlett's test (unless the P value is really tiny) and interpret the ANOVA results as usual. Some statisticians recommend ignoring Bartlett's test altogether if the sample sizes are equal (or nearly so).

In some experimental contexts, finding different variances may be as important as finding different means. If the variances are different, then the populations are different -- regardless of what ANOVA concludes about differences between the means. See "Bartlett's test for equal variances" on page 67.

Questions about experimental design

Are the data unmatched?

One-way ANOVA works by comparing the differences among group means with the pooled standard deviations of the groups. If the data are matched, then you should choose repeated measures ANOVA instead. If the matching is effective in controlling for experimental variability, repeated measures ANOVA will be more powerful than regular ANOVA.

Are the "errors" independent?

The term "error" refers to the difference between each value and the group mean. The results of one-way ANOVA only make sense when the scatter is random – that whatever factor caused a value to be too high or too low affects only that one value. There is no way for InStat to test this assumption. You must think about the experimental design. For example, the errors are not independent if you have six values in each group, but these were obtained from two animals in each group (in triplicate). In this case, some factor may cause all triplicates from one animal to be high or low. See "The need for independent samples" on page 10.

Do you really want to compare means?

One-way ANOVA compares the means of three or more groups. It is possible to have a tiny P value – clear evidence that the population means are different – even if the distributions overlap considerably. In some situations – for example, assessing the usefulness of a diagnostic test – you may be more interested in the overlap of the distributions than in differences between means.

Is there only one factor?

One-way ANOVA compares three or more groups defined by one factor. For example, you might compare a control group, with a drug treatment group and a group treated with drug plus antagonist. Or you might compare a control group with five different drug treatments.

Some experiments involve more than one factor. For example, you might compare three different drugs in men and women. There are two factors in that experiment: drug treatment and gender. These data need to be analyzed by two-way ANOVA, also called two factor ANOVA. InStat does not perform two-way ANOVA.

Is the factor "fixed" rather than "random"?

InStat performs Type I ANOVA, also known as fixed-effect ANOVA. This tests for differences among the means of the particular groups you have collected data from. Type II ANOVA, also known as random-effect ANOVA, assumes that you have randomly selected groups from an infinite (or at least large) number of possible groups, and that you want

to reach conclusions about differences among ALL the groups, even the ones you didn't include in this experiment. Type II random-effects ANOVA is rarely used in biology, and InStat does not perform it.

How to think about results from one-way ANOVA

One-way ANOVA compares the means of three or more groups, assuming that data are sampled from Gaussian populations. The most important results are the P value and the post tests.

The overall P value answers this question: If the populations really have the same mean, what is the chance that random sampling would result in means as far apart from one another (or more so) than you observed in this experiment?

If the overall P value is large, the data do not give you any reason to conclude that the means differ. Even if the true means were equal, you would not be surprised to find means this far apart just by coincidence. This is not the same as saying that the true means are the same. You just don't have evidence that they differ.

If the overall P value is small, then it is unlikely that the differences you observed are due to a coincidence of random sampling. You can reject the idea that all the populations have identical means. This doesn't mean that every mean differs from every other mean, only that at least one differs from the rest. Look at the results of post tests to understand where the differences are.

If the columns are organized in a natural order, the post test for linear trend tells you whether the column means have a systematic trend, increasing (or decreasing) as you go from left to right in the data table. See "Post test for linear trend" on page 68.

With other post tests, look at which differences between column means are statistically significant. For each pair of means, InStat reports whether the P value is less than 0.05, 0.01 or 0.001.

"Statistically significant" is not the same as "scientifically important". Before interpreting the P value or confidence interval, you should think about the size of the difference you are looking for. How large a difference would you consider to be scientifically important? How small a difference would you consider to be scientifically trivial? Use scientific judgment and common sense to answer these questions. Statistical calculations cannot help, as the answers depend on the context of the experiment.

You will interpret the post test results differently depending on whether the difference is statistically significant or not.

If the difference is statistically significant – the P value is small

If the P value for a post test is small, then it is unlikely that the difference you observed is due to a coincidence of random sampling. You can reject the idea that those two populations have identical means.

Because of random variation, the difference between the group means in this experiment is unlikely to equal the true difference between population means. There is no way to know what that true difference is. With most post tests (but not the Newman-Keuls test), InStat presents the uncertainty as a 95% confidence interval for the difference between all (or selected) pairs of means. You can be 95% sure that this interval contains the true difference between the two means.

To interpret the results in a scientific context, look at both ends of the confidence interval and ask whether they represent a difference between means that would be scientifically important or scientifically trivial.

Lower confidence limit	Upper confidence limit	Conclusion
Trivial difference	Trivial difference	Although the true difference is not zero (since the P value is low) the true difference between means is tiny and uninteresting. The treatment had an effect, but a small one.
Trivial difference	Important difference	Since the confidence interval ranges from a difference that you think are biologically trivial to one you think would be important, you can't reach a strong conclusion from your data. You can conclude that the means are different, but you don't know whether the size of that difference is scientifically trivial or important. You'll need more data to obtain a clear conclusion.
Important difference	Important difference	Since even the low end of the confidence interval represents a difference large enough to be considered biologically important, you can conclude that there is a difference between treatment means and that the difference is large enough to be scientifically relevant.

If the difference is not statistically significant -- the P value is large

If the P value from a post test is large, the data do not give you any reason to conclude that the means of these two groups differ. Even if the true means were equal, you would not be surprised to find means this far apart just by coincidence. This is not the same as saying that the true means are the same. You just don't have evidence that they differ.

How large could the true difference really be? Because of random variation, the difference between the group means in this experiment is unlikely to equal the true difference between population means. There is no way to know what that true difference is. InStat presents the uncertainty as a 95% confidence interval (except with the Newman-Keuls test). You can be 95% sure that this interval contains the true difference between the two means. When the P value is larger than 0.05, the 95% confidence interval will start with a negative number (representing a decrease) and go up to a positive number (representing an increase).

To interpret the results in a scientific context, look at both ends of the confidence interval for each pair of means, and ask whether those differences would be scientifically important or scientifically trivial.

Lower confidence limit	Upper confidence limit	Conclusion
Trivial decrease	Trivial increase	You can reach a crisp conclusion. Either the means really are the same or they are different by a trivial amount. At most, the true difference between means is tiny and uninteresting.
Trivial decrease	Large increase	You can't reach a strong conclusion. The data are consistent with the treatment causing a trivial decrease, no change, or a large increase. To reach a clear conclusion, you need to repeat the experiment with more subjects.
Large decrease	Trivial increase	You can't reach a strong conclusion. The data are consistent with a trivial increase, no change, or a decrease that may be large enough to be important. You can't make a clear conclusion without repeating the experiment with more subjects.

Results of one-way ANOVA. Line by line.

P value

One-way ANOVA compares three or more unmatched groups, based on the assumption that the two populations are Gaussian. The P value answers this question: If the populations really have the same mean, what is the chance that random sampling would result in means as far apart (or more so) as observed in this experiment?

See "P values" on page 12.

R^2 value

This is the fraction of the overall variance (of all the data, pooling all the groups) attributable to the difference mea the group means. It compares the variability among group means with the variability within the groups. A large value means that a large fraction of the variation is due to the treatment that defines the groups. The R^2 value is calculated from the ANOVA table and equals the between group sum-of-squares divided by the total sum-of-squares (for a definition of sum-of-squares see "ANOVA table " on page 67). Some programs (and books) don't bother reporting this value. Others refer to it as η^2 (eta squared) rather than R^2. It is a descriptive statistic that quantifies the strength of the relationship between group membership and the variable you measured.

Bartlett's test for equal variances

ANOVA is based on the assumption that the populations all have the same variance. If your samples have five or more values, InStat tests this assumption with Bartlett's test. It reports the value of Bartlett's statistic and the P value that answers this question: If the populations really have the same variance, what is the chance that you'd randomly select samples whose variances are as different (or more different) as observed in your experiment. (Since the variance is the standard deviation squared, testing for equal variances is the same as testing for equal standard deviations).

Bartlett's test is very sensitive to deviations from a Gaussian distribution – more sensitive than the ANOVA calculations are. A low P value from Bartlett's test may be due to data that are not Gaussian, rather than due to unequal variances. Since ANOVA is fairly robust to nongaussian data (at least when sample sizes are equal), the Bartlett's test can be misleading. Some statisticians suggest ignoring the Bartlett's test, especially when the sample sizes are equal (or nearly so).

If the P value is small, you have to decide whether you wish to conclude that the variances of the two populations are different. Obviously Bartlett's test is based only on the values in this one experiment. Think about data from other similar experiments before making a conclusion.

If you conclude that the populations have different variances, you have three choices:

- Conclude that the populations are different – the treatments had an effect. In many experimental contexts, the finding of different variances is as important as the finding of different means. If the variances are truly different, then the populations are different regardless of what ANOVA concludes about differences among the means. This may be the most important conclusion from the experiment.

- Transform the data to equalize the variances, then rerun the ANOVA. Often you'll find that converting values to their reciprocals or logarithms will equalize the variances and make the distributions more Gaussian. See "Transforming data to create a Gaussian distribution" on page 19.

- Use a modified ANOVA that does not assume equal variances. InStat does not provide such a test.

ANOVA table

The P value is calculated from the ANOVA table. The key idea is that variability among the values can be partitioned into variability among group means and variability within the groups. Variability within groups is quantified as the sum of the squares of the differences between each value and its group mean. This is the residual sum-of-squares. Total variability is quantified as the sum of the squares of the differences between each value and the grand mean (the mean of all values in all groups). This is the total sum-of-squares. The variability between group means is calculated as the

total sum-of-squares minus the residual sum-of-squares. This is called the between-groups sum-of-squares.

Even if the null hypothesis is true, you expect values to be closer (on average) to their group means than to the grand mean. The calculation of the degrees of freedom and mean square account for this. See a statistics book for detail. The end result is the F ratio. If the null hypothesis is true, you expect F to have a value close to 1.0. If F is large, the P value will be small. The P value answers this question: If the populations all have the same mean, what is the chance that randomly selected groups would lead to an F ratio as big (or bigger) as the one obtained in your experiment?

Post tests (one-way ANOVA)

Post test for linear trend

If the columns represent ordered and equally spaced (or nearly so) groups, the post test for linear trend determines whether the column means increase (or decrease) systematically as the columns go from left to right. The post test reports these results:

Result	Discussion
Slope	The slope of the best-fit line where the X values are column number (1, 2, 3...) and the Y values are the column means. It is the average increase (decrease, if negative) in column mean as you go from one column to the next column to the right.
R squared	A measure of goodness-of-fit for that best-fit line. See "r^2" on page 92.
P value for linear trend	This P value answers this question: If there really is no linear trend between column number and column mean, what is the chance that random sampling would result in a slope as far from zero (or further) than you obtained here? Equivalently, it is the chance of observing a value of r^2 that high or higher, just by coincidence of random sampling.
P value for nonlinear variation	After correcting for the linear trend, this P value tests whether the remaining variability among column means is greater than expected by chance. It is the chance of seeing that much variability due to random sampling.
ANOVA table	This ANOVA table partitions total variability into three components: linear variation, nonlinear variation, and random or residual variation. It is used to compute the two F ratios, which lead to the two P values. The ANOVA table is included to be complete, but will not be of use to most scientists.

For more information about the post test for linear trend, see the excellent text, Practical Statistics for Medical Research by DG Altman, published in 1991 by Chapman and Hall.

Other post tests

For each pair of columns, InStat reports the P value as >0.05, <0.05, <0.01 or <0.001. These P values account for multiple comparisons. If the null hypothesis is true (all the values are sampled from populations with the same mean), then there is only a 5% chance that any one or more comparisons will have a P value less than 0.05. The probability is for the entire family of comparisons, not for each individual comparison.

InStat also reports the 95% confidence intervals for the difference between each pair of means. These intervals account for multiple comparisons. There is a 95% chance that all of these intervals contain the true differences between population means, and only a 5% chance that any one or more of these intervals misses the true population difference.

The results of repeated measures ANOVA

Checklist. Is repeated measures one way ANOVA the right test for these data?

Before accepting the results of any statistical test, first think carefully about whether you chose an appropriate test. Before accepting results from repeated measures one-way ANOVA, ask yourself these questions. InStat can help you answer the first; you must answer the rest based on experimental design.

Was the matching effective?

The whole point of using a repeated measures test is to control for experimental variability. Some factors you don't control in the experiment will affect all the measurements from one subject equally, so will not affect the difference between the measurements in that subject. By analyzing only the differences, therefore, a matched test controls for some of the sources of scatter.

The matching should be part of the experimental design and not something you do after collecting data. InStat tests the effectiveness of matching with an F test (distinct from the main F test of differences between columns). If this P value is large (say larger than 0.05), you should question whether it made sense to use a repeated measures test. Your choice of whether to use a repeated measures test should not be based solely on this one P value, but also on the experimental design and the results you have seen in other similar experiments.

Are the subjects independent?

The results of repeated measures ANOVA only make sense when the subjects are independent. There is no way for InStat to test this assumption. You must think about the experimental design. For example, the errors are not independent if you have six rows of data of values, but these were obtained from three animals, with duplicate measurements in each animal. In this case, some factor may affect the measurements from one animal. Since this factor would affect data in

two (but not all) rows, the rows (subjects) are not independent. See "The need for independent samples" on page 10.

Is the random variability distributed according to a Gaussian distribution?

Repeated measures ANOVA assumes that each measurement is the sum of an overall mean, a treatment effect (the same for each individual), an individual effect (the same for each treatment) and a random component. Furthermore, it assumes that the random component follows a Gaussian distribution and that the standard deviation does not vary between individuals (rows) or treatments (columns). While this assumption is not too important with large samples, it can be important with small sample sizes. InStat does not test for violations of this assumption.

Is there only one factor?

One-way ANOVA compares three or more groups defined by one factor. For example, you might compare a control group, with a drug treatment group and a group treated with drug plus antagonist. Or you might compare a control group with five different drug treatments. Some experiments involve more than one factor. For example, you might compare three different drugs in men and women. There are two factors in that experiment: drug treatment and gender. These data need to be analyzed by two-way ANOVA, also called two factor ANOVA. InStat does not perform two-way ANOVA.

Is the factor "fixed" rather than "random"?

InStat performs Type I ANOVA, also known as fixed-effect ANOVA. This tests for differences among the means of the particular groups you have collected data from. Type II ANOVA, also known as random-effect ANOVA, assumes that you have randomly selected groups from an infinite (or at least large) number of possible groups, and that you want to reach conclusions about differences among ALL the groups, even the ones you didn't include in this experiment. Type II random-effects ANOVA is rarely used in biology, and InStat does not perform it.

How to think about results from repeated measures one-way ANOVA

Repeated measures ANOVA compares the means of three or more matched groups. The term *repeated measures* strictly applies only when you give treatments repeatedly to each subject, and the term *randomized block* is used when you randomly assign treatments within each block of matched subjects. The analyses are identical for repeated measures and randomized block experiments, and InStat always uses the term repeated measures.

Your approach to interpreting repeated measures ANOVA results will be the same as interpreting the results of ordinary one-way ANOVA. See "How to think about results from one-way ANOVA" on page 64.

The results of repeated measures ANOVA, line by line

P value

Repeated measures one-way ANOVA compares three or more matched groups, based on the assumption that the differences between matched values are Gaussian. The P value answers this question: If the populations really have the same mean, what is the chance that random sampling would result in means as far apart (or more so) as observed in this experiment?

Interpreting the P value from repeated measures ANOVA requires thinking about one of the assumptions of the analysis. Repeated measures ANOVA assumes that the random error truly is truly random. A random factor that causes a measurement in one subject to be a bit high (or low) should have no affect on the next measurement in the same subject.

This assumption is called *circularity* or (equivalently) *sphericity*. It is closely related to another term you may encounter, *compound symmetry*.

You'll violate this assumption when the repeated measurements are made too close together so that random factors that cause a particular value to be high (or low) don't wash away or dissipate before the next measurement. To avoid violating the assumption, wait long enough between treatments so the subject is essentially the same as before the treatment. Also randomize the order of treatments, when possible.

Repeated measures ANOVA is quite sensitive to violations of the assumption of circularity. InStat does not attempt to test for violations of the assumption of circularity. When the assumption is violated, the P value from repeated measures ANOVA will be too low. InStat also reports a second P value calculated using the method of Geisser and Greenhouse. This P value is computed from the same F ratio but uses different numbers of degrees of freedom (the numerator df equals one; the denominator df equals one less than the number of subjects). This P value is conservative (too high). No matter how badly the assumption of circularity is violated, the true P value will be between the two P values that InStat presents. If these two P values are very different and you think your experiment may have violated the circularity assumption, use a more advanced program that can apply complicated methods (Huynh&Feldt or Box) that correct for violations of circularity more precisely.

You only have to worry about the assumption of circularity and the Geisser and Greenhouse corrected P value when you perform a repeated measures experiment, where each row of data represents repeated measurements from a single subject. If you performed a randomized block experiment, where each row of data represents data from a matched set of subjects, use the standard ANOVA P value and ignore the corrected P value.

ANOVA table

The P value is calculated from the ANOVA table. With repeated measures ANOVA, there are three sources of variability: between columns (treatments), between rows (individuals) and random (residual). The ANOVA table partitions the total sum-of-squares into those three

components. It then adjusts for the number of groups and number of subjects (expressed as degrees of freedom) to compute two F ratios. The main F ratio tests the null hypothesis that the column means are identical. The other tests the null hypothesis that the row means are identical (this is the test for effective matching). In both cases, the F ratio is expected to be near 1.0 if the null hypotheses are true. If F is large, the P value will be small.

Was the matching effective?

A repeated measures experimental design can be very powerful, as it controls for factors that cause variability between subjects. If the matching is effective, the repeated measures test will yield a smaller P value than ordinary ANOVA. The repeated measures test is more powerful because it separates between-subject variability from within-subject variability. If the pairing is ineffective, however, the repeated measures test can be less powerful because it has fewer degrees of freedom.

InStat tests whether the matching was effective and reports a P value that tests the null hypothesis that the population row means are all equal. If this P value is low, you can conclude that the matching is effective. If the P value is high, you can conclude that the matching was not effective and should consider using ordinary ANOVA rather than repeated measures ANOVA.

Post tests

Interpret post tests following repeated measures ANOVA the same as regular ANOVA. See "Post test for linear trend" on page 68, and "Other post tests" on page 69.

The results of a Kruskal-Wallis test

Checklist. Is the Kruskal-Wallis test the right test for these data?

Before interpreting the results of any statistical test, first think carefully about whether you have chosen an appropriate test. Before accepting results from a Kruskal-Wallis test, ask yourself these questions (InStat cannot help you answer them):

Are the "errors" independent?
The term "error" refers to the difference between each value and the group median. The results of a Kruskal-Wallis test only make sense when the scatter is random – that whatever factor caused a value to be too high or too low affects only that one value. There is no way for InStat to test this assumption. You must think about the experimental design. For example, the errors are not independent if you have nine values in each of three groups, but these were obtained from two animals in each group (in triplicate). In this case, some factor may cause all triplicates from one animal to be high or low. See "The need for independent samples" on page 10.

Are the data unpaired?
If the data are paired or matched, then you should consider choosing the Friedman test instead. If the pairing is effective in controlling for experimental variability, the Friedman test will be more powerful than the Kruskal-Wallis test.

Are the data sampled from nongaussian populations?
By selecting a nonparametric test, you have avoided assuming that the data were sampled from Gaussian distributions. But there are drawbacks to using a nonparametric test. If the populations really are Gaussian, the nonparametric tests have less power (are less likely to give you a small P value), especially with small sample sizes. Furthermore, InStat (along with most other programs) does not calculate confidence intervals when calculating nonparametric tests. If the distribution is clearly not bell-shaped, consider transforming the values (perhaps logs or reciprocals) to create a Gaussian distribution and then using ANOVA. See "Transforming data to create a Gaussian distribution" on page 19.

Do you really want to compare medians?
The Kruskal-Wallis test compares the medians of three or more groups. It is possible to have a tiny P value – clear evidence that the population medians are different – even if the distributions overlap considerably.

Are the shapes of the distributions identical?
The Kruskal-Wallis test does not assume that the populations follow Gaussian distributions. But it does assume that the shapes of the distributions are identical. The medians may differ – that is what you are testing for – but the test assumes that the shapes of the distributions are identical. If two groups have very different distributions, consider transforming the data to make the distributions more similar.

