
Groundwater Sampling Report and Statistical Analysis

Prepared for

Greene Co. Closed MSWLF and Active C&D Landfill
Walstonburg, North Carolina

March, 2006

Permit Number: 40-02

MESCO Project Number: G06010.0

Completed on September 6, 2006



Municipal Engineering Services Company, P.A.
Garner, Boone and Morehead City, North Carolina

**Municipal
Services****Engineering
Company, P.A.**

September 5, 2006

Mr. Ethan Brown
Solid Waste Section
Division of Waste Management
North Carolina Department of Environment and Natural Resources
401 Oberlin Road, Suite 150
Raleigh, NC 27605

Re: Groundwater Sampling Report and Statistical Analysis
Greene County Closed MSWLF and C&D Landfill
Permit No. 40-02
MESCO Project No. G06010.0

Dear Mr. Brown:

Municipal Engineering Company, P.A. (MESCO), has completed the sampling report and statistical analysis for the Greene County Closed MSWLF and active C&D Landfill for the March 3, 2006 sampling event. Environment I of Greenville NC completed the field sampling and laboratory analyses for the Appendix I list of metals and volatile organic constituents (VOCs) as part of the detection monitoring program. Samples were procured and analyzed from all monitoring locations which includes background well MW-1R, downgradient wells MW-4, MW-5, MW-6, and surface waters upstream and downstream. The laboratory results and statistical analysis are included herein.

All detected constituents were compared with North Carolina Groundwater Standards for regulatory exceedance. The results are shown in the enclosed table titled "Exceedance Scan". There were only a few constituents detected during this sampling event. Downgradient well MW-6 was found to contain concentrations of chromium and lead below the NCGW2L Standard. A water sample procured from downgradient well MW-4 was found to contain the intermediate chlorinated hydrocarbon cis-1,2-dichloroethene in a concentration well below the MCL.

MESCO also completed the statistical analysis as required by the Solid Waste Section. The purpose of these analyses is to determine, in comparison to background levels, statistical significance of constituents detected within the downgradient wells during this sampling event.

Statistical Analysis Methodology

Metals

An inter-well statistical analysis was conducted upon metals detected during this sampling event. Monitoring well MW-1R was defined as the background well, and an upper tolerance limit (UTL) with 95% coverage was computed for each detected constituent from the background data at a 95% level of confidence. For each tested constituent, an appropriate statistical analysis method was selected based on the percentages of non-detects (%ND) in the historical background data. The following table (Table 1) summarizes the methods used for four different %ND ranges.

Table 1. Statistical Analysis Methods for Various %ND Ranges

%ND	Analysis Method	ND Substitution
%ND<15%	Parametric tolerance limit	1/2 ND
15%<%ND<50%	Parametric tolerance limit	Cohen or 1/2 ND
50%<%ND<90%	Non-parametric tolerance limit	1/2 ND
90%<%ND	Poisson tolerance limit	-

NOTE: For parametric tolerance interval, normality of the background data was checked by the Shapiro-Wilks normality test, as the method requires that the data be normally distributed.

A total of 2 metals were tested for statistical significance. For chromium and lead, the non-parametric tolerance interval method with ½ ND substitution was utilized because the data was not normally distributed when evaluated via the Shapiro Wilks normality test.

VOCs

All historical VOC detections in the background well MW-1R were pooled in order to determine the total number of detections, from which the expected number of detections in a single down gradient monitoring point (y^*) was derived by utilizing the Poisson prediction interval. The parameter y^* is defined by the following equation:

$$y^* = cy + \frac{t^2 c}{2} + tc \sqrt{y \left(1 + \frac{1}{c}\right) + \frac{t^2}{4}}$$

where

$c = 1/n$ (n = number of background samples)

t = one-sided value of student's t -Statistic at 95% confidence ^a

y = number of events observed in n previous samples

y^* = expected number of events in a single future sample

^a Gibbons, R.D., 1994, Statistical methods for groundwater monitoring: John Wiley & Sons, Inc., p.12.

For each monitoring location showing any VOC detections, the number of detected VOCs was counted with each detection being considered a “hit”. The number was then compared with the expected number of detections derived from the background VOC data. The value of Student’s t -Statistic was derived from tabulated values included in Gibbons (1994).

