

IMPROVED EXTRACTION EFFICIENCY OF POLYCHLORINATED BIPHENYLS FROM CONTAMINATED SOIL USING A TOTAL HALOGEN SCREENING METHOD

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ABSTRACT

Polychlorinated biphenyls (PCBs) are strictly regulated on the state and federal levels. Responsible parties must determine the concentration and extent of contamination to make appropriate decisions regarding remediation of PCB contaminated soils. Gas chromatography (GC) analysis has been traditionally used to delineate PCB contamination in soil. On-site, field-screening techniques have been developed within the last decade to reduce the number of samples requiring laboratory confirmation. All field-screening methods require the use of organic solvents to extract the contamination from soil. Soils sampled for analysis frequently contain water, which, with some solvents, may result in poor extraction efficiencies and can subsequently produce false negatives. In this study, GZA GeoEnvironmental, Inc. (GZA) utilized a total organic halogen (TOX) screening kit to characterize complex, multi-component PCB contaminated soil at an industrial property located in the Midwest. Furthermore, the results demonstrated the effectiveness of two novel solvent systems to extract PCBs from wet clay soil for reliable quantification with a portable field analyzer. Preliminary GC analyses indicated that the soil was contaminated with Aroclor 1248 as well as diesel range organics. The excavated soil consisted of wet, red clay. Two types of field test methods are available for PCB screening, both of which may exhibit lower extraction efficiencies for wet clay soils. One method relies on immunoassay chemistry, and the second method involves chemical dehalogenation of the PCBs followed by analysis with a colorimetric reaction or chloride-specific electrode. Immunoassay PCB kits suffer severe negative interferences in the presence of hydrocarbon co-contaminants and are not suitable for this site. Dexasil Corporation's L2000[®] PCB Analyzer (U.S. EPA SW-846 Draft Method 9078, "Screening Test Method for Polychlorinated Biphenyls in Soil") is not adversely affected by the presence of the aforementioned co-contaminating fuels and oils and was therefore selected to quantify the PCBs. Aroclor 1248 concentrations were determined in over 71 wet samples by extracting the contaminated wet soil samples with a new, two-step, ozone-friendly solvent system followed by analysis using the L2000. An additional, modified aqueous-organic solvent extraction method with a Florisil cleanup column was also used to determine the PCB content of 42 of the same wet samples. The second method was designed to quantify PCBs in the presence of some non-PCB halogenated solvents. A portion of each wet soil sample was then dried and reanalyzed. Ten percent of the "non-detect" samples along with all samples testing positive (>2 ppm) for PCBs were analyzed using U.S. EPA Method 8080 (gas chromatography with Soxhlet extraction) to establish the extraction efficiencies of each new two-step solvent system. The L2000 results of wet soil samples were adjusted for water content and compared to the values generated by Method 8080 (GC). Both solvent systems demonstrated the ability to efficiently extract (>73%) PCBs from wet and dry lacustrine red-clay soil. Data generated by L2000 analysis of PCBs extracted into both new solvent systems exhibit excellent correlation to the data produced by the more sophisticated laboratory (GC) technique. This information lends confidence in PCB field screening data for field engineers.

INTRODUCTION

Under the authority of the Toxic Substances Control Act (TSCA) of 1976, the U.S. Environmental Protection Agency (EPA) regulates the use, storage, and disposal of polychlorinated biphenyls (PCBs)¹. These rules were imposed because of the health-related concerns and potential environmental impacts associated with PCBs. In July 1979 the U.S. EPA banned the manufacture of PCBs and most uses in which the PCBs were not contained within a closed system (e.g., transformers and capacitors). Latitude was given to certain industries whose PCB usage, such as electrical applications, were not considered to pose unreasonable risk to the environment or human health. In July 1985 the U.S. EPA developed regulations for phasing out the use of PCBs in all enclosed systems.

The U.S. EPA promulgated a PCB Spill Cleanup Policy in April 1987, which is codified in 40 CFR Part 761. The

PCB Spill Cleanup Policy requires notification for PCB spills into sensitive areas and for all spills greater than 10 pounds. The PCB Spill Policy also establishes cleanup concentrations for soil and solid surfaces. Clean up of the affected media is required, whether it is soil, groundwater, surface water, infrastructure, equipment, or inventory.