Approach to interpreting the results of a Kruskal-Wallis test

The Kruskal-Wallis test is a nonparametric test to compare three or more unpaired groups. It is also called Kruskal-Wallis one-way analysis of variance by ranks. The key result is a P value that answers this question: If the populations really have the same median, what is the chance that random sampling would result in medians as far apart (or more so) as you observed in this experiment?

If the P value is small, you can reject the idea that the differences are all a coincidence. This doesn't mean that every group differs from every other group, only that at least one group differs from the others. Then look at post tests to see which group(s) differ from which other group(s).

Dunn's post test calculates a P value for each pair of columns. These P values answer this question: If the data were sampled from populations with the same median, what is the chance that one or more pairs of

columns would have medians as far apart as observed here? If the P value is low, you'll conclude that the difference is statistically significant. The calculation of the P value takes into account the number of comparisons you are making. If the null hypothesis is true (all data are sampled from populations with identical distributions, so all differences between groups are due to random sampling), then there is a 5% chance that at least one of the post tests will have P<0.05. The 5% chance does not apply to EACH comparison but rather to the ENTIRE family of comparisons.

If the overall Kruskal-Wallis P value is large, the data do not give you any reason to conclude that the overall medians differ. This is not the same as saying that the medians are the same. You just have no evidence that they differ. If you have small samples, the Kruskal-Wallis test has little power. In fact, if the total sample size is seven or less, the Kruskal-Wallis test will always give a P value greater than 0.05 no matter how the groups differ.

How the Kruskal-Wallis test works

The Kruskal-Wallis test is a nonparametric test that compares three or more unpaired groups. To perform the Kruskal-Wallis test, InStat first ranks all the values from low to high, paying no attention to which group each value belongs. If two values are the same, then they both get the average of the two ranks for which they tie. The smallest number gets a rank of 1. The largest number gets a rank of N, where N is the total number of values in all the groups. InStat then sums the ranks in each group, and reports the sums. If the sums of the ranks are very different, the P value will be small.

The discrepancies among the rank sums are combined to create a single value called the Kruskal-Wallis statistic (some books refer to this value as H). A larger value of the Kruskal-Wallis statistic corresponds to a larger discrepancy among rank sums.

The P value answers this question: If the populations really have the same median, what is the chance that random sampling would result in sums of ranks as far apart (or more so) as observed in this experiment? More precisely, if the null hypothesis is true then what is the chance of obtaining a value of the Kruskal-Wallis statistic as high (or higher) as observed in this experiment.

If your samples are small, InStat calculates an exact P value. If your samples are large, it approximates the P value from the chi-square distribution. The approximation is quite accurate with large samples. With medium size samples, InStat can take a long time to calculate the exact P value. You can interrupt the calculations if an approximate P value is good enough for your purposes.

Post tests following the Kruskal-Wallis test

Dunn's post test compares the difference in the sum of ranks between two columns with the expected average difference (based on the number of groups and their size). For each pair of columns, InStat reports the P value as >0.05, <0.05, <0.01 or < 0.001. The calculation of the P value takes into

account the number of comparisons you are making. If the null hypothesis is true (all data are sampled from populations with identical distributions, so all differences between groups are due to random sampling), then there is a 5% chance that at least one of the post tests will have $P<0.05$. The 5% chance does not apply to EACH comparison but rather to the ENTIRE family of comparisons.

For more information on the post test, see Applied Nonparametric Statistics by WW Daniel, published by PWS-Kent publishing company in 1990 or Nonparametric Statistics for Behavioral Sciences by S Siegel and NJ Castellan, 1988. The original reference is O.J. Dunn, Technometrics, 5:241-252, 1964.

InStat refers to the post test as the Dunn's post test. Some books and programs simply refer to this test as the post test following a Kruskal-Wallis test, and don't give it an exact name.

The results of a Friedman test

Checklist. Is the Friedman test the right test for these data?

Before interpreting the results of any statistical test, first think carefully about whether you have chosen an appropriate test. Before accepting results from a Friedman test, ask yourself these questions:

Was the matching effective?
The whole point of using a paired test is to control for experimental variability. Some factors you don't control in the experiment will affect all the measurements from one subject equally, so will not affect the difference between the measurements in that subject. By analyzing only the differences, therefore, a matched test controls for some of the sources of scatter.
The pairing should be part of the experimental design and not something you do after collecting data. InStat does not test the adequacy of matching with the Friedman test.

Are the subjects (rows) independent?
The results of a Friedman test only make sense when the subjects (rows) are independent – that no random effect can affect values in more than one row. There is no way for InStat to test this assumption. You must think about the experimental design. For example, the errors are not independent if you have six rows of data obtained from three animals in duplicate. In this case, some random factor may cause all the values from one animal to be high or low. Since this factor would affect two of the rows (but not the other four), the rows are not independent.

Are the data clearly sampled from nongaussian populations?
By selecting a nonparametric test, you have avoided assuming that the data were sampled from Gaussian distributions. But there are

drawbacks to using a nonparametric test. If the populations really are Gaussian, the nonparametric tests have less power (are less likely to give you a small P value), especially with small sample sizes. Furthermore, InStat (along with most other programs) does not calculate confidence intervals when calculating nonparametric tests. If the distribution is clearly not bell-shaped, consider transforming the values (perhaps logs or reciprocals) to create a Gaussian distribution and then using repeated measures ANOVA.

Approach to interpreting the results of a Friedman test

The Friedman test is a nonparametric test to compare three or more matched groups. It is also called Friedman two-way analysis of variance by ranks. (Repeated measures one-way ANOVA is the same as two-way ANOVA without any replicates.)

The P value answers this question: If the median difference really is zero, what is the chance that random sampling would result in a median difference as far from zero (or more so) as observed in this experiment?

If the P value is small, you can reject the idea that all of the differences between columns are coincidences of random sampling, and conclude instead that at least one of the treatments (columns) differs from the rest. Then look at post tests to see which group(s) differ from which other group(s).

If the P value is large, the data do not give you any reason to conclude that the overall medians differ. This is not the same as saying that the medians are the same. You just have no evidence that they differ. If you have small samples, Friedman's test has little power.

How the Friedman test works

The Friedman test is a nonparametric test that compares three or more paired groups. The Friedman test first ranks the values in each matched set (each row) from low to high. Each row is ranked separately. It then sums the ranks in each group (column). If the sums are very different, the P value will be small. InStat reports the value of the Friedman statistic, which is calculated from the sums of ranks and the sample sizes.

The whole point of using a matched test is to control for experimental variability between subjects. Some factors you don't control in the experiment will increase (or decrease) all the measurements in a subject. Since the Friedman test ranks the values in each row, it is not affected by sources of variability that equally affect all values in a row (since that factor won't change the ranks within the row).

The P value answers this question: If the different treatments (columns) really are identical, what is the chance that random sampling would result in sums of ranks as far apart (or more so) as observed in this experiment?

If your samples are small, InStat calculates an exact P value. If your samples are large, it calculates the P value from a Gaussian approximation.

The term Gaussian has to do with the distribution of sum of ranks, and does not imply that your data need to follow a Gaussian distribution. With medium size samples, InStat can take a long time to calculate the exact P value. You can interrupt the calculations if an approximate P value is close enough.

Post tests following the Friedman test

Dunn's post test compares the difference in the sum of ranks between two columns with the expected average difference (based on the number of groups and their size). For each pair of columns, InStat reports the P value as >0.05, <0.05, <0.01 or < 0.001. The calculation of the P value takes into account the number of comparisons you are making. If the null hypothesis is true (all data are sampled from populations with identical distributions, so all differences between groups are due to random sampling), then there is a 5% chance that at least one of the post tests will have P<0.05. The 5% chance does not apply to EACH comparison but rather to the ENTIRE family of comparisons.

For more information on the post test, see Applied Nonparametric Statistics by WW Daniel, published by PWS-Kent publishing company in 1990 or Nonparametric Statistics for Behavioral Sciences by S Siegel and NJ Castellan, 1988. The original reference is O.J. Dunn, Technometrics, 5:241-252, 1964.

InStat refers to the post test as the Dunn's post test. Some books and programs simply refer to this test as the post test following a Friedman test, and don't give it an exact name.

Contingency tables

Creating contingency tables

Use contingency tables to display the results of five kinds of experiments.

Term	Design of experiment and arrangement of data
Cross-sectional study	Recruit a single group of subjects and then classify them by two criteria (row and column). As an example, let's consider how to conduct a cross-sectional study of the link between electromagnetic fields (EMF) and leukemia. To perform a cross-sectional study of the EMF-leukemia link, you would need to study a large sample of people selected from the general population. You would assess whether or not each subject has been exposed to high levels of EMF. This defines the two rows in the study. You then check the subjects to see who has leukemia. This defines the two columns. It would not be a cross-sectional study if you selected subjects based on EMF exposure or on the presence of leukemia.
Prospective study	Use two samples of subjects. To perform a prospective study of the EMF-leukemia link, you would select one group of subjects with low exposure to EMF and another group with high exposure. These two groups define the two rows in the table. Then you would follow all subjects and tabulate the numbers that get leukemia. Subjects that get leukemia are tabulated in one column; the rest are tabulated in the other column.
Retrospective case-control study	Use two samples of subjects selected based on the outcome variable. To perform a retrospective study of the EMF-leukemia link, you would recruit one group of subjects with leukemia and a control group that does not have leukemia but is otherwise similar. These groups define the two columns. Then you would assess EMF exposure in all subjects. Enter the number with low exposure in one row, and the number with high exposure in the other row. This design is also called a case control study
Experiment	Use a single group of subjects. Half get one treatment, half the other (or none). This defines the two rows in the study. The outcomes are tabulated in the columns. For example, you could perform a study of the EMF/leukemia link with animals. Half are exposed to EMF, while half are not. These are the two rows. After a suitable period of time, assess whether each animal has leukemia. Enter the number with leukemia in one column, and the number without leukemia in the other column.
Assess accuracy of diagnostic test	Select two samples of subjects. One sample has the disease or condition you are testing for, the other does not. Then perform the test on all subjects and tabulate positive test results in one column and negative test results in the other.

You must enter data in the form of a contingency table. InStat cannot tabulate raw data to create a contingency table. InStat also cannot compare

proportions directly. You need to enter the number of subjects in each category – you cannot enter fractions or percentages.

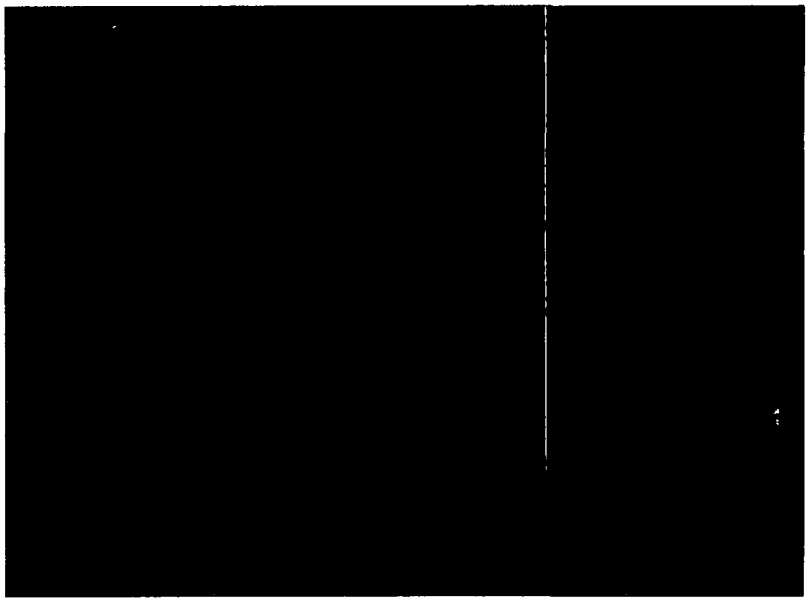
Here is an example contingency table. Subjects with HIV infection were divided into two groups and given placebo or AZT. The result was recorded as disease progression or no progression (from New Eng. J. Med. 329:297-303, 1993).

	Disease progression	No progression	Total
AZT	76	399	475
Placebo	129	332	461
Total	205	731	936

The values in a contingency table represent the number of subjects actually observed in this experiment. Tables of averages, percentages or rates are not contingency tables. Note also that the columns are mutually exclusive. A subject can be in one or the other, but not both. The rows are also mutually exclusive.

Analysis choices for contingency tables

Tables with two rows and two columns



InStat offers two methods for calculating a P value from tables with two rows and two columns: Fisher's exact test and the chi-square test. We recommend always picking Fisher's test, as it calculates a P value that is

exactly correct. The only advantage of the chi-square test is that it is easier to calculate by hand, and so is better known. We don't recommend it.

If you choose a chi-square test, also choose whether to apply Yates' continuity correction. This correction is designed to make the approximate results from a chi-square test more accurate with small samples. Statisticians disagree about whether to use it. If you always select Fisher's exact test (recommended), Yates' correction is of no concern.

If your table includes very large numbers (thousands), InStat will automatically perform the chi-square test even if you select Fisher's test. This is because the Fisher's test calculations are slow with large samples. With large samples, the chi-square test is very accurate and Yates' continuity correction has negligible effect.

Choose a two-sided P value, unless you have a good reason to pick a one-sided P value. (With contingency tables, InStat refers to "two-sided" P values rather than "two-tail P value" -- the distinction is subtle and not worth worrying about.) See "One- vs. two-tail P values" on page 13.

In addition to calculating a P value, InStat can summarize your data and compute a confidence interval. There are many ways to summarize the results of a contingency table. Your choice depends on your experimental design.

Choice	Type of experiment	How to arrange data
Relative risk, P1-P2, etc.	Prospective and experimental studies	The top row is for exposure to risk factor or treatment; the bottom row is for controls. The left column tabulates the number of individuals with disease; the right column is for those without the disease.
Odds ratio	Case-control retrospective studies	The left column is for cases; the right column is for controls. The top row tabulates the number of individuals exposed to the risk factor; the bottom row is for those not exposed.
Sensitivity, specificity, etc.	Determining the accuracy of a diagnostic test	The left column is for people who do have the condition being tested for, and the right column is for people who don't have that condition. Use an established test (or the test of time) to make this decision. Use the top row to tabulate the number of individuals with a positive test result and the bottom row to tabulate the number of individuals with a negative test result.

Contingency tables with more than two rows or columns

If your table has more than two rows or two columns, skip over the choose test step (which will be unavailable). InStat always calculates the chi-

square test. Although statisticians have developed tests analogous to Fisher's exact test for larger tables, InStat doesn't offer them. Yates' continuity correction is never used with larger tables.

If your table has two columns and three or more rows (or two rows and three or more columns), InStat will also perform the chi-square test for trend. This calculation tests whether there is a linear trend between row (column) number and the fraction of subjects in the left column (top row). This test only makes sense when the rows (columns) are arranged in a natural order (i.e. age, dose, time) and are equally spaced.

Results of contingency table analyses

Checklist. Are contingency table analyses appropriate for your data?

Before interpreting the results of any statistical test, first think carefully about whether you have chosen an appropriate test. Before accepting results from a chi-square or Fisher's test, ask yourself these questions:

Are the subjects independent?
The results of a chi-square or Fisher's test only make sense if each subject (or experimental unit) is independent of the rest. That means that any factor that affects the outcome of one subject only affects that one subject. There is no way for InStat to test this assumption. You must think about the experimental design. For example, suppose that the rows of the table represent two different kinds of preoperative antibiotics and the columns denote whether or not there was a postoperative infection. There are 100 subjects. These subjects are not independent if the table combines results from 50 subjects in one hospital with 50 subjects from another hospital. Any difference between hospitals, or the patient groups they serve, would affect half the subjects but not the other half. You do not have 100 independent observations. To analyze this kind of data, use the Mantel-Haenszel test (not offered by InStat).

Are the data unpaired?
In some experiments, subjects are matched for age and other variables. One subject in each pair receives one treatment while the other subject gets the other treatment. Data like this should be analyzed by special methods such as McNemar's test (which InStat does not do, but GraphPad StatMate does). Paired data should not be analyzed by chi-square or Fisher's test.

Is your table really a contingency table?
To be a contingency table, the values must represent numbers of subjects (or experimental units). If it tabulates averages, percentages, ratios, normalized values, etc. then it is not a contingency table and the results of chi-square or Fisher's tests will not be meaningful.

Does your table contain only data?
The chi-square test is not only used for analyzing contingency tables. It can also be used to compare the observed number of subjects in each category with the number you expect to see based on theory. InStat cannot do this kind of chi-square test. It is not correct to enter observed values in one column and expected in another. When analyzing a contingency table with the chi-square test, InStat generates the expected values from the data – you do not enter them.

Are the rows or columns arranged in a natural order?
If your table has two columns and more than two rows (or two rows and more than two columns), InStat will perform the chi-square test for trend as well as the regular chi-square test. The results of the test for trend will only be meaningful if the rows (or columns) are arranged in a natural order, such as age, duration, or time. Otherwise, ignore the results of the chi-square test for trend and only consider the results of the regular chi-square test.

Interpreting relative risk, odds ratio, P1-P2, etc.

If any of the four values in the contingency table are zero, InStat adds 0.5 to all values before calculating the relative risk, odds ratio and P1-P2 (to avoid dividing by zero).

Relative risk

The relative risk is the proportion of subjects in the top row who are in the left column divided by the proportion of subjects in the bottom row who are in the left column. For the AZT example, the relative risk is 16%/28%=0.57. A subject treated with AZT has 57% the chance of disease progression as a subject treated with placebo. The word "risk" is appropriate in some studies, but not others. Think of the relative risk as being simply the ratio of proportions. InStat also reports the 95% confidence interval for the relative risk, calculated by the approximation of Katz. For the example, the 95% confidence interval ranges from 0.4440 to 0.7363. You can be 95% certain that this range includes the true population relative risk.

P1-P2

You can also summarize the results by taking the difference of the two proportions. In the example, the disease progressed in 28% of the placebo-treated patients and in 16% of the AZT-treated subjects. The difference is 28% - 16% = 12%. InStat also reports an approximate 95% confidence interval (unless the sample sizes are very small). For the example, the confidence interval ranges from 6.68% to 17.28%.

Odds ratio

When analyzing case-control retrospective studies, you cannot meaningfully calculate the difference between proportions or the relative

risk. The best way to summarize the data is via an odds ratio. In most cases, you can think of an odds ratio as an approximate relative risk. So if the odds ratio equals 4, the disease occurs four times as often in people exposed to the risk factor as in people not exposed.

Sensitivity, specificity, and predictive values

Term	Meaning
Sensitivity	The fraction of those with the disease correctly identified as positive by the test.
Specificity	The fraction of those without the disease correctly identified as negative by the test.
Positive predictive value	The fraction of people with positive tests who actually have the condition.
Negative predictive value	The fraction of people with negative tests who actually don't have the condition.
Likelihood ratio	If you have a positive test, how many times more likely are you to have the disease? If the likelihood ratio equals 6.0, then someone with a positive test is six times more likely to have the disease than someone with a negative test. The likelihood ratio equals sensitivity/(1.0-specificity).

The sensitivity, specificity and likelihood ratios are properties of the test. The positive and negative predictive values are properties of both the test and the population you test. If you use a test in two populations with different disease prevalence, the predictive values will be different. A test that is very useful in a clinical setting (high predictive values) may be almost worthless as a screening test. In a screening test, the prevalence of the disease is much lower so the predictive value of a positive test will also be lower.

Interpreting P values from analyses of a 2x2 contingency table

If you set up the contingency table to evaluate the accuracy of a diagnostic test, the most important results will be the sensitivity, specificity and predictive power (see page 83), and you'll probably ignore the P value. In other situations, you'll be interested both in the P value and the confidence interval for the relative risk, odds ratio, or P1-P2.

The P value answers this question: If there really is no association between the variable defining the rows and the variable defining the columns in the overall population, what is the chance that random sampling would result in an association as strong (or stronger) as observed in this experiment? Equivalently, if there really is no association between rows and columns overall, what is the chance that random sampling would lead to a relative risk or odds ratio as far (or further) from 1.0 (or P1-P2 as far from 0.0) as observed in this experiment?