Results

Historical data compiled for monitoring well MW-1R was used as the baseline. Data distribution and potential outliers were reviewed using time series and box and whiskers plots (enclosed charts). Neither chromium nor lead within MW-6 were found to have increased compared to background levels through interwell comparison analysis.

Based upon the complete lack of historical VOC detections within the background well every well that contained a single VOC detection is considered to be statistically significant according to the Poisson Prediction Interval at a 95% confidence level. Although the concentration of cis-1,2-Dichloroethene is well below the MCL the groundwater in the region monitored by MW-4 is still considered to be impacted at a 95% confidence level.

Conclusion

Although the detection of cis-1,2-dichloroethene within MW-4 is statistically significant the concentration remains only slightly above the detection limit. Downgradient well MW-4, is the only well that has ever contained any VOC detections since monitoring was initiated in 1994. MW-4 has contained a single VOC during the previous 3 events but the all of the detected concentrations remain very low. Due to the extremely low concentrations it is very unlikely that any VOC would be detected at the property boundary at levels in exceedance of the Standard.

MESCO completed the enclosed potentiometric map with groundwater elevations on the day of sampling, flow rates and direction. The site is scheduled to be sampled again for the complete list of Appendix I list of constituents in September 2006. Please contact me either by phone at (919) 772-5393, or by email at jpfohl@mesco.com should you have any questions or concerns regarding this report.

Sincerely,
MUNICIPAL ENGINEERING SERVICES CO., P.A.



Jonathan Pfohl
Environmental Specialist

Enclosures

cc: Mr. David Jones
Greene County

**Exceedance Scan
Greene County Closed MSWLF and C&D Landfill**

Well ID	Parameter Name¹	Sample Date	Result	Unit	PQL²	NCGW2L³	Exceedance
MW-6	Chromium	03/03/2006	0.013	mg/l	0.01	0.05	
MW-6	Lead	03/03/2006	0.013	mg/l	0.01	0.015	
MW-4	Cis-1,2-Dichloroethene	03/03/2006	10.8	ug/l	5	70	

¹ Table only contains detected constituents.

² PQL = Practical Quantitation Limit

³ NCGW2L = North Carolina Ground Water 2L Standard

**Hydrologic Properties at Monitoring Well Locations
Greene County Closed MSWLF and C&D Landfill**

Monitoring Well	Hydraulic Conductivity (cm/sec)	Effective Porosity (%)	Hydraulic Gradient	Flow Rate (ft/yr)	Flow Direction	Water Table Depth (ft)	Water Table Elev. (ft)
MW-1R	1.20E-04	37%	0.026	8.7	N65E	5.13	116.65
MW-4	1.10E-04	40%	0.021	6.1	S61E	13.57	104.32
MW-5	1.40E-04	37%	0.017	6.6	N16E	14.64	101.12
MW-6	1.90E-04	43%	0.166	75.4	N15E	4.4	113.01

NOTE: Data for hydraulic conductivities obtained from GAI Consultants' WaterQuality Modifications (October, 1994)

Hydrologic Gradient taken from the March 3, 2006 sampling event.

Flow rate (Q) is defined by the equation:

where
$$Q = -\frac{K}{n_e} \cdot \frac{dh}{dl}$$

K = hydraulic conductivity

n_e = effective porosity

dh = head difference

dl = horizontal distance

Statistical Analysis Results Summary

**Inter-Well Analysis Summary
Greene County Closed Sanitary Landfill
Background Well: (MW-1R)**

Chromium, total

%ND	Normality	Method	ND Adj.	Upper Limit (a = 95%)	Unit
48.00	no	Non-Parametric Tolerance Limit	1/2 ND	40	ug/l

Well	Result	Significance
MW-6	13	no

Lead, total

%ND	Normality	Method	ND Adj.	Upper Limit (a = 95%)	Unit
68.00	no	Non-Parametric Tolerance Limit	1/2 ND	32	ug/l

Well	Result	Significance
MW-6	13	no

NOTE: Bold-faced monitoring points indicate detected levels exceed North Carolina Groundwater Standard.