"Statistically significant" is not the same as "scientifically important". Before interpreting the P value or confidence interval, you should think about the size of the relative risk, odds ratio or P1-P2 you are looking for. How large does the value need to be for you consider it to be scientifically important? How small a value would you consider to be scientifically trivial? Use scientific judgment and common sense to answer these questions. Statistical calculations cannot help, as the answers depend on the context of the experiment.

You will interpret the results differently depending on whether the P value is small or large.

If the P value is small

If the P value is small, then it is unlikely that the association you observed is due to a coincidence of random sampling. You can reject the idea that the association is a coincidence, and conclude instead that the population has a relative risk or odds ratio different than 1.0 (or P1-P2 different than zero). The association is statistically significant. But is it scientifically important? The confidence interval helps you decide.

Your data include the effects of random sampling, so the true relative risk (or odds ratio or P1-P2) is probably not the same as the value calculated from the data in this experiment. There is no way to know what that true value is. InStat presents the uncertainty as a 95% confidence interval. You can be 95% sure that this interval contains the true relative risk, odds ratio or P1-P2.

To interpret the results in a scientific context, look at both ends of the confidence interval and ask whether they represent values that would be scientifically important or scientifically trivial.

Lower confidence limit	Upper confidence limit	Conclusion
Trivial	Trivial	Although the true relative risk or odds ratio is not 1.0 (and the true P1-P2 is not 0.0) the association is tiny and uninteresting. The rows and columns are associated, but weakly.
Trivial	Important	Since the confidence interval ranges from a relative risk (or odds ratio or P1-P2) that you think is biologically trivial to one you think would be important, you can't reach a strong conclusion from your data. You can conclude that the rows and columns are associated, but you don't know whether the association is scientifically trivial or important. You'll need more data to obtain a clear conclusion.

Important	Important	Since even the low end of the confidence interval represents an association large enough to be considered biologically important, you can conclude that the rows and columns are associated, and the association is strong enough to be scientifically relevant.

If the P value is large

If the P value is large, the data do not give you any reason to conclude that the relative risk or odds ratio differs from 1.0 (or P1-P2 differs from 0.0). This is not the same as saying that the true relative risk or odds ratio equals 1.0 (or P1-P2 equals 0.0). You just don't have evidence that they differ.

How large could the true relative risk really be? Your data include the effects of random sampling, so the true relative risk (or odds ratio or P1-P2) is probably not the same as the value calculated from the data in this experiment. There is no way to know what that true value is. InStat presents the uncertainty as a 95% confidence interval. You can be 95% sure that this interval contains the true relative risk (or odds ratio or P1-P2). When the P value is larger than 0.05, the 95% confidence interval includes the null hypothesis (relative risk or odds ratio equal to 1.0 or P1-P2 equal to zero) and extends from a negative association (RR<1.0, OR<1.0, or P1-P2<0.0) to a positive association (RR>1.0, OR>1.0, or P1-P2>0.0)

To interpret the results in a scientific context, look at both ends of the confidence interval and ask whether they represent an association that would be scientifically important or scientifically trivial.

Lower confidence limit	Upper confidence limit	Conclusion
Trivial	Trivial	You can reach a crisp conclusion. Either there is no association between rows and columns, or it is trivial. At most, the true association between rows and columns is tiny and uninteresting.
Trivial	Large	You can't reach a strong conclusion. The data are consistent with the treatment causing a trivial negative association, no association, or a large positive association. To reach a clear conclusion, you need to repeat the experiment with more subjects.
Large	Trivial	You can't reach a strong conclusion. The data are consistent with a trivial positive association, no association, or a large negative association. You can't make a clear conclusion without repeating the experiment with more subjects.

Interpreting analyses of larger contingency tables

If your table has two columns and more than two rows (or two rows and more than two columns), InStat will perform both the chi-square test for independence and the chi-square test for trend.

Chi-square test for independence

The chi-square test for independence asks whether there is an association between the variable that defines the rows and the variable that defines the columns.

InStat first computes the expected values for each value. These expected values are calculated from the row and column totals, and are not displayed in the results. The discrepancies between the observed values and expected values are then pooled to compute chi-square, which is reported. A large value of chi-squared tells you that there is a large discrepancy. The P value answers this question: If there is really no association between the variable that defines the rows and the variable that defines the columns, then what is the chance that random sampling would result in a chi-square value as large (or larger) as you obtained in this experiment.

Chi-square test for trend

The P value from the test for trend answers this question: If there is no linear trend between row (column) number and the fraction of subjects in the left column (top row), what is the chance that you would happen to observe such a strong trend as a coincidence of random sampling? If the P value is small, you will conclude that there is a statistically significant trend.

For more information about the chi-square test for trend, see the excellent text, Practical Statistics for Medical Research by D. G. Altman, published in 1991 by Chapman and Hall.

Linear regression and correlation

Introduction to linear regression and correlation

Introduction to correlation

Correlation is used when you have measured two variables in each subject, and wish to quantify how consistently the two variables vary together. When the two variables vary together, statisticians say that there is a lot of covariation or correlation. The direction and magnitude of correlation is quantified by the correlation coefficient, r.

InStat calculates the correlation coefficient, r, and its 95% confidence interval. It also calculates a P value that answers this question: If the two variables really aren't correlated at all in the overall population, what is the chance that you would obtain a correlation coefficient as far from zero as observed in your experiment from randomly selected subjects?

Introduction to linear regression

Linear regression is used to analyze the relationship between two variables, which we will label X and Y. For each subject (or experimental unit), you know both X and Y and you want to find the best straight line through the data. In some situations, the slope and/or intercept have a scientific meaning. In other cases, you use linear regression to create a standard curve to find new values of X from Y, or Y from X.

InStat determines the best-fit linear regression line, including 95% confidence interval bands. You may force the line through a particular point (usually the origin), perform the runs test, and interpolate unknown values from a standard curve determined by linear regression. InStat also creates a notebook-quality graph of your data with the best-fit line. You can not customize this graph.

InStat cannot perform nonlinear or polynomial regression, but GraphPad Prism can (see page 120).

How does linear regression work?

Linear regression finds the line that best predicts Y from X. It does this by finding the line that minimizes the sum of the squares of the vertical distances of the points from the line.

Why minimize the square of the distances? If the scatter of points around the line is Gaussian, it is more likely to have two points somewhat close to the line (say 5 units each) than to have one very close (1 unit) and one further (9 units). The total distance is 10 in each of those situations. The sum of the squares of the distances is 50 in the first situation and 81 in the second. A strategy that minimized the total distance would have no

preference between the two situations. A strategy that minimizes the sum of squares of the distances prefers the first situation, which is more likely to be correct.

Note that linear regression does not *test* whether your data are linear (except for the runs test). It assumes that your data are linear, and finds the slope and intercept that make a straight line come as close as possible to your data.

Entering data for correlation and linear regression

Enter X values into the first column (labeled X), and Y values into the second column (Y1). Only use the remaining columns if you have replicate Y values for each value of X (i.e. triplicate measurements of the same variable).

If you want to interpolate values from a standard curve, enter the unknowns directly below the standard curve. For the unknowns, enter X or Y (but not both). See "Reading unknowns from standard curves" on page 95.

If you want to look at the relationship of more than two variables (for example, if you want to look at how blood pressure is affected by both age and weight), format the data table for multiple regression (see "Introduction to multiple regression and correlation" on page 97) rather than linear regression.

Note that X and Y are asymmetrical for linear regression. If you switch X and Y you'll get a different best-fit regression line (but the same correlation coefficient).

Choosing linear regression or correlation

Regression or correlation?

Linear regression and correlation are related, but different, tests. Linear regression finds the line that best predicts Y from X. Correlation quantifies how well X and Y vary together. When choosing, consider these points:

- If you control X (i.e., time, dose, concentration), don't select correlation. Select linear regression.
- Only choose linear regression if you can clearly define which variable is X and which is Y. Linear regression finds the best line that predicts Y from X by minimizing the sum of the square of the vertical distances of the points from the regression line. The X and Y variables are not symmetrical in the regression calculations (they are symmetrical in the correlation calculations).
- In rare cases, it might make sense to perform both regression and correlation. InStat can only perform one at a time, but you can go back and change the analysis choices.

Pearson or Spearman correlation?

If you choose correlation, choose between standard (Pearson) correlation and nonparametric (Spearman) correlation. Pearson correlation calculations are based on the assumption that both X and Y values are sampled from populations that follow a Gaussian distribution, at least approximately. With large samples, this assumption is not too important. If you don't wish to make the Gaussian assumption, select nonparametric (Spearman) correlation instead. Spearman correlation is based on ranking the two variables, and so makes no assumption about the distribution of the values.

When to force a regression line through the origin?

If you choose regression, you may force the line to go through a particular point such as the origin. In this case, InStat will determine only the best-fit slope, as the intercept will be fixed. Use this option when scientific theory tells you that the line must go through a particular point (usually the origin, X=0, Y=0) and you only want to know the slope. This situation arises rarely.

Use common sense when making your decision. For example, consider a protein assay. You measure optical density (Y) for several known concentrations of protein in order to create a standard curve. You then want to interpolate unknown protein concentrations from that standard curve. When performing the assay, you adjusted the spectrophotometer so that it reads zero with zero protein. Therefore you might be tempted to force the regression line through the origin. But you don't particularly care where the line is in the vicinity of the origin. You really care only that the line fits the standards very well near the unknowns. You will probably get a better fit by not constraining the line.

Most often, you will let InStat find the best-fit line without any constraints.

Test departure from linearity with runs test?

Linear regression is based on the assumption that the relationship between X and Y is linear. If you select this option, InStat can test that assumption with the runs test.

A run is a series of consecutive points that are either all above or all below the regression line. If the points are randomly distributed above and below the regression line, InStat knows how many runs to expect. If there are fewer runs, it suggests that the data follow a curve rather than a line.

Interpolate unknowns from a standard curve?

InStat can interpolate unknown values from the standard curve created by linear regression. See "Reading unknowns from standard curves" on page 95.

Results of correlation

Checklist. Is correlation the right analysis for these data?

To check that correlation is an appropriate analysis for these data, ask yourself these questions. InStat cannot help answer them.

Are the subjects independent?
Correlation assumes that any random factor that affects only one subject, and not others. You would violate this assumption if you choose half the subjects from one group and half from another. A difference between groups would affect half the subjects and not the other half.

Are X and Y measured independently?
The calculations are not valid if X and Y are intertwined. You'd violate this assumption if you correlate midterm exam scores with overall course score, as the midterm score is one of the components of the overall score.

Were X values measured (not controlled)?
If you controlled X values (i.e. concentration, dose or time) you should calculate linear regression rather than correlation.

Is the covariation linear?
The correlation would not be meaningful if Y increases as X increases up to a point, and then Y decreases as X increases further.

Are X and Y distributed according to Gaussian distributions?
To accept the P value from standard (Pearson) correlation, the X and Y values must each be sampled from populations that follow Gaussian

distributions. Spearman nonparametric correlation does not make this assumption.

How to think about results of linear correlation

The P value answers this question: If there really is no correlation between X and Y in the overall population, what is the chance that random sampling would result in a correlation coefficient as far from zero as observed in this experiment?

If the P value is small, you can reject the idea that the correlation is a coincidence. Look at the confidence interval for r. You can be 95% sure that the true population r lies somewhere within that range.

If the P value is large, the data do not give you any reason to conclude that the correlation is real. This is not the same as saying that there is no correlation at all. You just have no evidence that the correlation is real and not a coincidence. Look at the confidence interval for r. It will extend from a negative correlation to a positive correlation. If the entire interval consists of values near zero that you would consider biologically trivial, then you have strong evidence that either there is no correlation in the population or that there is a weak (biologically trivial) association. On the other hand, if the confidence interval contains correlation coefficients that you would consider biologically important, then you couldn't make any strong conclusion from this experiment. To make a strong conclusion, you'll need data from a larger experiment.

Correlation results line by line

Correlation coefficient

The correlation coefficient, r, ranges from -1 to 1. The nonparametric Spearman correlation coefficient is abbreviated r_s but is interpreted the same way.

Value of r or r_s	Interpretation
Zero	The two variables do not vary together at all.
Positive fraction	The two variables tend to increase or decrease together.
Negative fraction	One variable increases as the other decreases.
1.0	Perfect correlation.
-1.0	Perfect negative or inverse correlation.

If r is far from zero, there are four possible explanations:

- The X variable helps determine the value of the Y variable.
- The Y variable helps determine the value of the X variable.

- Another variable influences both X and Y.
- X and Y don't really correlate at all, and you just happened to observe such a strong correlation by chance. The P value determines how often this could occur.

r^2

Perhaps the best way to interpret the value of r is to square it to calculate r^2. Statisticians call the quantity the *coefficient of determination*, but scientists call it *r squared*. It is has a value that ranges from zero to one, and is the fraction of the variance in the two variables that is shared. For example, if $r^2=0.59$, then 59% of the variance in X can be explained by (or goes along with) variation in Y. Likewise, 59% of the variance in Y can be explained by (or goes along with) variation in X. More simply, 59% of the variance is shared between X and Y.

Only calculate r^2 from the Pearson correlation coefficient, not from the nonparametric Spearman correlation coefficient.

P value

The P value answers this question: If the two variables really aren't correlated at all in the overall population, what is the chance that you would obtain a correlation coefficient as far from zero as observed in your experiment from randomly selected subjects?

Results of linear regression

Checklist. Is linear regression the right analysis for these data?

To check that linear regression is an appropriate analysis for these data, ask yourself these questions. InStat cannot help answer them.

Can the relationship between X and Y be graphed as a straight line?
In many experiments, the relationship between X and Y is curved, making linear regression inappropriate. Either transform the data, or use a program (such as GraphPad Prism) that can perform nonlinear curve fitting.

Is the scatter of data around the line Gaussian (at least approximately)?
Linear regression assumes that the scatter is Gaussian.

Is the variability the same everywhere?
Linear regression assumes that scatter of points around the best-fit line has the same standard deviation all along the curve. The assumption is violated if the points with higher (or lower) X values also tend to be further from the best-fit line. The assumption that the standard deviation is the same everywhere is termed *homoscedasticity*.

Do you know the X values precisely?
The linear regression model assumes that X values are exactly correct, and that experimental error or biological variability only affects the Y values. This is rarely the case, but it is sufficient to assume that any imprecision in measuring X is very small compared to the variability in Y.

Are the data points independent?
Whether one point is above or below the line is a matter of chance, and does not influence whether another point is above or below the line. See "The need for independent samples" on page 10.

How to think about the results of linear regression

Your approach to linear regression will depend on your goals.

If your goal is to analyze a standard curve, you won't be very interested in most of the results. Just make sure that r^2 is high and that the line goes near the points. Then go straight to the standard curve results. See "Reading unknowns from standard curves" on page 95.

In other cases, you will be most interested in the best-fit values for slope and intercept. Also look at the 95% confidence interval for these values. You can be 95% certain that these ranges include the true best-fit values. If the intervals are too wide, repeat the experiment collecting more data points.

Don't forget to look at a graph of the data by clicking the Graph button (the sixth step button at the bottom of the InStat window). InStat shows you the best-fit line, and an error envelope. You can be 95% sure that the true best-fit line (if you had an infinite amount of data) will lie somewhere within the envelope.

Linear regression results line by line

Slope and intercept

InStat displays the values of the slope and Y-intercept with standard errors and 95% confidence intervals. If the assumptions of linear regression are true, then you can be 95% certain that confidence interval contains the true population values of the slope and intercept.

Goodness of fit

InStat assesses goodness-of-fit by reporting $s_{y.x}$ and r^2.

The value r^2 is a fraction between 0.0 and 1.0, and has no units. When r^2 equals 0.0, there is no linear relationship between X and Y. In this case, the best-fit line is a horizontal line going through the mean of all Y values, and knowing X does not help you predict Y. When r^2=1.0, all points lie exactly

on a straight line with no scatter. If you know X, you can predict Y exactly. With most data, r^2 is between 0.0 and 1.0.

You can think of r^2 as the fraction of the total variance of Y that is "explained" by the linear regression model. More simply, the variation of points around the regression line equals $1.0-r^2$ of the total variation in Y.

The value $s_{y.x}$ is the standard deviation of the vertical distances of the points from the line. Since the distances of the points from the line are termed residuals, $s_{y.x}$ is the standard deviation of the residuals. Its value is expressed in the same units as Y. You'll only be interested in its value if you plan to perform more advanced calculations.

Is the slope significantly different than zero?

InStat tests whether the slope differs significantly from zero (horizontal). The null hypothesis is that there is no linear relationship between X and Y overall, so the true best-fit line is horizontal. The P value answers this question: If the null hypothesis is true, what is the probability that randomly selected points would result in a regression line as far from horizontal (or further) as you observed? The P value is calculated from an F test, and InStat reports the value of F and its degrees of freedom.

Residuals and the runs test

The runs test determines whether your data differ significantly from a straight line.

A run is a series of consecutive points that are either all above or all below the regression line. In other words, a run is a series of consecutive points whose residuals are either all positive or all negative.

If the data follow a curve rather than a line, the points will tend to be clustered together above or below the line. There will be too few runs. The P value answers this question: If the data points are randomly scattered around a straight line, what is the chance of finding as few (or fewer) runs as you observed. If there are fewer runs than expected, the P value will be low, suggesting that your data follow a curve rather than a straight line.

Standard Curve

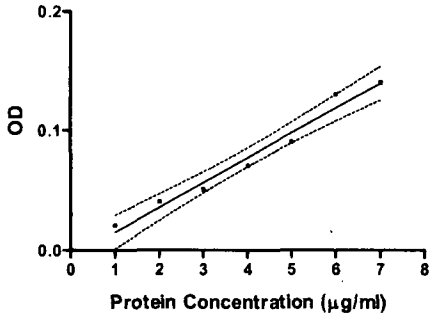
To read unknown values from a standard curve, you must enter unpaired X or Y values below the X and Y values for the standard curve and check the option to interpolate unknowns from a standard curve. See "Reading unknowns from standard curves" on page 95.

InStat's graph of linear regression results

InStat graphs the best-fit line along with the data. It also plots the 95% confidence interval as dotted lines. Assuming that all the assumptions of linear regression are true, you can be 95% sure that the true best-fit line (if you had an infinite amount of data) lies within those confidence limits.

To include uncertainty in both the slope and the intercept, the confidence limits are curved. This does not mean that they include the possibility of a nonlinear relationship between X and Y. Instead, the curved confidence limits demarcate the area that can contain the best-fit straight regression line.

With InStat, you cannot customize this graph in any way. GraphPad Prism (see page 120) can do the same analyses, but lets you customize the graph for publications or presentations. Here is a Prism graph showing a linear regression line with 95% confidence intervals (similar to the graph made by InStat).



Reading unknowns from standard curves

What is a standard curve?

An *assay* is an experimental procedure used to determine the concentration of a substance. The measurement (which might be optical density, radioactivity, luminescence, or something else) varies with the concentration of the substance you are measuring. A *standard curve* is a graph of assay measurement (Y) as a function of known concentrations of the substance (X) used to calibrate the assay. Standard curves can be linear or curved.

Once you have created a standard curve using known concentrations of the substance, you can use it to determine the concentration of unknowns. Perform the same assay with the unknown sample. Then read across the graph from the spot on the Y-axis that corresponds to the assay measurement of the unknown until you intersect the standard curve. Read down the graph until you intersect the X-axis. The concentration of substance in the unknown sample is the value on the X-axis.

Entering standard curve data into InStat

InStat can interpolate unknown values from linear standard curves. Simply enter the unknowns directly below the standard curve. Enter either X or Y, but not both. Most often you will enter Y. This example has four standards, and four unknowns entered underneath.

Row	X	Y
1	1	3.2
2	2	7.1
3	3	12.5
4	4	16.3
5		4.2
6		5.6
7		9.4
8		10.2

On the step where you choose the test, check the option box for standard curve calculations. InStat will include the standard curve results on the result page.

InStat will flag (with an asterisk) any unknowns that are outside of the range of the standard curve. While you may accept the results from unknowns that are just barely out of range, be cautious about results from unknowns far from the standard curve.

InStat does not do any kind of curve fitting. If your standard curve is not linear, you have two choices:

- Transform the data to create a linear standard curve. If you transform Y values of your standards, also be sure to transform the Y values of the unknowns. If you transform the X values of your standards, InStat will report the unknowns in that transformed scale and you'll need to do a reverse transform.

- Use a program, such as GraphPad Prism, that can fit nonlinear curves and read unknown values off that curve.

Multiple Regression and correlation

Introduction to multiple regression and correlation

Uses of multiple regression

In laboratory experiments, you can generally control all the variables. You change one variable, measure another, and then analyze the data with one of the standard statistical tests. But in some kind of experiments, and many observational studies, you need to analyze the interaction of several variables. Multiple regression is one way to do this.

Multiple regression fits an equation that predicts one variable (the dependent variable, Y) from two or more independent (X) variables. For example, you might use multiple regression to predict blood pressure from age, weight and gender.

In some situations, your goal may really be to examine several variables at once. With the blood pressure example, your goal may be to find out which variable has the largest influence on blood pressure: age, weight or gender. Or your goal may be to find an equation that best predicts blood pressure from those three variables.

In other situations, you really only care about one of the independent variables, but your analysis needs to adjust for differences in other variables. For this example, you might ask: Does blood pressure vary with age, after correcting for differences in weight and differences between the sexes? Or you might ask: Does blood pressure differ between men and women, after correcting for differences in age and weight?

InStat, like other multiple regression programs, presents you with many results and it is easy to be overwhelmed. Your approach to the results will depend, in part, on what question you are trying to answer. Before looking at the results, try to clearly articulate your questions.

Multiple regression is more complicated than the other statistical tests offered by InStat, so the results can be confusing and misleading to someone who has never used multiple regression before. Before analyzing your data with multiple regression, find an experienced consultant or consult one of these books:

- SA Glantz and BK Slinker, Primer of Applied Regression and Analysis of Variance, McGraw-Hill, 1990.
- LD Fisher and G vanBelle, Biostatistics. *A Methodology for the Health Sciences*, Wiley, 1993.

The multiple regression model and its assumptions

Multiple regression fits your data to this equation, where each X_i represents a different X variable.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \ldots + \text{random scatter}$$

If there is only a single X variable, then the equation is $Y = \beta_0 + \beta_1 X_1$, and the "multiple regression" analysis is the same as simple linear regression (β_0 is the Y intercept; β_1 is the slope).

For the example, the equation would be

Blood pressure = $\beta_0 + \beta_1$*age +β_2*weight +β_3*gender + random scatter

Gender is coded as 0=male and 1=female. This is called a *dummy variable.*

InStat finds the values of β_0, β_1, etc. that make the equation generate a curve that comes as close as possible to your data. More precisely, InStat finds the values of those coefficients that minimize the sum of the square of the differences between the Y values in your data and the Y values predicted by the equation.

The model is very simple, and it is surprising that it turns out to be so useful. For the blood pressure example, the model assumes:

- On average, blood pressure increases (or decreases) a certain amount (the best- fit value of β_1) for every year of age. This amount is the same for men and women of all ages and all weights.

- On average, blood pressure increases (or decreases) a certain amount per pound (the best-fit value of β_2). This amount is the same for men and women of all ages and all weights.

- On average, blood pressure differs by a certain amount between men and women (the best-fit value of β_3). This amount is the same for people of all ages and weights.

The mathematical terms are that the model is *linear* and allows for *no interaction. Linear* means that holding other variables constant, the graph of blood pressure vs. age (or vs. weight) is a straight line. *No interaction* means that the slope of the blood pressure vs. age line is the same for all weights and for men and women.

You can sometimes work around the linearity assumption by transforming one or more of the X variables. You could transform weight to square root of weight, for example.

You can sometimes work around the assumption of no interaction by creating a new column by multiplying two variables together (in this example create a new variable defined as weight times age). Including this column as an additional variable in the multiple regression model partially takes into account interactions. Consult a statistician or an advanced statistics book before trying this.

Additionally, the multiple regression procedure makes assumptions about the random scatter. It assumes that the scatter is Gaussian, and that the standard deviation of the scatter is the same for all values of X and Y. Furthermore, the model assumes that the scatter for each subject should be random, and should not be influenced by the deviation of other subjects. See "The need for independent samples" on page 10.

There is an additional complexity with this example, in that the variables are intertwined — weight tends to go up with age, and men tend to be heavier than women. See "Is multicollinearity a problem?" on page 105.

Entering data for multiple regression and correlation

Enter each subject (or experimental unit) into a row, with each variable in a separate column. You don't have to decide (yet) which column contains the dependent (Y) variable, although it is customary to place it in the first column.

Each variable (column) can be:

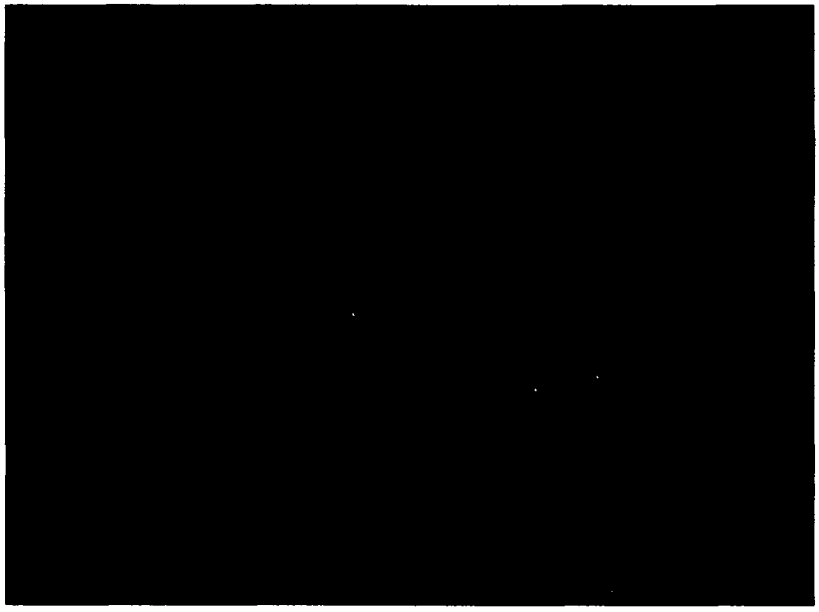
- A measured variable (blood pressure).
- A transformation of a measured variable (i.e., age squared or logarithm of serum LH levels). Since the multiple regression only fits data to a linear equation, you may get better results in some cases by transforming the variables first.
- A discrete variable which has only two possible values. For example a column could code gender; enter 0 for male and 1 for female.

You must enter more rows of data (more subjects) than independent variables. For the results of multiple regression to be useful, you'll need many more subjects than variables. One rule of thumb is that you should have at least 5-10 times more subjects than variables.

Get statistical help (or consult advanced books) before you do any of the following:

- Enter a discrete variable with more than two possible values, for example prior treatment with one of three drugs or residence in one of four states. Don't enter the code into a single variable. Instead, you have to create several dummy variables (several columns) to encode all the possibilities. This is more complicated than it sounds, and you'll need expert guidance to do it properly and to make sense of the results.
- Enter a variable into one column and a function of that variable (perhaps the variable squared) in another column.
- Enter the product of two variables into a column by itself to account for interaction.

Analysis choices for multiple regression and correlation



Decide first whether you want to compute a correlation matrix or perform multiple regression.

Multiple correlation finds the correlation coefficient (r) for every pair of variables. Your only choice is to select the variables (columns) you want to include. The other columns are ignored. InStat computes the correlation coefficient for each pair of columns independently, and shows the results as a correlation matrix. InStat does not compute partial correlation coefficients.

Multiple regression finds the linear equation that best predicts the value of one of the variables (the dependent variable) from the others. To use multiple regression, therefore, you have to designate one of the columns as the dependent (Y) variable and choose which of the remaining columns contain independent (X) variables you want to include in the equation. InStat ignores the rest of the columns. Some programs can decide which X variables to include in the regression model. They do this by performing step-wise multiple regression, using one of several methods. InStat does not perform any kind of stepwise regression.

Note that the Y variable should **not** be a discrete (binary) variable, for example a variable that equals 0 for failure and 1 for success. If you want to find an equation that predicts a binary variable, then you need to use multiple *logistic* regression. InStat does not do this.

Interpreting a correlation matrix

InStat reports the correlation coefficient (r) for each pair of variables (columns). Each r is calculated based on the values in those two columns,

without regard to the other columns. The value of r can range from −1 (a perfect negative correlation) to +1 (perfect positive correlation). InStat does not calculate partial correlation coefficients.

If data are missing, those rows are excluded from all calculations. For example if the value for row 5 is missing for column 3, then all values in row 5 are ignored when calculating all the correlation coefficients.

The results of multiple regression

Checklist. Is multiple regression the right analysis?

To check that multiple regression is an appropriate analysis for these data, ask yourself these questions.

Is the relationship between each X variable and Y linear?
In many experiments, the relationship between X and Y is nonlinear, making multiple regression inappropriate. In some cases you may be able to transform one or more X variables to create a linear relationship. You may also be able to restrict your data to a limited range of X variables, where the relationship is close to linear. Some programs (but none currently available from GraphPad Software) can perform nonlinear regression with multiple independent variables.

Is the scatter of data around the prediction of the model Gaussian (at least approximately)?
Multiple regression assumes that the distribution of values from the prediction of the model is random and Gaussian.

Is the variability the same everywhere?
Multiple regression assumes that scatter of data from the predictions of the model has the same standard deviation for all values of the independent variables. The assumption is violated if the scatter goes up (or down) as one of the X variables gets larger. The assumption that the standard deviation is the same everywhere is termed *homoscedasticity*.

Do you know the X values precisely?
The linear regression model assumes that all the X values are exactly correct, and that experimental error or biological variability only affects the Y values. This is rarely the case, but it is sufficient to assume that any imprecision in measuring X is very small compared to the variability in Y.

Are the data points independent?
Whether one value is higher or lower than the regression model predicts should be random. See "The need for independent samples" on page 10.

General approach

Multiple regression is far more complicated than the other analyses offered by InStat, and the information in the manual and help screens may not be sufficient to analyze your data completely and correctly. Consider getting expert guidance.

The results of multiple regression help you answer these questions, each discussed below. Depending on your scientific goals, you may be very interested in some of these questions and less interested in others.

- What is the best fit?
- How good is the fit?
- Which X variable(s) make a significant contribution?
- Is multicollinearity a problem?
- Would a simpler model fit as well?

What is the best fit?

Multiple regression fits an equation to data, so InStat reports the values of the parameters in the equation that make it fit the data best. Each best-fit parameter has the units of the Y variable divided by the units of its X variable.

Here again is the multiple regression model for the blood pressure example.

Blood pressure = β_0 + β_1*age +β_2*weight +β_3*gender + random scatter

Assuming that blood pressure is measured in torr (same as mm Hg) and age is measured in years, the variable β_1 will have units of torr/year. It is the amount by which blood pressure increases, on average, for every year increase in age, after correcting for differences in gender and weight. If weight is measured in kg, then β_2 has units of torr/kg. It is the average amount by which blood pressure increases for every kg increase in weight, adjusting for differences in age and gender. Gender is a dummy variable with no units, coded so that males are zero and females are one. Therefore, the variable β_3 has units of torr. It is the average difference in blood pressure between men and women, after taking into account differences in age and weight.

The variable β_0, which InStat calls "constant", is needed to complete the equation. It is expressed in units of the Y variable. It is the value of Y when all X variables equal zero. This will rarely make any biological sense, since many X variables are never anywhere near zero. In the blood pressure example, you could think of it as the average blood pressure of men (since gender is coded as zero) with age=0 and weight=0!

The only way you could really know the best-fit values of the parameters in the model would be to collect an infinite amount of data. Since you can't do this, the best-fit values reported by InStat are influenced, in part, by random variability in picking subjects. InStat reports this uncertainty as a

95% confidence interval for each parameter. These take into account the number of subjects in your study, as well as the scatter of your data from the predictions of the model. If the assumptions of the analysis are true, you can be 95% sure that the interval contains the true best-fit value of the variable.

InStat also presents the standard error of each parameter in the model. These are hard to interpret, but are used to compute the 95% confidence intervals for each coefficient. InStat shows them so that its results can be compared to those of other programs.

How good is the fit?

InStat quantifies goodness-of-fit in several ways.

Term	Explanation
R^2	The fraction of all variance in Y that is explained by the multiple regression model. If R^2 equals 1.0, then each Y value is predicted perfectly by the model, with no random variability. If R^2 equals 0.0, then the regression model does a terrible job of predicting Y values – you'll get equally accurate predictions by simply predicting that each Y value equals the mean of the Y values you measured. With real data, of course, you won't see those extreme R^2 values, but instead will see R^2 values between 0.0 and 1.0.
P value	The P value answers this question: If you collected random data, what is the chance that you'd happen to obtain an R^2 value as large, or larger, than you obtained in this experiment. More simply, the P value tests whether the regression model predicts Y in a statistically significant manner – whether the predictions of the model are any better than chance alone.
Sum-of-squares and SD of residuals	Multiple regression finds values for coefficients in the model that minimize the sum-of-squares of the differences between the predicted Y values and the actual Y values. InStat reports the sum-of-squares along with the SD of the residuals (square root of SS divided by N-V, where N is number of subjects, and V is the number of independent variables). These values are used if you perform advanced calculations.

Adjusted R^2	Even if the data are all random, you expect R^2 to get larger as you add more variables to the equation. Just by chance the model will predict the data better if it has more components. The adjusted R^2 value corrects for this, by correcting for the number of X variables in the model. If you collect random data, you'd expect the adjusted R^2 value to be zero on average. If you collected many sets of random data, the adjusted R^2 value will be negative half the time, and positive half the time. If the adjusted R^2 were really the square of anything, then it would always be positive. But the adjusted R^2 is not the square of anything – it is just R^2 minus a correction. The adjusted R^2 is mostly useful for comparing the fits of models with different numbers of independent variables. You can't compare R^2, because you expect R^2 to be smaller in the fit with more variables just by chance.
Multiple R	Multiple R is the square root of R^2. It is not particularly useful, but other programs report it so InStat does too. You can interpret it much like you interpret a correlation coefficient.
F	This F ratio is used to compute the P value. InStat includes it for completeness.

Which variable(s) make a significant contribution?

If the overall P value is high, you can conclude that the multiple regression model does not explain your data. In this case, there is not much point in looking at the results for individual variables. If the overall P value is low, you probably will next want to find out which variables in the model are useful and which are extraneous.

For each independent variable in the model, InStat reports a P value that answers this question: After accounting for all the other independent variables, does adding this variable to the model significantly improve the ability of the model to account for the data? If the P value is small, the variable contributes in a statistically significant manner. If the P value is large, then the contribution of the variable is no greater than you'd expect to see by chance alone. InStat uses the standard threshold (alpha) value of 0.05. If a P value is less than 0.05, then InStat reports that the variable made a statistically significant contribution to the fit. If a P value is greater than 0.05, InStat concludes that the influence of that variable is not statistically significant. This threshold (0.05) is arbitrary but conventional.

A common use of multiple regression is to determine the influence of one independent variable after correcting for others. For example, suppose that you want to compare blood pressure between men and women after correcting for age and weight. In this case, you'll interpret the P value for the main X variable (gender) somewhat differently than the P value for the other X variables (age and weight). What you really care about is the P value for the main variable (gender). If it is low, conclude gender affects blood pressure, after correcting for differences in age and weight. The P value for the other X variables (age and weight) are less interesting. A low P value tells you that there is a linear relationship between that variable and

the outcome, which justifies your decision to include it in the multiple regression model.

For each variable, InStat also reports a t ratio, an intermediate result that won't be of interest to most InStat users. It equals the absolute value of the coefficient divided by its standard error. The P value is defined more precisely in terms of t. If the true best-fit value of this coefficient (given an infinite amount of data) were really zero, what is the chance that analysis of randomly selected data (of the same sample size you used) would lead to a value of t as far from zero (or further) as you obtained here?

Is multicollinearity a problem?

The term *multicollinearity* is as hard to understand as it is to say. But it is important to understand, as multicollinearity can interfere with proper interpretation of multiple regression results. To understand multicollinearity, first consider an absurd example. Imagine that you are running multiple regression to predict blood pressure from age and weight. Now imagine that you've entered weight-in-pounds and weight-in-kilograms as two separate X variables. The two X variables measure exactly the same thing – the only difference is that the two variables have different units. The P value for the overall fit is likely to be low, telling you that blood pressure is linearly related to age and weight. Then you'd look at the individual P values. The P value for weight-in-pounds would be very high – after including the other variables in the equation, this one adds no new information. Since the equation has already taken into account the effect of weight-in-kilograms on blood pressure, adding the variable weight-in-pounds to the equation adds nothing. But the P value for weight-in-kilograms would also be high for the same reason. After you include weight-in-pounds to the model, the goodness-of-fit is not improved by including the variable weight-in-kilograms. When you see these results, you might mistakenly conclude that weight does not influence blood pressure at all since both weight variables have very high P values. The problem is that the P values only assess the incremental effect of each variable. In this example, neither variable has any incremental effect on the model. The two variables are collinear.

That example is a bit absurd, since the two variables are identical except for units. The blood pressure example -- model blood pressure as a function of age, weight and gender – is more typical. It is hard to separate the effects of age and weight, if the older subjects tend to weigh more than the younger subjects. It is hard to separate the effects of weight and gender if the men weigh more than the women. Since the X variables are intertwined, multicollinearity will make it difficult to interpret the multiple regression results.

Multicollinearity is an intrinsic problem of multiple regression, and it can frustrate your ability to make sense of the data. All InStat can do is warn you about the problem. It does this by asking how well each independent (X) variable can be predicted from the other X variables (ignoring the Y variable). There are three ways to express the result.

Term	Explanation
R^2 with other X variables.	The fraction of all variance in one X variable that can be predicted from the other X variables.
Variance Inflation Factor (VIF).	If the X variables contain no redundant information, you expect VIF to equal one. If the X variables are collinear (contain redundant information), then VIF will be greater than one. Multicollinearity increases the width of the confidence interval (which is proportional to the square root of variance) by a factor equal to the square root of VIF. If a variable has a VIF of 9, the confidence interval of that coefficient is three times wider than it would be were it not for multicollinearity.
Tolerance	The fraction of the total variance in one X variable that is not predicted by the other X variables.

The three terms measure exactly the same thing – the degree of multicollinearity. InStat reports both R^2 and VIF, so you can use the value you are more familiar with. For each X variable, the corresponding VIF is computed from R^2 by this formula: $VIF=1/(1-R^2)$. InStat does not report tolerance, but you can easily calculate it yourself for each variable as $1.0 - R^2$.

If R^2 and VIF are high for some X variables, then multicollinearity is a problem in your data. How high is high? Any threshold is somewhat arbitrary, but here is one rule of thumb. If any of the R^2 values are greater than 0.75 (so VIF is greater than 4.0), suspect that multicollinearity might be a problem. If any of the R^2 values are greater than 0.90 (so VIF is greater than 10) then conclude that multicollinearity is a serious problem.

Don't confuse these individual R^2 values for each X variable with the overall R^2. The individual R^2 values quantify how well each X variable can be predicted from the other X variables. The overall R^2 quantifies goodness-of-fit of the entire multiple regression model. Generally you want the overall R^2 value to be high (good fit) while all the individual R^2 values to be low (little multicollinearity).

If multicollinearity is a problem, the results of multiple regression are unlikely to be helpful. In some cases, removing one or more variables from the model will reduce multicollinearity to an acceptable level. In other cases, you may be able to reduce multicollinearity by collecting data over a wider range of experimental conditions. This is a difficult problem, and you will need to seek statistical guidance elsewhere.

Would a simpler model work as well?

More advanced multiple regression programs can perform variable selection procedures to determine which of the X variables should be kept in the model and which should be omitted. This is trickier than it sounds, and different programs do the job differently, and can wind up with different results. You need to use a great deal of care and experience to use variable selection procedures appropriately, and you may wish to consult with a statistician.

InStat does not do any automatic variable selection, but can help you do one form of variable selection, *backward elimination,* manually. Follow these steps:

1. Perform multiple regression with all potential X variables.
2. Look at the individual P values in the section labeled "Which variable(s) make a significant contribution". If all of the P values are below a threshold you set in advance (usually 0.05), then you are done. Keep all the X variables in the model.
3. If one or more X variables have a P value higher than the threshold, remove the one with the highest P value (it will also have the lowest t ratio). To do so, go back to the Select Test step and uncheck that variable. Then go back to the results to see the new fit without that variable.
4. Go back to step 2. Keep removing variables until all the P values are less than 0.05.