**Summary of Pooled Appendix I VOCs in Background Well (MW-1R)
Greene County Closed Sanitary Landfill**

Constituent	Samples	NDs	% NDs
1,1,1,2-Tetrachloroethane	25	25	100.00
1,1,1-Trichloroethane	25	25	100.00
1,1,2,2-Tetrachloroethane	25	25	100.00
1,1,2-Trichloroethane	25	25	100.00
1,1-Dichloroethane	25	25	100.00
1,1-Dichloroethene	25	25	100.00
1,2,3-Trichloropropane	25	25	100.00
1,2-Dibromo-3-chloropropane	25	25	100.00
1,2-Dibromoethane	25	25	100.00
1,2-Dichlorobenzene	25	25	100.00
1,2-Dichloroethane	25	25	100.00
1,2-Dichloropropane	25	25	100.00
1,4-Dichlorobenzene	25	25	100.00
2-Butanone	25	25	100.00
2-Hexanone	25	25	100.00
4-Methyl-2-Pentanone	25	25	100.00
Acetone	25	25	100.00
Acrylonitrile	25	25	100.00
Benzene	25	25	100.00
Bromochloromethane	25	25	100.00
Bromodichloromethane	25	25	100.00
Bromoform	25	25	100.00
Bromomethane	25	25	100.00
Carbon disulfide	25	25	100.00
Carbon tetrachloride	25	25	100.00
Chlorobenzene	25	25	100.00
Chloroethane	25	25	100.00
Chloroform	25	25	100.00
Chloromethane	25	25	100.00
cis-1,2-Dichloroethene	25	25	100.00
cis-1,3-Dichloropropene	25	25	100.00
Chlorodibromomethane	25	25	100.00
Dibromomethane	25	25	100.00
Ethylbenzene	25	25	100.00
Iodomethane	25	25	100.00
Dichloromethane	25	25	100.00
Styrene	25	25	100.00
Tetrachloroethylene	25	25	100.00
Toluene	25	25	100.00
trans-1,2-Dichloroethene	25	25	100.00
trans-1,3-Dichloropropene	25	25	100.00
trans-1,4-Dichloro-2-butene	25	25	100.00
Trichloroethylene	25	25	100.00
Trichlorofluoromethane	25	25	100.00
Vinyl acetate	25	25	100.00
Vinyl chloride	25	25	100.00
Xylene	25	25	100.00
Total	1175	1175	100.00

**Poisson Prediction Interval Based upon Pooled Background Appendix I VOCs
Greene County Closed Sanitary Landfill**

All detected VOCs (Background Well: MW-1)