Graphing multiple regression results

InStat does not graph the results of multiple regression. To graph the best-fit results of a model with two X variables would require a three dimensional graph. The results of models with more than two variables cannot readily be graphed.

InStat does let you look at the relationship between any two variables in the model.

If you check the box "analyzed data only", InStat graphs only the data included in the analysis. This means that it graphs only variables included in the model, and only rows of data with no missing values (if any values are missing, all the values on that row are omitted). InStat can plot any X variable vs. the dependent variable (Y). Or InStat can graph any X variable vs. the residuals. Residuals are defined to be the distance between the independent (Y) value of each row and the Y value predicted by the model. If you've picked an appropriate model, the residuals ought to be random — you should observe no relationship between any of the independent (X) variables and the size or sign of the residual.

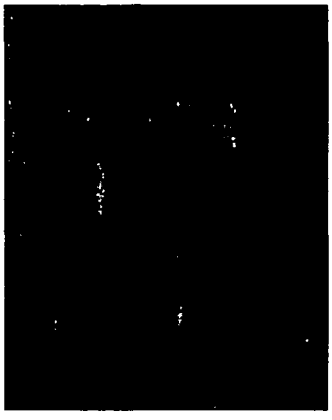
If you uncheck the box "analyzed data only", InStat graphs any column of data vs. any other column. This can be a useful way to examine relationships in your data before selecting variables for multiple regression.

Using InStat

Online Help

The InStat Guide

The InStat Guide window helps you learn InStat. It appears when you first run InStat, and comes back every time you move from step to step until you uncheck the option box "Keep showing the InStat Guide". Show the Guide again by dropping the Help menu and choosing InStat Guide.



Using the help system

The entire contents of this manual are available in the online help system. InStat uses the standard Windows and Mac help engine, so the commands should be familiar to you. Note particularly the button at the right of Help's tool bar labeled like this: >> Click that button to go to the next help screen. Click it repeatedly to step through every InStat help screen.

Importing and exporting data

Importing data tables from other programs

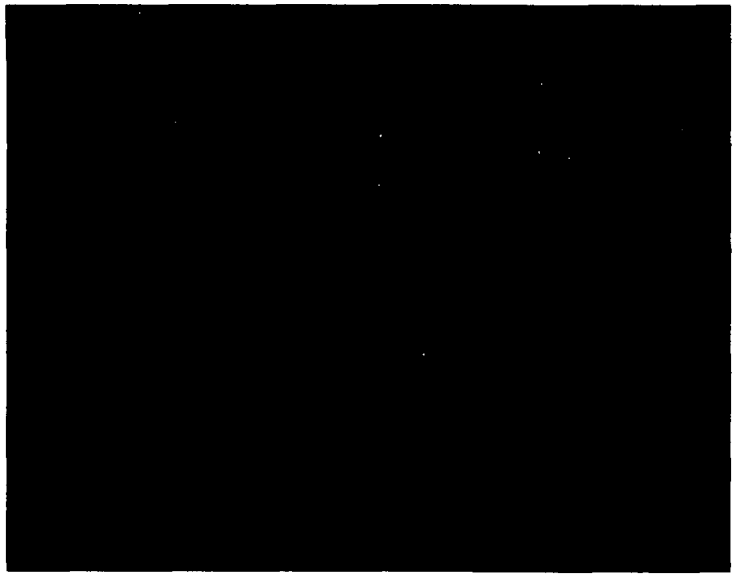
If you've already entered your data into another program, there is no need to retype. You may import the data into InStat via a text file, or copy and paste the values using the clipboard.

InStat imports text files with adjacent values separated by commas, spaces or tabs. Some programs refer to these files as ASCII files rather than text files. To save a text file from Excel (versions 4 or later) use the File Save As command and set the file type to Text or CSV (one uses tabs, the other commas to separate columns). With other programs, you'll need to find the

appropriate command to save a text file. If a file is not a text file, changing the extension to .TXT won't help.

To import data from text (ASCII) files:

- Go to the data table and position the insertion point. The cell that contains the insertion point will become the upper left corner of the imported data.
- Choose Import from the File menu.
- Choose a file.
- Choose import options.



If you have trouble importing data, inspect the file using the Windows Notepad to make sure it contains only numbers clearly arranged into a table. Also note that it is not possible to import data into a 2x2 contingency table.

Importing indexed data

Some statistics programs save data in an indexed format (sometimes called a stacked format). Each row is for a case, and each column is for a variable. Groups are not defined (as in InStat) by different columns, but rather by a grouping variable.

InStat can import indexed data. On the import dialog, specify one column that contains all the data and another column that contains the group identifier. The group identifiers must be integers (not text), but do not have to start at 1 and do not have to be sequential.

For example, in this sample indexed data file, you may want to import only the data in column 2 and use the values in column 3 to define the two groups.

Row #	Col. 1	Col. 2	Col. 3
1	12	123	5
2	14	142	9
3	13	152	5
4	12	116	9
5	11	125	9
6	15	134	5

In the Import dialog, specify that you want to import data only from column 2 and that column 3 contains the group identifier. InStat will automatically rearrange the data, so they look this like:

Row #	Group A	Group B
1	123	142
2	152	116
3	134	125

Filtering data

You don't have to import all rows of data from a file. InStat provides two ways to import only a range of data. You can specify a range of rows to import (i.e. import rows 1-21). Or you can filter data by applying criteria. For example, only import rows where column 3 equals 2, or where column 5 is greater than 100. InStat filters data by comparing the values in one column with a value you enter. It cannot compare values in two columns. For example, it is not possible to import rows where the data in column 3 is larger than the value in column 5.

Exporting data

Transfer data from InStat to other programs either by exporting the data to disk or copying to the clipboard. Other programs cannot read InStat data (ISD) files.

InStat exports data formatted as plain ASCII text with adjacent values separated by commas or tabs. These files have the extensions *.CSV or *.TXT.

To export data:

- Choose Export from the File menu.

- Choose the disk and directory, if necessary. Enter a file name. Press OK.
- Specify whether the exported file should contain column titles or the overall data set (sheet) title (entered on top of the data table).
- Choose whether you want to export in standard format (so the exported table is arranged the same as the data table) or indexed format (for importing into other statistics programs).

Here is an example of exported indexed data. The data look like this in InStat:

Row #	Group A	Group B	Group C
1	126	123	124
2	142	142	165
3	135	152	174

Here is what the file looks like when exported in index format:

Row #	Col. 1	Col. 2
1	126	1
2	142	1
3	135	1
4	123	2
5	142	2
6	152	2
7	124	3
8	165	3
9	174	3

Working with the data table

Editing values

To move the insertion point, point to a cell with the mouse and click, or press an arrow key on the keyboard. Tab moves to the right; shift-Tab

moves to the left. Press the Enter (Return) key to move down to the next row.

When you move the insertion point to a cell in the data table, you also select the number (if any) in that cell. To overwrite that number, just start typing. To edit that number, click once to go to the cell and then click again to place the insertion point inside the cell. Then you can edit individual digits within the number.

The InStat data table has 1000 rows and 26 columns.

Number format

Initially, InStat automatically chooses the number of decimal points to display in each column. To change the number of decimal points displayed, select the column or columns you wish to change. Then pull down the Data menu and choose Number Format and complete the dialog. It is not possible to change the numerical format of selected cells. InStat displays all data in each column with the same number of decimal places.

Altering the numerical format does **not** change the way InStat stores numbers, so will not affect the results of any analyses. Altering the numerical format **does** affect the way that InStat copies numbers to the clipboard. When you copy to the clipboard, InStat copies exactly what you see.

Missing values and excluded data

If a value is missing, simply leave its spot on the data table blank. InStat handles missing values appropriately. If you pick multiple regression, InStat will ignore an entire row of values if one or more is missing. InStat does not allow missing values with a paired t test, repeated measures ANOVA, or the analogous nonparametric tests.

If a value is too high or too low to be believable, you can exclude it. Excluded values are shown in blue italics on the data table, but are not included in analyses and are not shown on graphs. From the point of view of analyses and graphs, it is just as if you had deleted the value. But the number remains on the data table to document its value.

To exclude data:

- Select the cell or cells you wish to exclude.
- Pull down the Data menu and choose exclude. The excluded values appear in blue Italics.
- Repeat the process to include the value again.

Tip: If you want to run some analyses both with and without the excluded values, duplicate the window (Window Duplicate command). Then exclude values from one of the copies.

Row and column titles

Enter column titles on the data table right below the column identifiers (A, B, C...).

InStat labels each row with the row number, but you can create different row labels. When you enter paired or matched data, this lets you identify individual subjects.

To add your own row label:

1. Click to the left of the row number, in the small area labeled "...".
2. Enter or edit the row label. Initially the insertion point appears after the row number. Type additional characters if you want to label the row with both row number and label. Press backspace to delete the row number.
3. After entering or editing one row number, press the down arrow key or Enter to move down to the row label for the next row.

Using the clipboard

InStat uses the clipboard in a standard way to copy data from one location and to paste it somewhere else. Before copying, you must select a region on the data table.

To Select	Mouse	Keyboard
A range of data.	Point to one corner of the block. Hold down the left mouse button and drag to the opposite corner.	Move to one corner of the block. Hold down the Shift key and move to the opposite corner (using arrow keys).
One or more columns.	Click on one of the column headers ("A", "B", etc.). Drag over the desired range of columns.	Hold Ctrl, and press the spacebar (Windows only).
One or more rows.	Click on one of the row headers ("1", "2", etc.). Drag over the desired range of rows.	Hold Shift, and press the spacebar (Windows only).
All data on the table.	Click on the rectangle to the left of column A and above row 1.	Ctrl-A (Windows only)

Cut or copy the selection, then paste, using the toolbar buttons, commands on the Edit menu, commands on the shortcut menu (click the right mouse button) or keyboard shortcuts (using Windows hold Ctrl and using Mac hold Command, and then press X for cut, C for copy, V for paste).

Note: InStat copies exactly what you see. Changing the number (decimal) format will alter what is copied to the clipboard.

When you paste data, InStat maintains the arrangement of rows and columns. You can also transpose rows and columns by selecting Transpose

Paste from the Edit menu. InStat will paste what was the first row into the first column, what was the second row into the second column and so on.

Deleting data

Pressing the DEL key is not the same as selecting Delete from the Edit menu.

After selecting a range of data, press the DEL key to delete the selected range. InStat does not place deleted data on the clipboard and does not move other numbers on the table to fill the gaps.

Select Delete Cells from the Edit menu to delete a block of data completely, moving other data on the table to fill the gap. If you have selected one or more entire rows or columns, InStat will delete them. Remaining numbers move up or to the left to fill the gap. If you have selected a range of values, InStat presents three choices: Delete entire rows, delete entire columns, or delete just the selected range (moving other numbers up to fill the gap).

To delete an entire data table, pull down the Edit menu and choose Clear All.

Transforming data

To transform data:

1. Select a block of data you wish to transform. Or to transform a single value, place the insertion point in that cell.
2. Pull down the Data menu and choose Transform.
3. Select a transformation from this list:

Function	Comments
Y=Y squared	
Y=Log(Y)	Logarithm base 10
Y=Ln(Y)	Natural logarithm
Y=10^Y	Antilog of log base10
Y=exp(Y)	e^Y (antilog of natural log)
Y=1/Y	
Y=Sqrt(Y)	Square root of Y
Y=Logit(Y)	ln[Y/(K-Y)]
Y=sin(Y)	Y is in radians
Y=cos(Y)	Y is in radians
Y=tan(Y)	Y is in radians
Y=arcsin(Y)	Result is in radians
Y=abs(Y)	Absolute value
Y=K*Y	
Y=Y+K	
Y=Y-K	
Y=Y/K	

4. Enter K if necessary.

Note: InStat transforms in place, so erases the original data. There is no undo command, so the only way to bring back the original data is to perform the inverse transformation.

Combining variables

Add, subtract, multiply or divide two columns to create a new column:

- Place the cursor in an empty column.
- Pull down the Data menu and choose Combine variables.
- Choose two columns and how you want to combine them.

Arranging data

Details on how to arrange various kinds of data appear elsewhere:

- "Entering t test data into InStat" on page 38.
- "Entering ANOVA data" on page 58.
- "Entering data for correlation and linear regression" on page 88.
- "Entering standard curve data into InStat" on page 95.
- "Creating contingency tables" on page 78.
- "Entering data for multiple regression and correlation" on page 99.

Selecting columns to analyze

With InStat, you select columns to analyze on a dialog. Selecting columns on the spreadsheet – as you would to copy to the clipboard – has no effect on the analyses.

Type of test	How to select columns
Compare means or medians	By default, InStat will analyze all the columns you entered. To analyze a subset of columns, click the "select other columns" button on top of the screen where you choose a test. InStat displays a dialog listing all the columns. Check the ones you wish to analyze.
X and replicate Y values for linear regression and correlation	InStat will analyze all the columns. There is no way to select columns.
Large contingency table	InStat will analyze all the data. There is no way to select columns.
Y and 2 or more X variables for multiple regression	To pick columns, see "Analysis choices for multiple regression and correlation" on page 100.

After you view the results

After you read the results, you may want to do the following:

Print or export the results

Print or export the results (as a text file) using commands on the File menu. Or select a portion of the results, and copy to the Windows clipboard as text.

View a graph

InStat displays a notebook quality graph of your data to help you see differences and spot typographical errors on data entry. You cannot customize the graph to create a publication quality graph. Print the graph or export it as a Windows Metafile (wmf) using commands on the File menu. Or copy to the clipboard, and paste into another program.

Record notes or append the results to the notes window

Click the Notes button, or pull down the Edit menu and choose View Notes, to pop up a notes editor. Use the notes page to record where the raw data are stored, why you excluded values, what you concluded, or why you chose certain tests. InStat saves the notes as part of the ISD file, so you can refer back to them after opening a file.

To append portions of the results to the notes window, first select a portion of the results. Then pull down the Edit menu and select Append to notes. If you don't select a portion of the results first, InStat appends all the results.

To print notes, click the alternate (right) mouse button and choose Print.

Analyze the same data with a different test

Each InStat file contains a single data table and the results of a single statistical test. If you want to analyze data in several ways (say to compare a parametric test with a nonparametric test), you have two choices.

The easiest approach is to simply replace one set of results with another. After completing the first analysis, consider appending the results to the Notes window. Then go back to the Choose test step and make different choices. Then click Results to see the answer. The new results will replace the previous results.

To view both sets of results at once, follow these steps.

1. Enter data and do your first analysis.
2. Pull down the Windows menu and choose Duplicate. You now have two identical open documents in separate windows.
3. Change the analysis choices in one of the windows and go to results.
4. The two analyses now exist in separate windows. Switch between them using the Windows menu. Save and print the two windows separately. Each Window will be saved as a separate file.

Perform the same analysis on new data

To perform the same analyses on a new set of data, go back to the data table and replace the data. Then go straight to results. You don't have to select a test, as InStat will remember your choices. The new results will replace the previous results, which you can no longer view.

To view both sets of results at once, follow these steps.

1. Enter data and do your first analysis.
2. Pull down the Windows menu and choose Duplicate. You now have two identical open documents in separate windows.
3. Change the data in one of the windows and go to results.
4. The two analyses now exist in separate windows. Switch between them using the Windows menu. Save and print the two windows separately.

Start InStat again

Pull down the File menu and choose New to start InStat again. You'll be able to start fresh (erase the current data set) or start a new window while keeping the current one.

Create an analysis template

An InStat file contains not only a data table, but also your analysis choices. This lets InStat recalculate the results when it opens a file. If you perform the same analysis often, create an analysis template. To do so, simply save a

file after deleting the data. The file will contain only analysis choices. To use the template, open the file, enter data and go straight to results. You can skip the Choose Test screen, as InStat reads the choices from the file. The Windows and Macintosh versions of InStat use identical file formats, so you can move files between platforms with no special conversion.

InStat files

Save an InStat file using the File Save command, then open it using File Open. The toolbar has shortcut buttons for both commands.

InStat files store your data table along with analysis choices and notes. InStat files are denoted by the extension .ISD (InStat Data). Note that each file contains only one data table.

If you want to share data with other programs, use the File Import and Export commands. See "Importing and exporting data" on page 109. Other programs will not be able to open InStat ISD files.

GraphPad Software

Technical support

Do you have the current version?

Like all software companies, GraphPad occasionally issues minor updates to Prism. If you are having trouble with InStat, check that you are running the current release.

The full version number is not on the manual cover or the CD label. You have to run the program and find out which version it is. Drop the Help menu (Windows), Apple menu (Mac OS8-9) or Prism menu (Mac OS X) and choose About InStat. Windows versions have two digits after the decimal point (i.e. 3.05). Mac versions have a single digit after the decimal followed by a letter (i.e. 3.0a).

Go to the Support page at www.graphpad.com to find out what version is most current. Download and install the updater if your version is not the most current. Updates (interim versions of GraphPad software containing bug fixes or minor improvements) are free to owners of the corresponding major releases. In contrast, upgrades (a new version with many new features) must be purchased.

Is the answer to your question on www.graphpad.com?

If you need help using InStat and can't find the answers in this manual, please visit our web site at www.graphpad.com. Your solution is very likely in the searchable Quick Answers Database in the Support section.

You can browse the list of most frequently asked questions, browse questions by topic or search for particular words. We update the Quick Answers database almost every week, and the answer to your question is very likely to be there.

If you have questions about data analysis, also browse the library of statistical articles and links on www.graphpad.com

Personal technical support

If you need personal help, contact us via email at support@graphpad.com or use the form on the support page. Be sure to mention the version of InStat you are running and if you are using InStat for Windows or for Mac.

If you really think that your issue is better solved by a phone call, please email your phone number. We give much higher priority to emailed questions, and you may not get a return call the same day. You will get faster personal support by email than by phoning.

While we reserve the right to charge for support in the future, we promise that you'll receive free support for at least one year.

We can't predict how computer hardware and system software will change in the future, so cannot promise that Prism 3, will work well with future versions of Windows or the Mac OS.

Note that your InStat license does not include free statistical consulting. Since the boundary between technical support and statistical consulting is often unclear, we will usually try to answer simple questions about data analysis.

GraphPad Prism

GraphPad Prism (for Windows and Macintosh) combines scientific graphics, curve fitting (nonlinear regression) and basic statistics.

Instant scientific graphs. Click one button to instantly graph your data. Prism even chooses an appropriate type of graph and creates error bars and legends automatically. Easily change symbols and annotate your graph (including Greek, math and international characters). Once you've created several graphs, arrange them using Prism's unique page layout tools. You can even include data and analysis results on the same page.

Instant curve fitting. Nonlinear regression couldn't be simpler. Just select the equation you want from the list (or enter your own equation) and Prism does the rest automatically - fits the curve, displays the results as a table, and draws the curves on the graph. Even better, Prism will automatically fit all related data sets at once. You don't have to repeat commands for each experimental condition. Prism also gives you many advanced fitting options - automatically interpolate unknown values from a standard curve, compare two equations with an F test, and plot residuals. To review the principles of nonlinear regression, go to www.graphpad.com and read the GraphPad Guide to Nonlinear Regression and the companion GraphPad Guide to Analyzing Radioligand Binding Data.

Clear statistical help. Prism performs the same tests as InStat (except for multiple regression), as well as two-way ANOVA and survival analysis. Like InStat, Prism explains the choices and results in plain language.

Intelligent automation. When you fix a data entry mistake, Prism automatically reanalyzes your data and updates your graph. You don't have to do anything. Because Prism links data to results and graphs, you can analyze data from a repeated experiment in a single step. Just plug in the new data and Prism handles all the graphing and analysis steps automatically - without programming or scripting! Every file you save can be a template for a repeated experiment.

Everything is automatically organized. Prism lets you store multiple data tables in one file, linked to analysis results, graphs, and layouts. Even your most complicated projects stay organized and easy to manage. Unlike other scientific graphics programs, Prism stores analysis results with your

data and remembers your analysis choices. When you open a Prism file, you can retrace every step of every analysis.

Try Prism with your own data. The demo version of Prism has some limitations in printing, exporting and saving - but no limitations in graphing or data analysis. Download it from www.graphpad.com.

Intuitive Biostatistics (book)

If you like the style of this manual, you'll probably also like *Intuitive Biostatistics*, by Harvey Motulsky, president of GraphPad Software and author of this manual. Here is the publisher's description:

"*Intuitive Biostatistics* provides a nonmathematical introduction to biostatistics for medical and health sciences students, graduate students in biological sciences, physicians and researchers. Using nontechnical language, this text focuses on explaining the proper scientific interpretation of statistical tests rather than on the mathematical logic of the tests themselves. *Intuitive Biostatistics* covers all the topics typically found in an introductory statistics text, but with the emphasis on confidence intervals rather than P values, making it easier for students to understand both. Additionally, it introduces a broad range of topics left out of most other introductory texts but used frequently in biomedical publications, including survival curves, multiple comparisons, sensitivity and specificity of lab tests, Bayesian thinking, lod scores, and logistic, proportional hazards and nonlinear regression. By emphasizing interpretation rather than calculation, *Intuitive Biostatistics* provides a clear and virtually painless introduction to statistical principles, enabling readers to understand statistical results published in biological and medical journals."

You can see the table of contents and read five complete chapters at www.graphpad.com. You may order the book from GraphPad Software with software purchases only. To order from a bookstore or the publisher (Oxford University Press), cite this number: ISBN 0-19-508607-4. Intuitive Biostatistics is also available from the online bookstore www.amazon.com.

Index

—G—

—H—

—I—

—K—

—L—

—M—

—N—

—O—

—V—

—W—

—Y—

ATTACHMENT E

Identifying Metals Contamination in Soil: A Geochemical Approach;
by Myers & Thorbjornsen

Soil & Sediment Contamination, 13:1–16, 2004

ISSN: 1058-8337 print
DOI: 10.1080/10588330490269732

Identifying Metals Contamination in Soil: A Geochemical Approach

JONATHAN MYERS

Shaw Environmental, Inc.
Albuquerque, New Mexico, USA

KAREN THORBJORNSEN*

Shaw Environmental, Inc.
Knoxville, Tennessee, USA

The geochemical evaluation methodology described in this paper is used to distinguish contaminated samples from those that contain only naturally occurring levels of inorganic constituents. Site-to-background comparisons of trace elements in soil based solely on statistical techniques are prone to high false positive indications. Trace element distributions in soil tend to span a wide range of concentrations and are highly right-skewed, approximating lognormal distributions, and background data sets are typically too small to capture this range. Geochemical correlations of trace versus major elements are predicated on the natural elemental associations in soil. Linear trends with positive slopes are expected for scatter plots of specific trace versus major elements in uncontaminated samples. Individual samples that may contain a component of contamination are identified by their positions off the trend formed by uncontaminated samples. In addition to pinpointing which samples may be contaminated, this technique provides mechanistic explanations for naturally elevated element concentrations, information that a purely statistical approach cannot provide. These geochemical evaluations have been successfully performed at numerous facilities across the United States. Removing naturally occurring constituents from consideration early in a site investigation reduces or eliminates unnecessary investigation and risk assessment, and focuses remediation efforts.

Keywords Background, metals, soil, geochemical correlations, naturally occurring.

Introduction

Site-to-background comparisons often consist solely of one or more statistical tests, without regard to the geochemistry of the environmental medium under analysis. Perhaps the most common statistical test is the background threshold comparison, which involves comparing the maximum detected concentration (MDC) of the site data to a background threshold value such as the 95th upper tolerance limit (UTL), twice the background mean, background mean plus three standard deviations, etc. Contamination is suspected if the site MDC exceeds this background value. It is well known that comparing a site concentration, such as the MDC,

*Corresponding author. Mailing address: Shaw Environmental, Inc., 312 Directors Drive, Knoxville, TN 37923. E-mail: karen.thorbjornsen@shawgrp.com

to a single background threshold value is an inadequate predictor of contamination. One reason is that, regardless of which background threshold value is used, the likelihood of an uncontaminated site sample exceeding the background threshold increases as the number of site samples increases. Another commonly applied test in site-to-background comparisons is the nonparametric Wilcoxon rank sum (WRS) test. Contamination is suspected if the test indicates that the site median is shifted higher than the background median. This test is also prone to a high false positive error rate for a number of reasons, and the test loses power to detect a difference between the two data sets as the number of site samples decreases relative to background.

Figure 1 provides an example of these statistical comparisons to background. Box-and-whisker plots of vanadium concentrations are provided for site and background soil at an Alabama Department of Defense (DoD) facility. The 20 site samples lie within the range of the 122 background samples, but the site median is higher than the background median (the median is represented by the small box within each box plot). The site MDC exceeds the background screening value (95th UTL) of 90.5 mg/kg, and the WRS test indicates a significant difference between the site and background medians at the 95 percent confidence level (p-level = 0.034). The standard CERCLA investigation approach for test results such as these would be to classify the site sample(s) as contaminated, and perhaps to evaluate the site data further in a risk assessment. If the site data happen not to exceed an action level or risk-based screening level, then additional assessment or remediation would not be necessary. If, however, the site data do exceed an action level or risk-based screening level, further assessment and possibly remedial action would be required. These activities would take place in spite of the fact that definitive evidence of site-related contamination had not been produced.

Site-to-background comparisons of trace metals in soil and sediment based solely on statistical techniques are prone to high false positive error rates for a number of reasons.

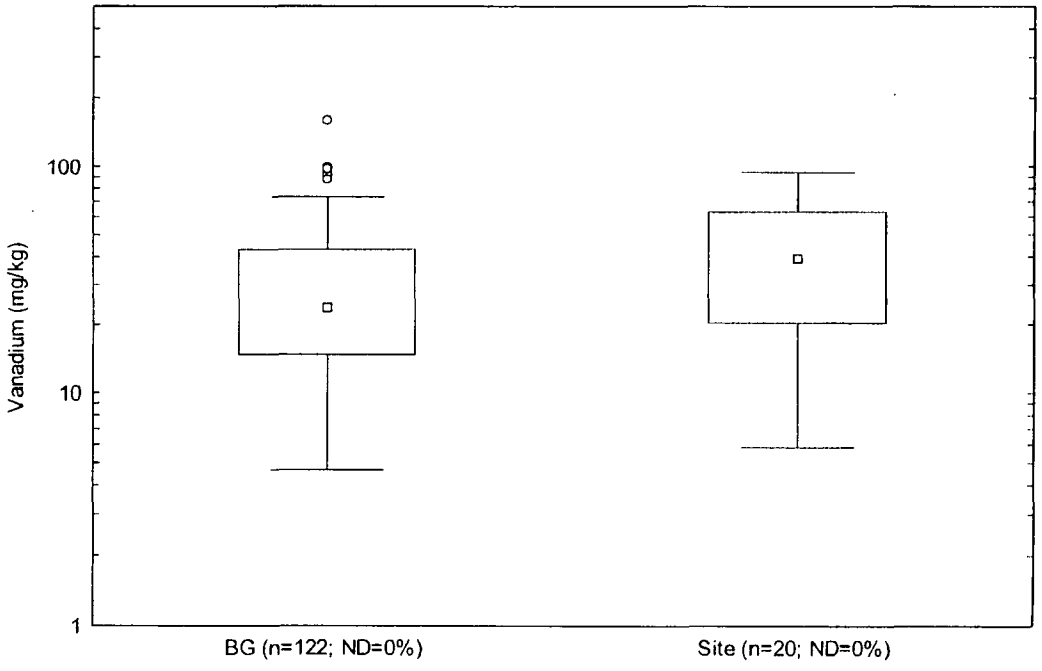


Figure 1. Box plot comparison for vanadium in soil, Alabama (Wilcoxon rank sum test p-level = 0.034).

Trace element distributions in soil tend to have very large ranges (two or three orders of magnitude are not uncommon), and are highly right-skewed, resembling lognormal distributions. Accurate characterization of the upper tails of broadly skewed distributions requires a large number of background samples, which are usually not available. The situation is compounded if the site data set is larger than the background data set, which further increases the probability of apparent background exceedances.

These statistical tests treat each analyte as an independently behaving entity, and do not consider the geochemical context in which each element resides. However, mineralogy and soil chemistry dictate that naturally occurring elements in soil and sediment exist in predictable proportion to other elements. Trace element concentrations are expected to covary with major element concentrations, and these relationships can be visualized with correlation plots. Such correlations have long been used for geochemical prospecting in the mining industry (Levinson, 1974). More recently, sediment studies have made effective use of these relationships to distinguish between naturally occurring and anthropogenic concentrations.

Aluminum is typically used in sediment studies as a normalizer of trace element concentrations because it is naturally abundant, anthropogenic contribution is uncommon, and it is a primary component of clay minerals, which concentrate many trace elements (Windom *et al.*, 1989; Hanson *et al.*, 1993; Daskalakis and O'Connor, 1995; Bahena-Manjarrez *et al.*, 2002). Iron is also an important reference element because of the relative abundance of iron oxide minerals, with which many trace elements associate, and thus it has also been used as a normalizer in sediment studies (Daskalakis and O'Connor, 1995; Schiff and Weisberg, 1997). Trace elements have also been correlated with total organic carbon (TOC); however, associations with TOC are often much less significant than those with reference elements and TOC is often increased through anthropogenic inputs (Windom *et al.*, 1989; Daskalakis and O'Connor, 1995).

The importance of geochemical evaluations in distinguishing between site and background data sets has been recognized in the environmental industry (USEPA, 1995; Barclift *et al.*, 2000; U.S. Navy, 2002). When properly evaluated, geochemistry can provide mechanistic explanations for apparently high, yet naturally occurring, constituents. Anomalous samples that may represent contamination can also be readily distinguished from uncontaminated samples. This paper discusses the geochemical evaluation methodology that has been successfully applied in many site-to-background comparisons at facilities across the United States. Several examples from these investigations are provided to illustrate the evaluation technique and demonstrate its utility in a variety of geological regimes and sites.

Methodology

The geochemical evaluation is based on the natural associations of trace elements with specific minerals in the soil matrix. As an example, arsenic in most uncontaminated oxic soils is almost exclusively associated with iron oxide minerals (Bowell, 1994; Schiff and Weisberg, 1997). (The term "iron oxide" is used here to include oxides, hydroxides, oxyhydroxides, and hydrous oxides of iron.) This association of arsenic with iron oxides is a result of the adsorptive behavior of this particular trace metal in an oxic soil environment. Arsenic is present in oxic soil pore fluid as negatively charged oxyanions ($HAsO_4^{-2}$, $H_2AsO_4^-$) (Brookins, 1988). These anions have strong affinities to adsorb on the surfaces of iron oxides, which maintain a strong positive surface charge (EPRI, 1986). If a soil sample has a high percentage of iron oxides, then it is expected to have a proportionally higher concentration of arsenic.

The absolute concentrations of arsenic and iron can vary by several orders of magnitude at a site, but the arsenic/iron ratios in each sample are usually quite constant at a given site as long as no contamination is present (Daskalakis and O'Connor, 1995). If a sample has some naturally occurring arsenic plus additional arsenic from an herbicide or some other source, then it will have an anomalously high ratio relative to the other uncontaminated samples. These ratios thus serve as a powerful technique for identifying contaminated samples.

The evaluation includes the generation of plots in which arsenic concentrations in a set of samples are plotted on the y-axis, and the corresponding iron concentrations are plotted on the x-axis. The slope of a best-fit line through the samples is equal to the average arsenic-to-iron background ratio. If the samples with the highest arsenic concentrations plot on the same linear trend as the other samples, then it is most probable that the elevated concentrations are natural, and are caused by the preferential enrichment of iron oxides in those samples. If the site samples with elevated arsenic concentrations plot above the trend displayed by the uncontaminated samples, then there is evidence that those samples have an excess contribution of arsenic, and contamination may be indicated.

For the example data set discussed in the Introduction, statistical comparisons to background indicated that one or more of the site samples may be contaminated with vanadium. However, a clearer picture emerges when the vanadium concentrations are plotted against their corresponding iron concentrations (Figure 2). Vanadium exists in soil pore water as negatively charged aqueous species such as HVO_4^{-2} and $H_2VO_4^-$ (Brookins, 1988). Iron oxides maintain a positive surface charge, and have a strong affinity for adsorbing the negatively charged vanadium species. The background and site vanadium concentrations in the example data set are highly correlated with iron ($R^2 = 0.60$ and $R^2 = 0.99$, respectively), and the site samples all lie on the trend formed by the background samples. This indicates that vanadium in the site and background samples is associated with iron oxides at a relatively constant ratio. The samples with the highest vanadium concentrations also contain the highest iron concentrations, indicating that those samples are preferentially enriched in iron oxides. If contamination was present in one or more site samples, they would contain

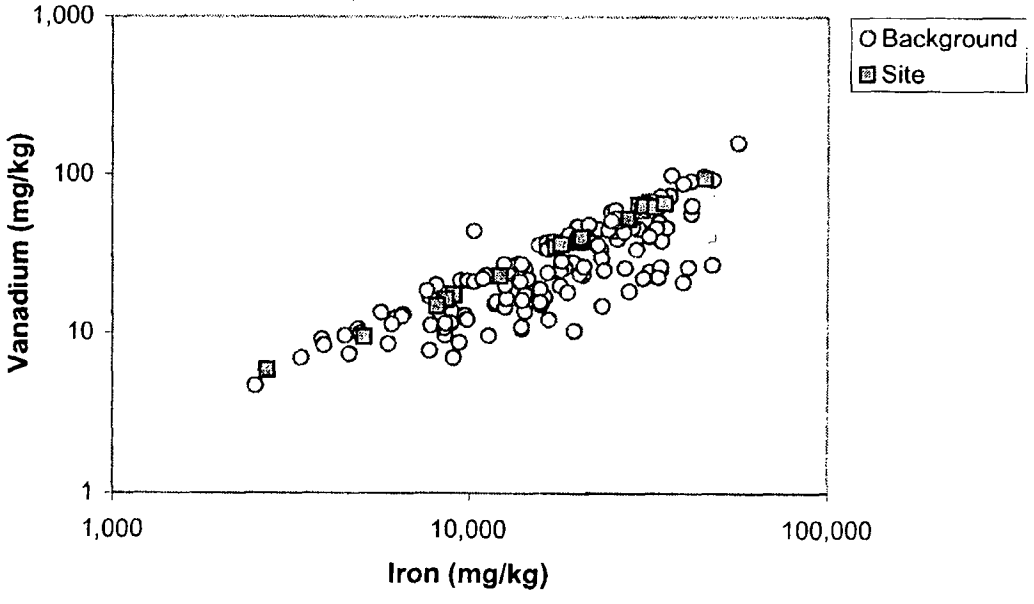


Figure 2. Vanadium versus iron in soil, Alabama.

an excess amount of vanadium relative to iron and hence a different vanadium/iron ratio, and would lie off the trend formed by the background samples. No such samples are present, and contamination is not indicated in this site data set.

Each trace element is associated with one or more minerals in the soil or sediment matrix. Arsenic, selenium, and vanadium form anionic species in solution, and are associated with iron oxides (EPRI, 1984; Brookins, 1988). Divalent metals such as barium, cadmium, lead, and zinc tend to form cationic species in solution and are attracted to clay mineral surfaces, which tend to maintain a negative charge (EPRI, 1984; Brookins, 1988). These trace elements can be evaluated against aluminum, which is a major component of clay minerals. Manganese oxides also have an affinity to adsorb certain trace elements, particularly divalent cations such as barium, cadmium, cobalt, and lead (EPRI, 1984). These trace elements can be evaluated against manganese.

Clays and iron oxides tend to exist as very fine particles, so both aluminum and iron are enriched in samples with finer grain sizes. Soils characterized by a high percentage of fine-grained material will exhibit higher concentrations of aluminum and iron, and also proportionally higher concentrations of associated trace elements.

Nondetect samples are not included in the geochemical correlation plots, as their replacement values (such as one-half of the reporting limit) are assumed quantities that have no meaning in the geochemical context. Censored data serve only to obscure the relationships that the correlation plots attempt to depict. Soil boring logs, geologic maps, and other available field observations should be examined to determine the soil lithology, which can indicate the probable mineralogical controls on natural trace element distributions and thus which reference elements should be used in the correlation plots.

Examples of the Methodology

This section provides examples of the methodology applied at various facilities around the United States and Puerto Rico. All of the soil samples in these examples had been submitted to off-site laboratories for metals analysis using standard Environmental Protection Agency SW-846 methods. In each case, the resultant site and background data had been compared using a background threshold comparison, the WRS test, and box-and-whisker plots. Each of the elements evaluated below had failed one or both of the statistical tests.

It is worth noting that the elemental correlations in the following examples are generally higher for the site samples than for background. This is expected, as in most cases the background data were obtained during installation-wide background studies encompassing hundreds or thousands of acres and several different soil types. Higher correlation is expected for the site samples, which represent substantially smaller land areas and similar soil types.

Nickel in Soil, Florida

Site-to-background comparisons of elements in soil were performed for a remedial investigation at a landfill site within a former military facility in Florida. Surficial geology at this facility consists of Late Miocene to Recent age, undifferentiated deposits including clean quartz sand, clayey sands, sandy clay, and shell material. All of the site and background soil samples were collected within these deposits. The background data set includes 20 soil samples collected from 0 to 1 foot below ground surface (bgs) and 24 soil samples collected from 1 to 3 feet bgs; the site data set contained 30 soil samples collected at varying depths, from 0 to 3 feet bgs. The following evaluation is an example of the site-to-background comparisons performed for soil at the landfill. Results of these comparisons were used to refine lists of chemicals of concern during the remedial investigation.

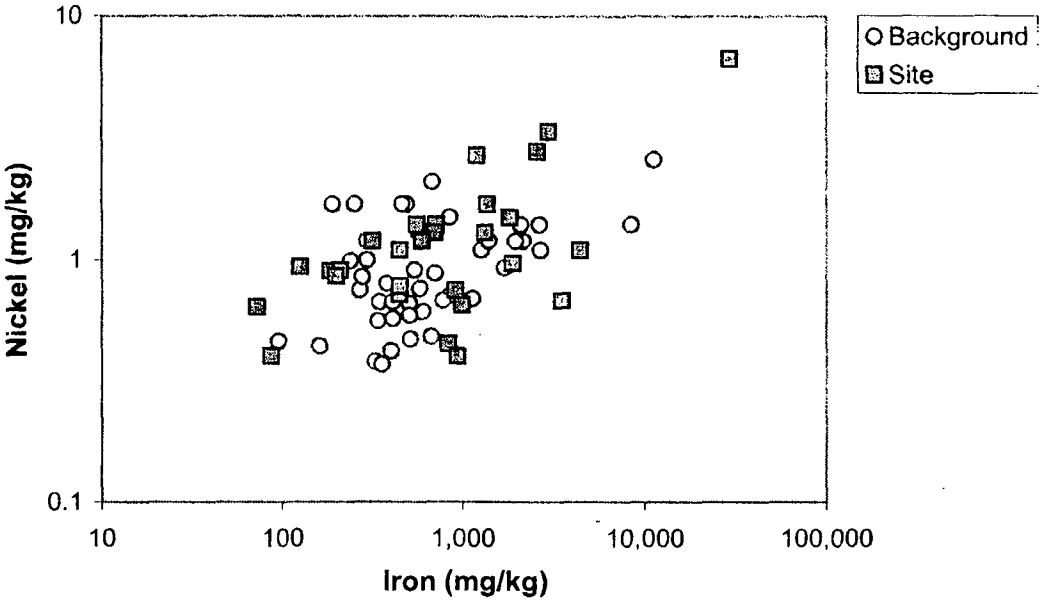


Figure 3. Nickel versus iron in soil, Florida.

Four site samples contained nickel at concentrations above the background screening value. Samples that contain a high proportion of iron oxides are expected to contain high concentrations of iron and associated trace elements. A plot of nickel concentrations versus iron concentrations reveals a linear trend, and the samples with high nickel concentrations also contain high iron (Figure 3). Nickel in the site samples is probably naturally occurring. Because no nickel contamination was suspected in the site soil samples, nickel was not carried through the risk assessment as a chemical of potential concern.

Chromium in Soil, Puerto Rico

A remedial investigation was performed at a disposal area in a former military facility in Puerto Rico. This facility is underlain by Miocene- to Holocene-age surficial deposits of up to 100 feet in thickness. These deposits include beach sand, lagoon and swamp mud, and recent alluvium. Parts of the facility are built on artificial fill composed of dredge spoils derived from nearby water bodies. The surficial deposits and fill areas are underlain by massive- to thick-bedded, fossiliferous limestone of Miocene age. The background data set includes 23 soil samples collected from 0 to 0.5 foot bgs and 23 soil samples collected from 0.5 to 3 feet bgs. The site data set contains 149 soil samples collected at varying depths from 0 to 12.5 feet bgs. The following evaluation is an example of the site-to-background comparisons performed for soil at the disposal area. Results of these evaluations were used to refine lists of chemicals of concern during the remedial investigation.