Constituent	MW-4
Cis-1,2-Dichloroethene	x
Detection(s) per Scan	1.00

Total number of sampling events [n] = 25

Total number of detections in background wells [y] = 0

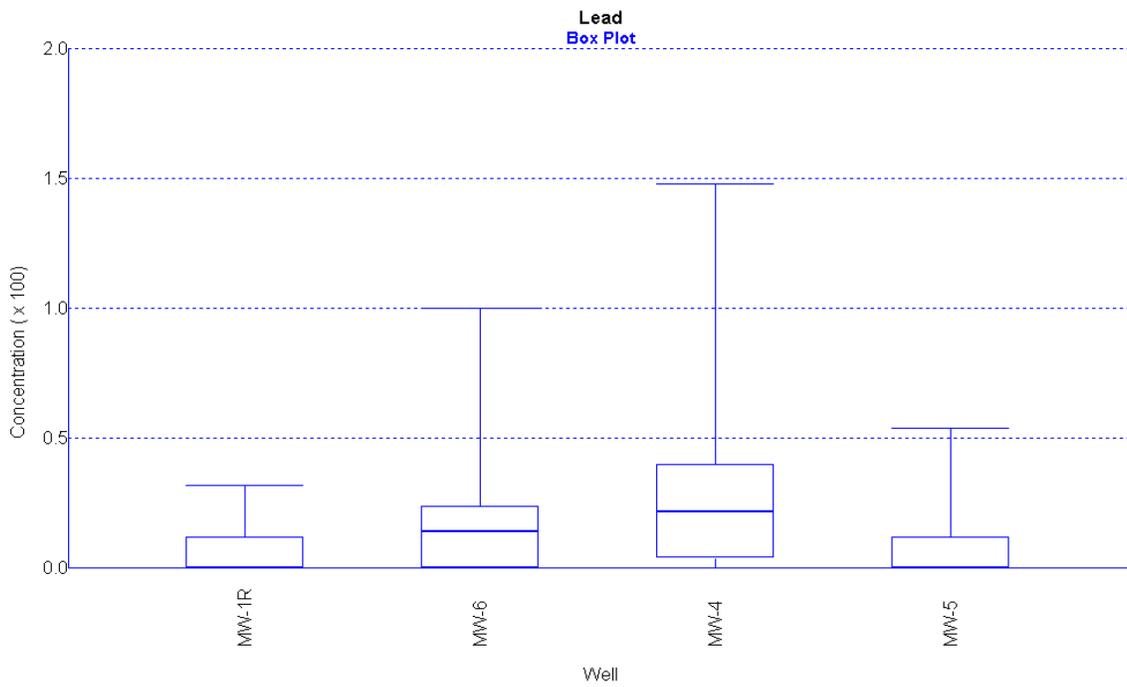
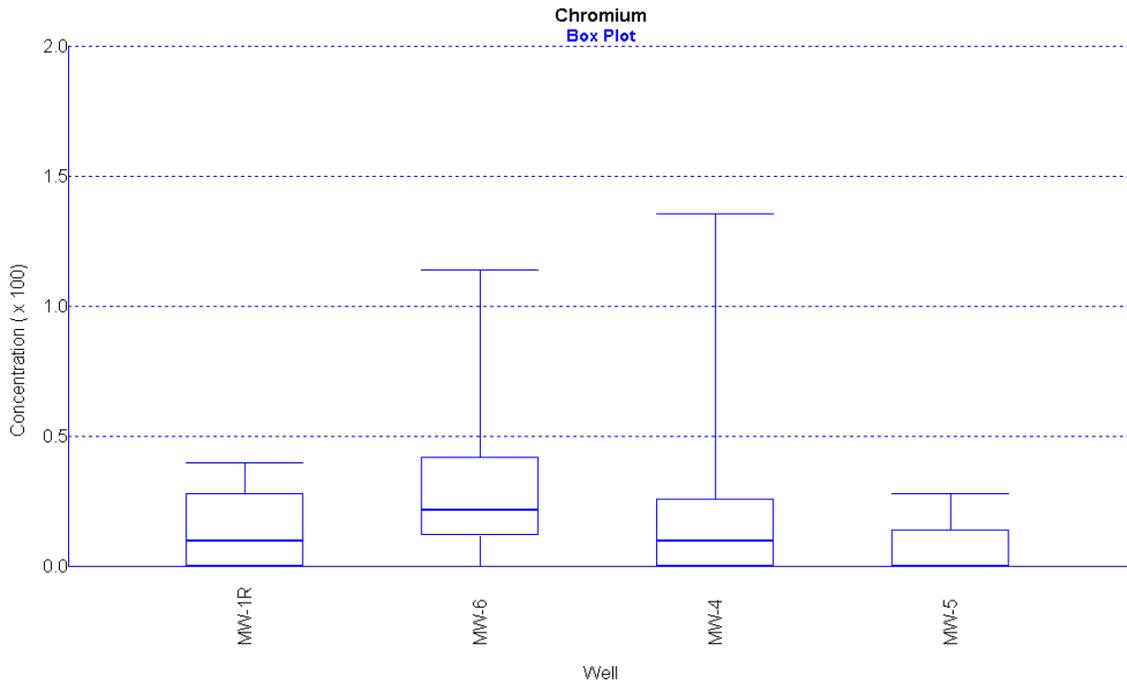
Number of comparisons (downgradient wells) [k] = 3