Chromium in the site data set exceeded the background screening value and failed the WRS test. A plot of chromium versus iron for the site and background samples reveals a strong correlation for most of the samples, with a correlation coefficient of 0.62 for the background samples (Figure 4). Most of the samples with high chromium concentrations also have high iron concentrations, indicating that chromium in those samples is associated with iron oxides at a relatively constant ratio. There are eleven samples that plot off the background trend and contain higher chromium concentrations than expected for

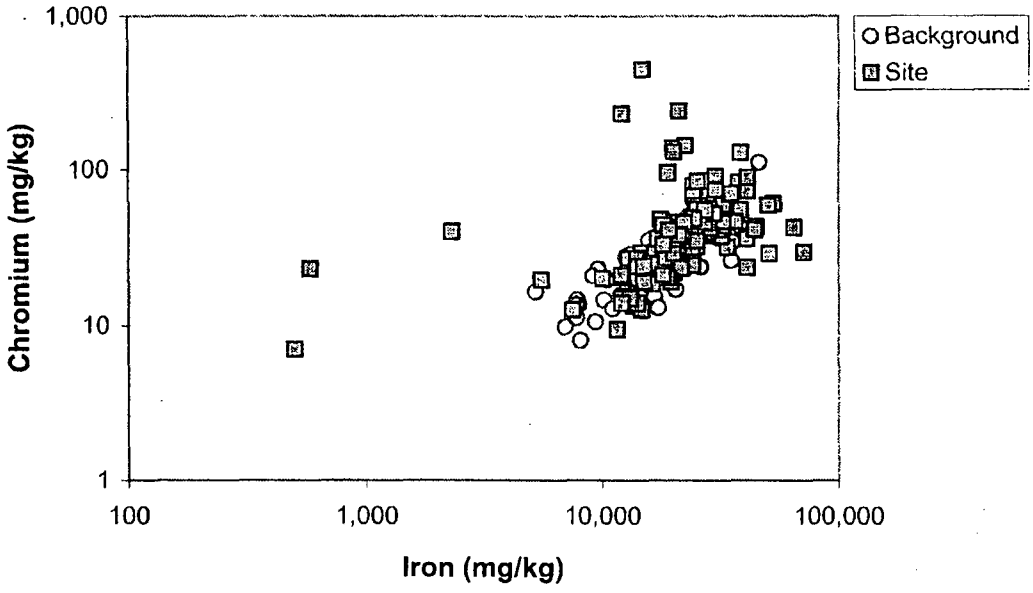


Figure 4. Chromium versus iron in soil, Puerto Rico.

uncontaminated samples. Accordingly, chromium contamination was suspected in these eleven samples and chromium was carried through the risk assessment as a chemical of potential concern.

Chromium, Lead, and Zinc in Soil, Alabama

Remedial investigations have been performed for several sites at a DoD facility in Alabama, and have incorporated site-to-background comparisons to explain elevated element concentrations. The facility lies within the Appalachian fold and thrust belt, and is characterized by a variety of soils developed from the weathering of sandstone, shale, limestone, and dolomite units. The background data set includes 122 soil samples, which were collected at varying depths from 0 to 10 feet bgs and represent all of the soil types present at the facility. The site data sets for the following three examples varied in size from 6 to 30 soil samples and were obtained from depths similar to background. The results of these evaluations were used to refine lists of chemicals of concern during risk assessment.

Chromium in one of the soil samples at a forestry compound site exceeded the background screening value, indicating potential contamination. A plot of chromium versus iron reveals that the site data are highly correlated and uniformly distributed on the background trend (Figure 5). The site sample with the highest chromium concentration also has the highest iron concentration of the site samples, and lies on the background trend. These observations indicate that chromium in the site samples is associated with iron oxides at a relatively constant ratio, and is naturally occurring.

Lead was an expected contaminant in soil at a former skeet range. Lead in the site samples exceeded the background screening value and failed the WRS test. A plot of lead versus manganese reveals a linear trend for most of the samples, indicating that lead in these samples is associated with manganese oxides at a relatively constant ratio (Figure 6). Five anomalous samples contain high lead concentrations but only moderate manganese, and plot off the trend formed by the other samples. The lead concentrations in these samples were identified as contaminated.

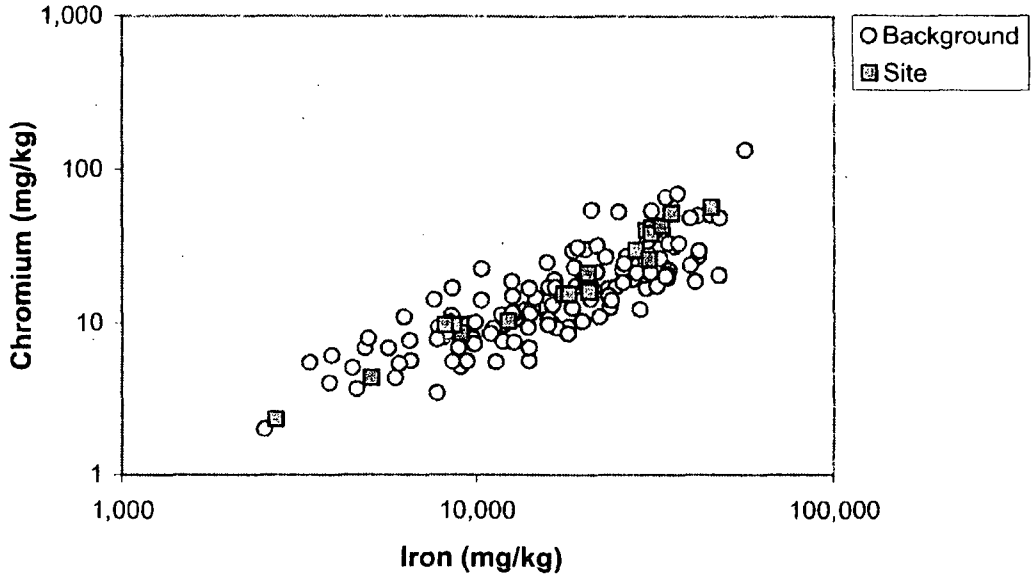


Figure 5. Chromium versus iron in soil, Alabama.

Zinc concentrations in soil samples from a small weapons repair shop site exceeded the background screening value, and contamination was suspected. A plot of zinc versus aluminum concentrations in the background soil samples exhibits a generally linear trend (Figure 7). All of the site samples plot on the trend formed by the background samples. Zinc in the site samples is most likely naturally occurring, and it was not evaluated further in the risk assessment associated with the investigation.

Barium, Cobalt, Lead, and Silver in Soil, Connecticut

Site-to-background comparisons of elements in soil were performed for an investigation at a former nuclear reactor operator training facility in Connecticut. Soils at the site were formed

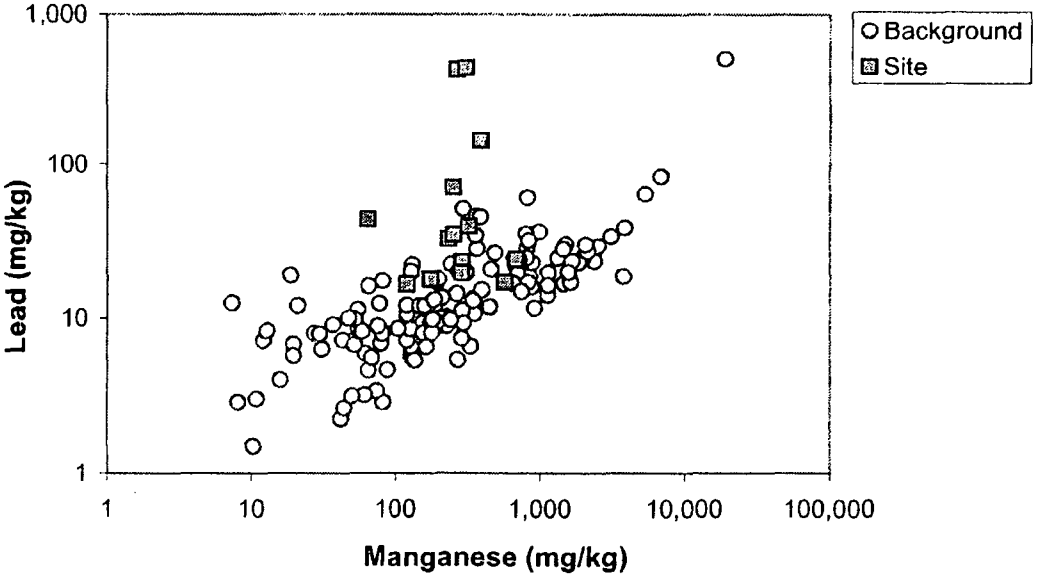


Figure 6. Lead versus manganese in soil, Alabama.

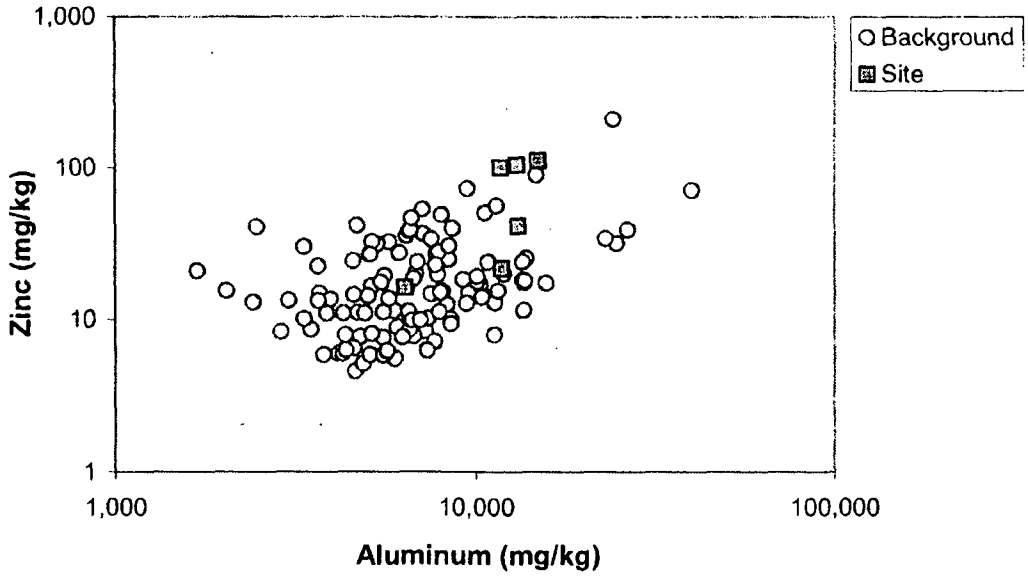


Figure 7. Zinc versus aluminum in soil, Alabama.

from Pleistocene glacial deposits consisting of sands with minor silts and gravels. The comparisons were based on a set of 334 site samples and 72 background samples. Element concentrations in some samples clearly showed a pattern of contamination, whereas others did not.

Barium concentrations in thirteen site samples exceeded the background screening value. A plot of barium versus aluminum is provided in Figure 8. The majority of samples form a linear trend, which represents the average background barium/aluminum ratio. The six samples that plot above the linear background trend contain elevated barium concentrations but only moderate aluminum content. These samples were collected from

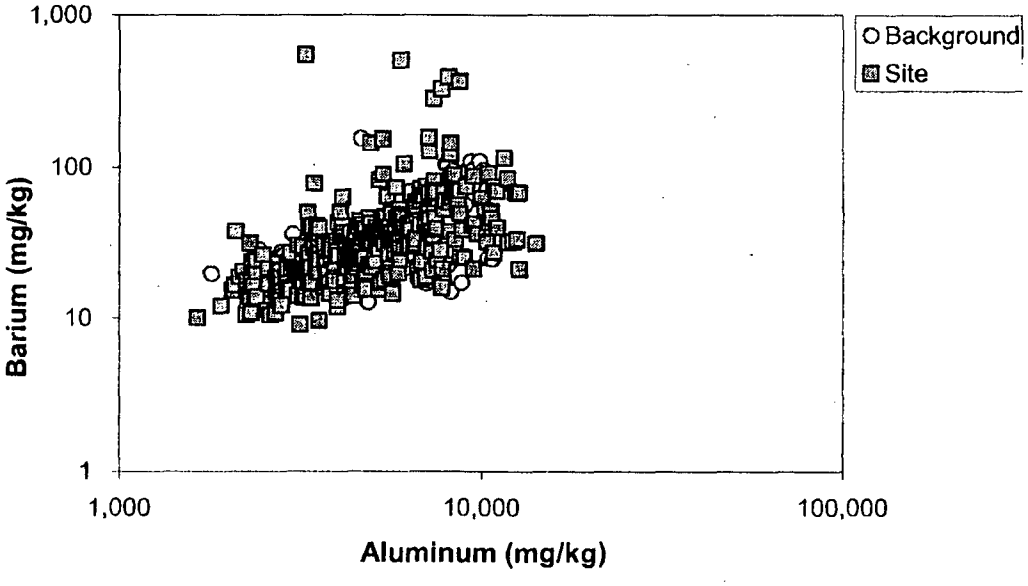


Figure 8. Barium versus aluminum in soil, Connecticut.

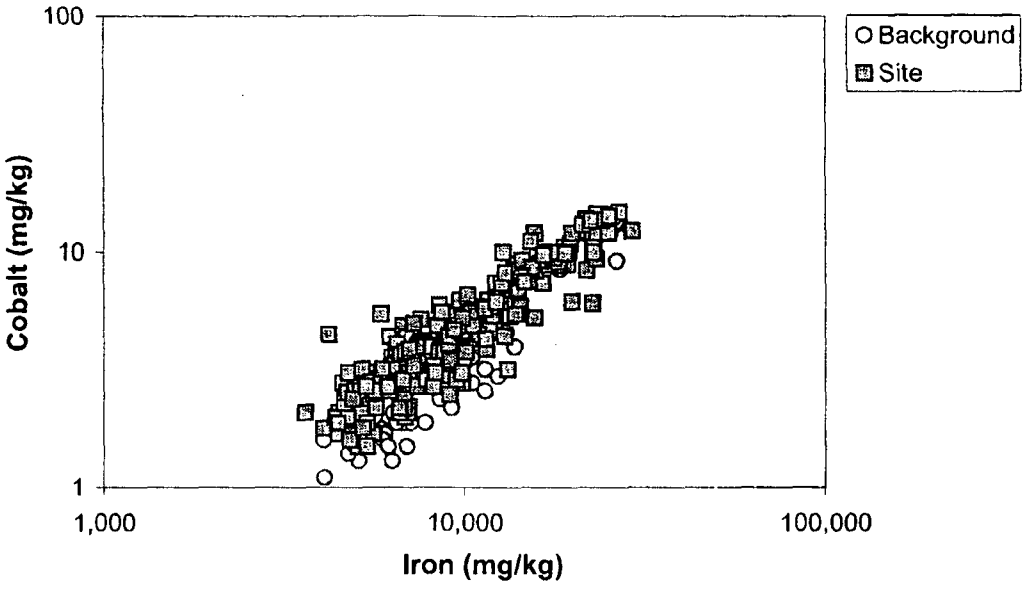


Figure 9. Cobalt versus iron in soil, Connecticut.

locations impacted by the demolition of barium-enriched concrete structures used for reactor shielding. Consequently, barium was identified as a constituent of concern and was retained for further evaluation.

One site sample contained cobalt above the background screening value, and the site data also failed the WRS test. A strong linear trend is evident in a plot of cobalt versus iron (Figure 9). This trend and absence of any samples plotting above the trend indicate that there is no cobalt contamination in these samples.

Lead in the site data set failed the background threshold comparison and the WRS test, so contamination was suspected. A plot of lead versus iron reveals that the majority of the samples form a linear trend, which represents the average background lead/iron ratio (Figure 10). Samples that plot above the linear trend were collected from locations where lead shielding was stockpiled during the decommissioning of the reactor. Lead was retained for further evaluation in the site investigation.

Silver concentrations in twelve site samples exceeded the background screening value. Detectable silver concentrations are plotted against iron concentrations in Figure 11. The majority of the samples fall on a linear trend with a positive slope. The samples that fall below the trend have estimated ("J"-qualified) silver concentrations that are below the practical quantitation limit and hence have uncertain positions on the plot. Samples that plot above the trend appear to have silver concentrations that exceed the expected concentrations based on their iron content. These samples are from a septic drain field adjacent to a building that housed a photographic laboratory that used silver compounds. These samples likely contain a component of silver contamination; accordingly, silver was retained for further evaluation in the site investigation.

Arsenic, Chromium, Lead, and Zinc in Soil, New Mexico

Although background data are preferred in an environmental investigation, the evaluation of elements in soil does not necessarily require a formal background data set to determine

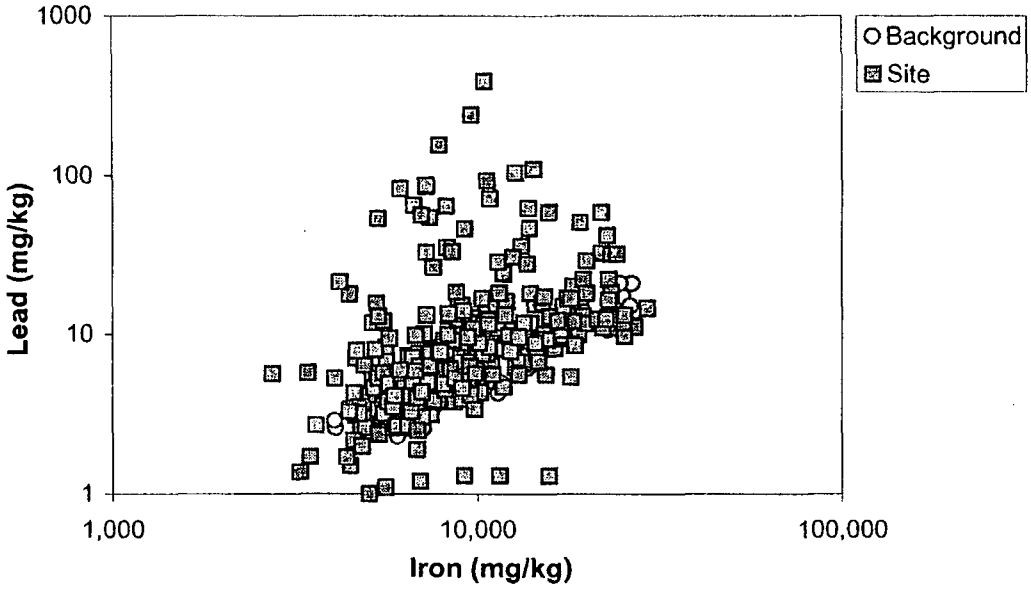


Figure 10. Lead versus iron in soil, Connecticut.

which samples may contain a component of contamination. An investigation at a DoD facility in New Mexico included the analyses of 20 site soil samples and no background soil samples. Soils at the site were developed on recent sand deposits. Some elements exhibited only naturally occurring concentrations, while others had contaminated samples.

Detectable arsenic concentrations are plotted against iron in Figure 12. The linear background trend can be seen in the lower half of the plot, which includes all of the samples with arsenic concentrations below 5 milligrams/kilogram (mg/kg). The samples on the left

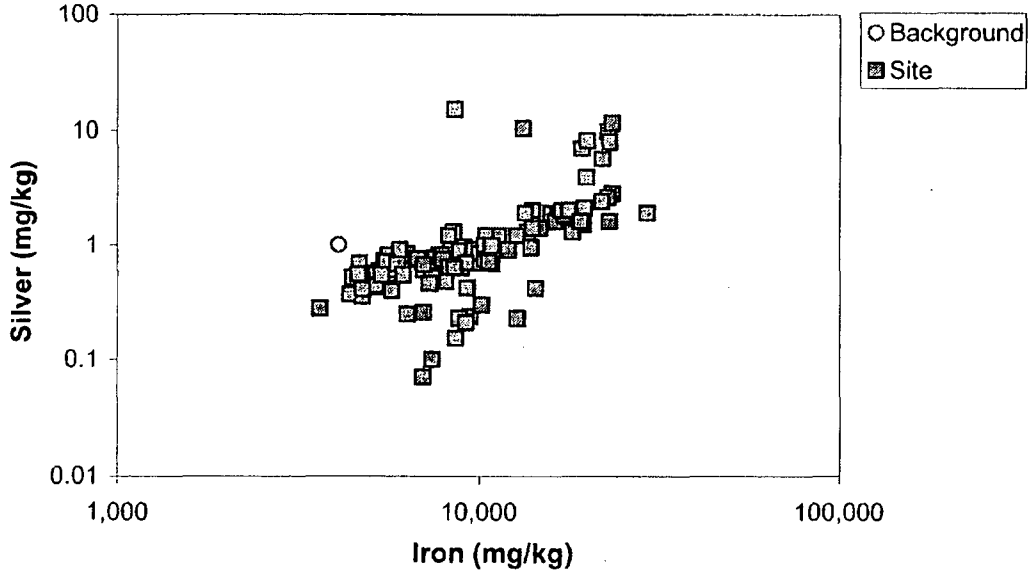


Figure 11. Silver versus iron in soil, Connecticut.