One-sided value of Student's t-statistic (95% confidence) [t] = 1.5

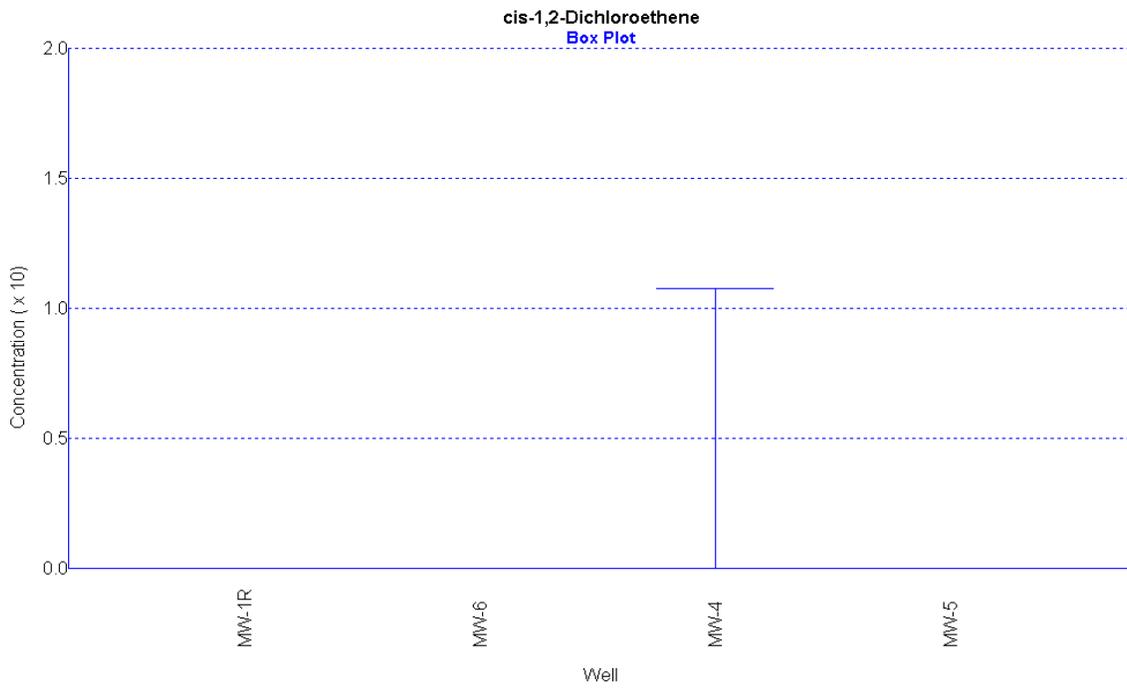
Expected number of detections in a single future sample [y*] = **0.0895**

Statistically Significant VOC detections within MW-4 at a 95% confidence level

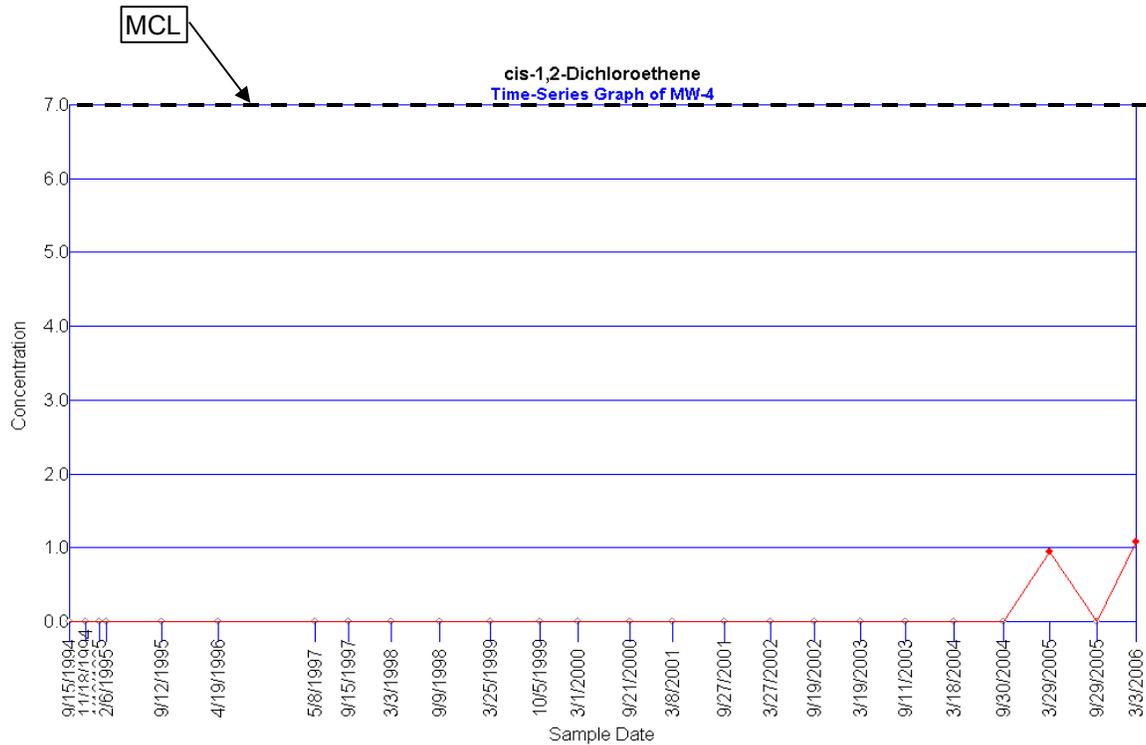
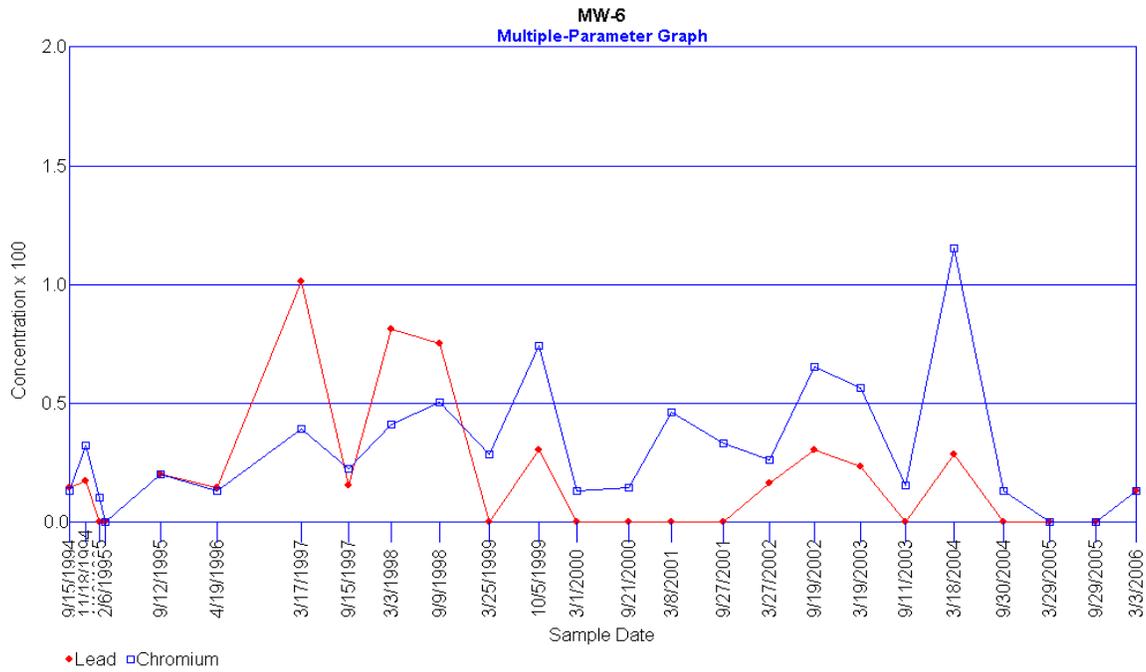
Box Plots for Select Constituents
Greene County Closed Sanitary Landfill



Box Plots for Select Constituents
Greene County Closed Sanitary Landfill



**Time Series Plots for Select Constituents
Greene County Closed Sanitary Landfill**



Basic Statistics

Basic Statistics**Parameter: Lead**

Original Data (Not Transformed)
 Non-Detects Replaced with 1/2 DL

	Total Observations
100	
Total Non-Detects	50
Pooled Mean	18.21
Pooled Std Dev	24.0636
Background Mean	8.92
Background Std Dev	7.11758

Background Wells

There is 1 background well

Well	Samples	Non-Detects	% ND	Total		
MW-1R	25	17	68	223		

Well	Mean	Std Dev	Std Err	Rank Sum	Rank Mean
MW-1R	8.92	7.11758	0	963.5	38.54

Compliance Wells

There are 3 compliance wells

Well	Samples	Non-Detects	% ND	Total		
MW-4	25	6	24	802		
MW-5	25	16	64	264		
MW-6	25	11	44	532		