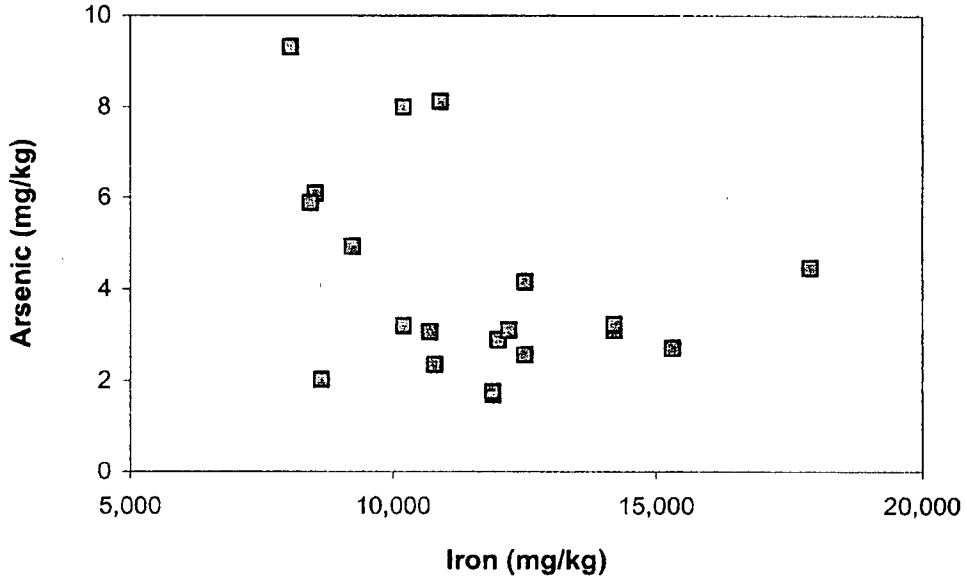


Figure 12. Arsenic versus iron in soil, New Mexico.

side of the plot that have concentrations above 5 mg/kg have unexpectedly high arsenic/iron ratios, and are thus considered to be suspect.

Detectable chromium concentrations are plotted against aluminum in Figure 13. The linear trend ($R^2 = 0.72$) indicates that the chromium is adsorbed on clay minerals at a fairly constant ratio, and is most likely natural in origin. Likewise, linear trends on plots of lead versus iron ($R^2 = 0.88$) and zinc versus iron ($R^2 = 0.89$) indicate that these trace elements are associated with iron oxides at a relatively constant ratio (Figures 14 and 15). This indicates a natural origin for lead and zinc in the site samples.

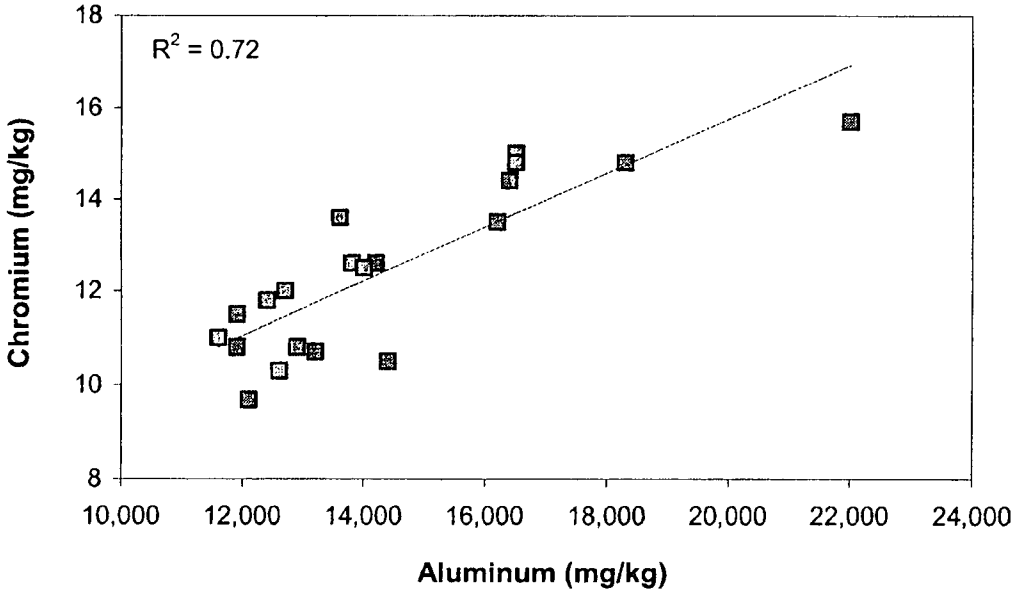


Figure 13. Chromium versus aluminum in soil, New Mexico.

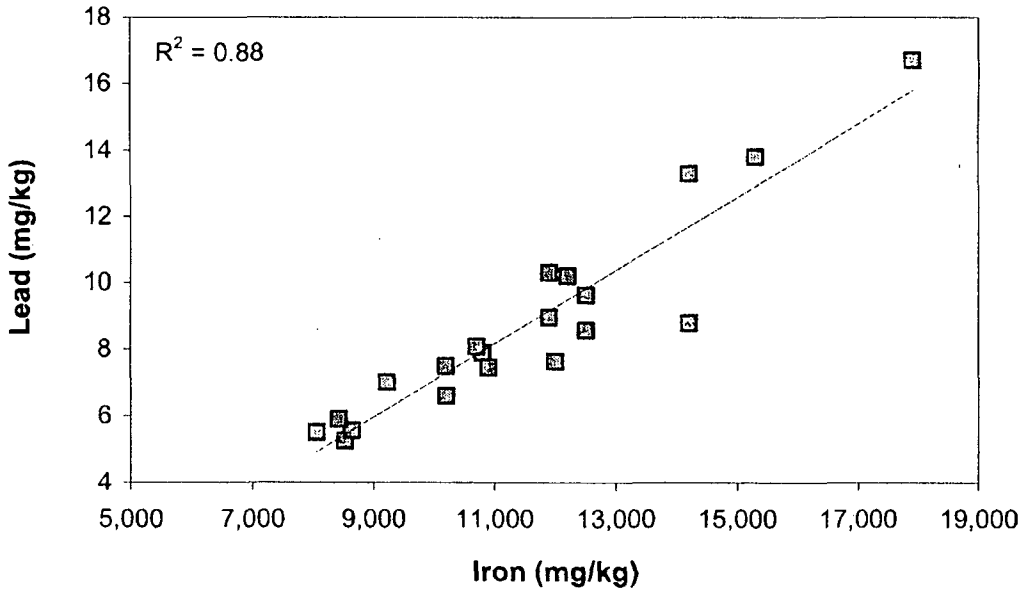


Figure 14. Lead versus iron in soil, New Mexico.

Multi-Site Correlation Plots

Several background soil data sets that were available to the authors were combined in the correlation plots shown in Figures 16 through 18. The background samples included on the plots represent soils at facilities in northeastern Alabama, northern Alabama, northeastern Florida, central North Carolina, and northern Puerto Rico. These plots of chromium versus iron, cobalt versus manganese, and vanadium versus iron reveal that the trace and major elements are present at similar ratios in the soil samples, regardless of geographical location.

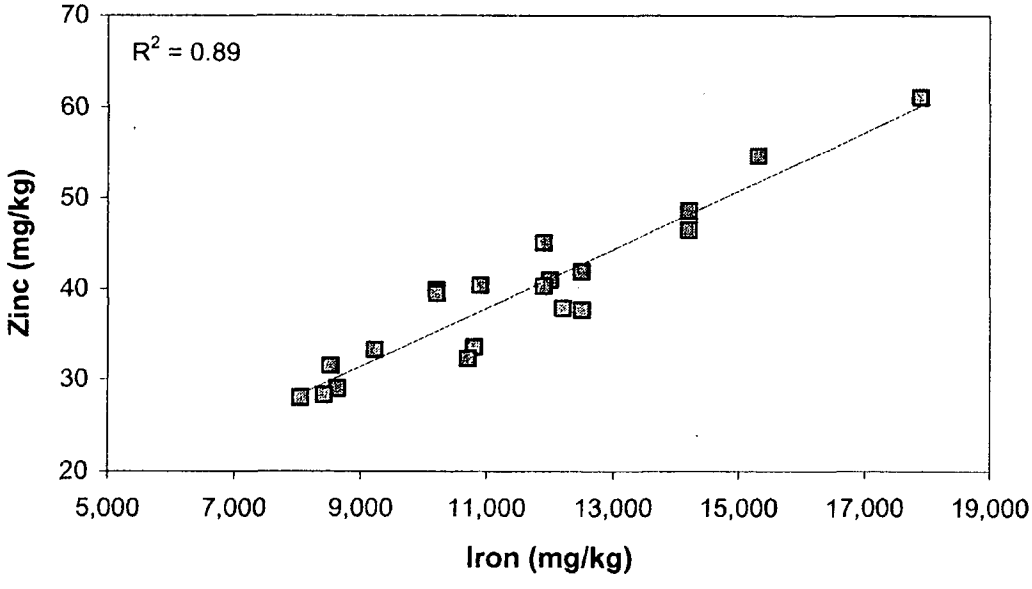


Figure 15. Zinc versus iron in soil, New Mexico.

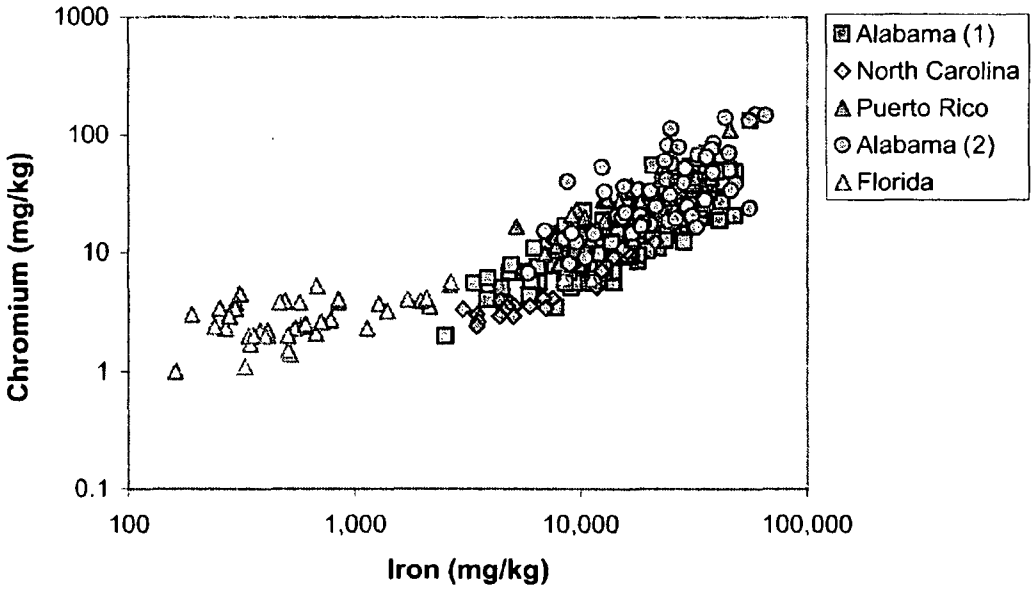


Figure 16. Chromium versus iron in various background soils.

For example, although the Alabama background soil samples are characterized by higher absolute concentrations of chromium than observed in the Florida background samples, these higher chromium concentrations are proportionally higher, maintaining a relatively consistent ratio with iron (Figure 16). Likewise, the linear trend in Figure 17 suggests that cobalt is associated with manganese oxides at a consistent ratio in the various soil types. Vanadium's strong association with iron oxides is expressed in Figure 18. The consistent ratios observed in diverse soils suggest that geochemical correlations can be used to explain elevated element concentrations in a variety of geological regimes.

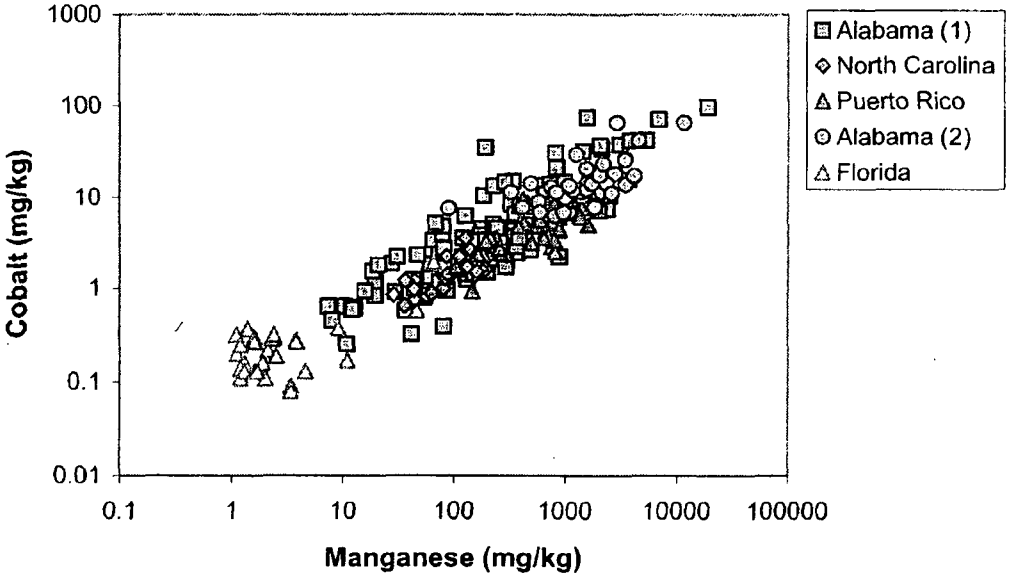


Figure 17. Cobalt versus manganese in various background soils.

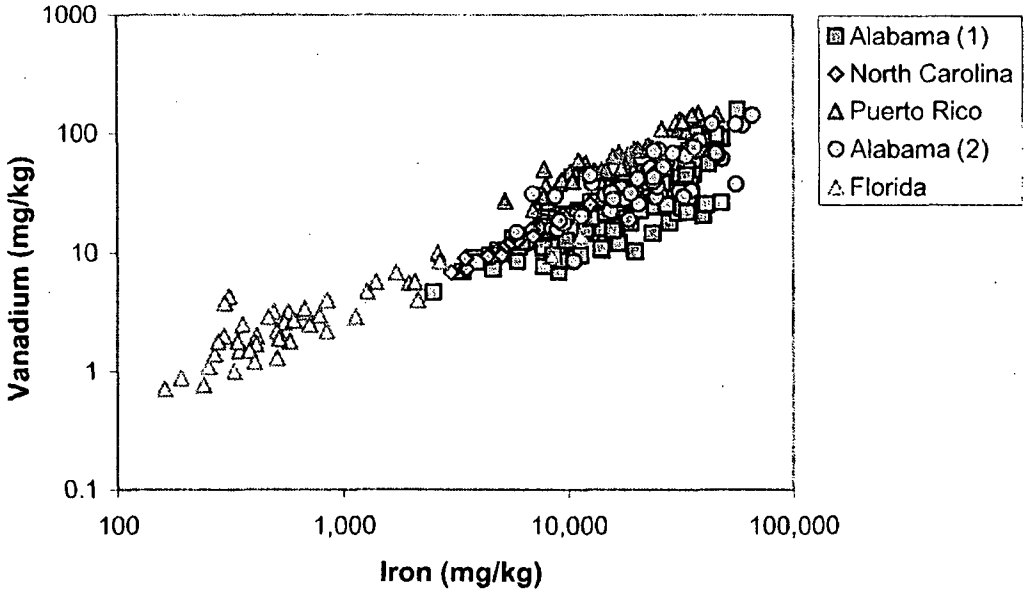


Figure 18. Vanadium versus iron in various background soils.

Summary

A high false positive error rate can be expected when a purely statistical approach is applied in site-to-background comparisons for elements in soil. Geochemical evaluations are required to discern if elevated element concentrations represent contamination or simply high natural background. These evaluations are predicated on the correlations of trace elements with major elements, and proper interpretation requires an understanding of geochemistry as well as site history. Evaluations of arsenic, barium, chromium, cobalt, lead, nickel, silver, and zinc have incorporated correlation plots of these trace elements versus aluminum, iron, and/or manganese to determine which site samples may contain a component of contamination. These evaluations have been employed at a variety of sites to refine lists of chemicals of potential concern and focus remediation efforts. They utilize analytical data that are obtained during typical site investigations, and do not require special laboratory analyses or additional analytical expense. Geochemical correlation plots such as those presented herein provide an easily grasped visualization of data sets, and are quite effective in distinguishing between high background versus contamination. An additional benefit is that they provide mechanistic explanations for naturally elevated element concentrations.

References

Bahena-Manjarrez, J.L., Rosales-Hoz, L., and Carranza-Edwards, A. 2002. Spatial and temporal variation of heavy metals in a tropical estuary. *Environ. Geol.* **42**, 575–582.

Barclift, D., Heath, J., and Drucker, A. 2000. Focus on environmental background data analysis. *Soil Sediment & Groundwater*, August/September, 10–17.

Bowell, R.J. 1994. Sorption of arsenic by iron oxides and oxyhydroxides in soils. *Appl. Geochem.* **9**, 279–286.

Brookins, D.G. 1988. *Eh-pH Diagrams for Geochemistry*, Springer-Verlag, Berlin.

Daskalakis, K.D. and O'Connor, T.P. 1995. Normalization and elemental sediment contamination in the coastal United States. *Environ. Sci. Technol.* **29**, 470–477.

EPRI (Electric Power Research Institute). 1984. *Chemical Attenuation Rates, Coefficients, and Constants in Leachate Migration, Volume 1: A Critical Review*, EPRI EA-3356, Palo Alto, California.

EPRI (Electric Power Research Institute). 1986. *Speciation of Selenium and Arsenic in Natural Waters and Sediments, Volume 2: Arsenic Speciation.* EPRI EA-4641, Palo Alto, California.

Hanson, P.J., Evans, D.W., Colby, D.R., and Zdanowicz, V.S. 1993. Assessment of elemental contamination in estuarine and coastal environments based on geochemical and statistical modeling of sediments. *Marine Environ. Res.* **36**, 237–266.

Levinson, A.A. 1974. *Introduction to Exploration Geochemistry.* Applied Publishing, Calgary.

Schiff, K. and Weisberg, S.B. 1997. Iron as a reference element for determining trace metal enrichment in California coastal shelf sediments. In: *Southern California Coastal Water Research Project Annual Report 1995–96*, pp. 68–78 (Weisberg, S., Francisco, C. and Hallock, D., Eds.).

USEPA (United States Environmental Protection Agency). 1995. *Determination of Background Concentrations of Inorganics in Soils and Sediments at Hazardous Waste Sites.* Office of Solid Waste and Emergency Response, Washington, DC. EPA/540/S-96/500. December 1995.

U.S. Navy. 2002. *Guidance for Environmental Background Analysis, Volume 1: Soil.* NFESC User's Guide UG-2049-ENV, Naval Facilities Engineering Command, Washington, D.C.

Windom, H. L., Schropp, S.J., Calder, F.D., Ryan, J.D., Smith, R.G. Jr., Burney, L.C., Lewis, F.G., and Rawlinson, C.H. 1989. Natural trace metal concentrations in estuarine and coastal marine sediments of the southeastern United States. *Environ. Sci. Technol.* **23**, 314–320.