Well	Mean	Std Dev	Dif From Bk	Std Err	Rank Sum	Rank Mean
MW-4	32.08	34.3134	23.16	6.36795	1685	67.4
MW-5	10.56	11.1844	1.64	6.36795	1022	40.88
MW-6	21.28	25.9688	12.36	6.36795	1379.5	55.18

Analysis of Variance Statistics

SS Wells	8665.71
SS Total	57326.6

Kruskal-Wallis Statistics

Non-Detect Rank	25.5
Background Rank Sum	963.5
Background Rank Mean	38.54
H Statistic	16.1316
H Adjusted for Ties	18.4354

Basic Statistics**Parameter: Chromium**

Original Data (Not Transformed)

Non-Detects Replaced with 1/2 DL

	Total Observations
100	
Total Non-Detects	42
Pooled Mean	19.35
Pooled Std Dev	21.675
Background Mean	15.96
Background Std Dev	13.3806

Background Wells

There is 1 background well

Well	Samples	Non-Detects	% ND	Total
MW-1R	25	12	48	399

Well	Mean	Std Dev	Std Err	Rank Sum	Rank Mean
MW-1R	15.96	13.3806	0	1196	47.84

Compliance Wells

There are 3 compliance wells

Well	Samples	Non-Detects	% ND	Total
MW-4	25	11	44	523
MW-5	25	16	64	247
MW-6	25	3	12	766

Well	Mean	Std Dev	Dif From Bk	Std Err	Rank Sum	Rank Mean
MW-4	20.92	27.9776	4.96	5.82618	1239.5	49.58
MW-5	9.88	7.47953	-6.08	5.82618	911	36.44
MW-6	30.64	26.067	14.68	5.82618	1703.5	68.14

Analysis of Variance Statistics

SS Wells	5777.55
SS Total	46510.7

Kruskal-Wallis Statistics

Non-Detect Rank	21.5
Background Rank Sum	1196
Background Rank Mean	47.84
H Statistic	15.3498
H Adjusted for Ties	16.5774

Basic Statistics**Parameter: cis-1,2-Dichloroethene**

Original Data (Not Transformed)

Non-Detects Replaced with 1/2 DL

	Total Observations
100	
Total Non-Detects	98
Pooled Mean	2.652
Pooled Std Dev	1.07398
Background Mean	2.5
Background Std Dev	0

Background Wells

There is 1 background well

Well	Samples	Non-Detects	% ND	Total
MW-1R	25	25	100	62.5

Well	Mean	Std Dev	Std Err	Rank Sum	Rank Mean
MW-1R	2.5	0	0	1237.5	49.5

Compliance Wells

There are 3 compliance wells

Well	Samples	Non-Detects	% ND	Total
MW-4	25	23	92	77.7
MW-5	25	25	100	62.5
MW-6	25	25	100	62.5

Well	Mean	Std Dev	Dif From Bk	Std Err	Rank Sum	Rank Mean
MW-4	3.108	2.11402	0.608	0.298968	1337.5	53.5
MW-5	2.5	0	0	0.298968	1237.5	49.5
MW-6	2.5	0	0	0.298968	1237.5	49.5

Analysis of Variance Statistics

SS Wells	6.9312
SS Total	114.19

Kruskal-Wallis Statistics

Non-Detect Rank	49.5
Background Rank Sum	1237.5
Background Rank Mean	49.5
H Statistic	0.356436
H Adjusted for Ties	6.06061

Interwell Analyses for Metals

Non-Parametric Tolerance Interval**Parameter: Chromium**

Original Data (Not Transformed)

Non-Detects Replaced with 1/2 DL

Total Percent Non-Detects = 30%

Background Samples (n) = 25

Maximum Background Concentration = 40

Minimum Coverage = 88.7%

Average Coverage = 96.1538%

Well	Sample	Result	Impacted
MW-6	9/15/1994	13	FALSE
MW-6	11/18/1994	32	FALSE
MW-6	1/12/1995	10	FALSE
MW-6	2/6/1995	ND<5	FALSE
MW-6	9/12/1995	20	FALSE
MW-6	4/19/1996	13	FALSE
MW-6	3/17/1997	39	FALSE
MW-6	9/15/1997	22	FALSE
MW-6	3/3/1998	41	TRUE
MW-6	9/9/1998	50	TRUE
MW-6	3/25/1999	28	FALSE
MW-6	10/5/1999	74	TRUE
MW-6	3/1/2000	13	FALSE
MW-6	9/21/2000	14	FALSE
MW-6	3/8/2001	46	TRUE
MW-6	9/27/2001	33	FALSE
MW-6	3/27/2002	26	FALSE
MW-6	9/19/2002	65	TRUE
MW-6	3/19/2003	56	TRUE
MW-6	9/11/2003	15	FALSE
MW-6	3/18/2004	115	TRUE
MW-6	9/30/2004	13	FALSE
MW-6	3/29/2005	ND<5	FALSE
MW-6	9/29/2005	ND<5	FALSE
MW-6	3/3/2006	13	FALSE

Shapiro-Wilks Test of Normality**Parameter: Chromium****Background Wells****Normality Test of Parameter Concentrations**

Original Data (Not Transformed)

Non-Detects Replaced with 1/2 DL

K = 12; Samples = 25

i	x(i)	x(n-i+1)	x(n-1+1)-x(i)	a(n-i+1)	b(i)
1	5	40	35	0.445	15.575
2	5	39	34	0.3069	10.4346
3	5	39	34	0.2543	8.6462
4	5	36	31	0.2148	6.6588
5	5	34	29	0.1822	5.2838
6	5	33	28	0.1539	4.3092
7	5	26	21	0.1283	2.6943
8	5	22	17	0.1046	1.7782
9	5	17	12	0.0823	0.9876
10	5	16	11	0.061	0.671
11	5	16	11	0.0403	0.4433
12	5	11	6	0.02	0.12
13	10	10	0		
14	11	5	-6		
15	16	5	-11		
16	16	5	-11		
17	17	5	-12		
18	22	5	-17		
19	26	5	-21		
20	33	5	-28		
21	34	5	-29		
22	36	5	-31		
23	39	5	-34		
24	39	5	-34		
25	40	5	-35		

Sum of b values = 57.602

Sample Standard Deviation = 13.3806

W Statistic = 0.772172

5% Critical value of 0.918 exceeds 0.772172

Evidence of non-normality at 95% level of significance

1% Critical value of 0.888 exceeds 0.772172

Evidence of non-normality at 99% level of significance

Non-Parametric Tolerance Interval**Parameter: Lead**

Original Data (Not Transformed)

Non-Detects Replaced with 1/2 DL

Total Percent Non-Detects = 56%

Background Samples (n) = 25

Maximum Background Concentration = 32

Minimum Coverage = 88.7%

Average Coverage = 96.1538%

Well	Sample	Result	Impacted
MW-6	9/15/1994	14	FALSE
MW-6	11/18/1994	17	FALSE
MW-6	1/12/1995	ND<5	FALSE
MW-6	2/6/1995	ND<5	FALSE
MW-6	9/12/1995	20	FALSE
MW-6	4/19/1996	14	FALSE
MW-6	3/17/1997	101	TRUE
MW-6	9/15/1997	15	FALSE
MW-6	3/3/1998	81	TRUE
MW-6	9/9/1998	75	TRUE
MW-6	3/25/1999	ND<5	FALSE
MW-6	10/5/1999	30	FALSE
MW-6	3/1/2000	ND<5	FALSE
MW-6	9/21/2000	ND<5	FALSE
MW-6	3/8/2001	ND<5	FALSE
MW-6	9/27/2001	ND<5	FALSE
MW-6	3/27/2002	16	FALSE
MW-6	9/19/2002	30	FALSE
MW-6	3/19/2003	23	FALSE
MW-6	9/11/2003	ND<5	FALSE
MW-6	3/18/2004	28	FALSE
MW-6	9/30/2004	ND<5	FALSE
MW-6	3/29/2005	ND<5	FALSE
MW-6	9/29/2005	ND<5	FALSE
MW-6	3/3/2006	13	FALSE