Delineation of the extent of contamination in soil is a critical step in any remediation project. Accurate delineation is more critical in a PCB remediation project due to the limited and expensive disposal alternatives. PCB disposal generally costs an order of magnitude more than disposal of non-PCB containing soil. After the specific Aroclor, concentration, and extent of PCB contamination are identified in the soil, an appropriate cleanup and disposal plan can be designed. Confirmation of the specific PCB Aroclor and concentration are accomplished using analytical testing procedures performed in accordance with *Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods*, U.S. EPA Publication SW-846. Traditionally, U.S. EPA SW-846 Method 8080, gas chromatography (GC)² for the detection of organochlorine pesticides and PCBs is used in conjunction with U.S. EPA SW-846 Method 3540, Soxhlet extraction³ to determine the PCB concentrations in soil.

While laboratory analyses are required to definitively confirm the type and concentration of PCBs, the methods are both time-consuming (requiring 2 to 3 days for off-site analyses) and expensive (ca. \$100 per analyses). Within the last decade, several field-screening techniques have been developed to preliminarily define the extent of PCB contamination in the field and reduce the number of samples requiring laboratory analytical testing. Field screening techniques provide field engineers with on-site, real-time information necessary to make field decisions regarding the investigation or remediation process.

Application of an appropriate field screening method can improve the quality of a site investigation, lessen the time required to characterize a site, decrease the project cost, and increase the efficiency of a remediation process. A reliable field screening technique is selective to the analyte of concern, insensitive to co-constituents, efficient, easy to use, and relatively inexpensive. The field method must also provide good correlation with analytical laboratory data. Inaccurate quantification of PCB concentrations by an ineffective field screening technique could cause responsible parties to make inappropriate and expensive decisions regarding crucial remediation steps.

Accurate quantification of a soil contaminate begins with an efficient extraction of that chemical from the soil media. This report accounts the careful selection and utilization of a total organic halogen (TOX) field screening kit by GZA GeoEnvironmental, Inc. (GZA) to aid in the characterization of a complex, multi-component PCB contaminated site. Furthermore, the results will demonstrate the effectiveness of two novel solvent systems to extract PCBs from clay soil for reliable quantification with a portable field analyzer.

BACKGROUND

GZA was contracted to delineate the extent of PCB containing soil at an industrial property in the Midwest. Due to the expense of GC analytical testing, GZA chose to use a PCB field screening method in addition to confirmational GC analysis. A properly chosen field screening method would provide quick, on-site, real-time data at a reduced cost.

Two types of field test methods are currently available for PCB screening. One method relies on immunoassay chemistry. The immunoassay chemistry method is based on enzyme-linked immuno-sorbent assays (ELISA) in which a competitive reaction between PCBs and a PCB conjugate is used to determine the PCB concentration in soil samples. The second method involves chemical dehalogenation of the PCBs followed by analysis with a colorimetric reaction or chloride-specific electrode. Colorimetric analysis yields an estimate of the PCB concentration greater or less than a fixed concentration. The chloride-specific electrode quantifies PCBs at concentrations ranging from 2 to 2,000 parts per million (ppm).

GZA chose to determine the PCB Aroclor 1248 concentrations in soil using the chemical dehalogenation method followed by analysis with Dexsil Corporation's L2000[®] PCB/Chloride Analyzer. The L2000 utilizes a chloride specific electrode to quantify the PCBs in accordance with its associated U.S. EPA SW-846 Draft Method 9078 "*Screening Test Method for Polychlorinated Biphenyls in Soil*"⁴. GZA selected the L2000 for two main reasons. First, immunoassay PCB field screening kits are subject to severe negative interferences in the presence of

hydrocarbon co-contaminants as documented by Gaskill, 1993.⁵ The study completed by Gaskill also indicated that immunoassay systems may be susceptible to other non-specific interferences present in organic solutions. Dexsil's L2000 is not adversely affected by the presence of hydrocarbon co-contaminating fuels and oils and was therefore selected to quantify the PCBs.

The second reason GZA chose to use the L2000 is because Dexsil volunteered to research and develop a unique solvent system to extract PCBs from the wet, red lacustrine clay characteristic of the area. Extracting organic contaminants from complex clay (wet and dry) matrices poses a notoriously difficult task. PCBs are especially difficult to extract from wet clays as previously documented by Gauger, *et al*, 1995.⁶ Based in part on research and testing completed on soil samples collected by GZA during this study, Dexsil has developed two novel solvent systems specifically designed to achieve high PCB extraction efficiencies from clay soil.

Prior to this study, the L2000 was demonstrated to be an effective PCB field-screening tool in a variety of soils including sand and several different clay soil types. The lacustrine red clay soil present in east central Wisconsin posed a new challenge for the L2000, which required modification to the extraction procedure and the need for this study.

One extraction method utilizes a novel aqueous-organic solvent system. The two-step procedure results in a high PCB extraction efficiency from complex soil matrices such as wet clays. For cases in which co-contaminating, non-PCB, halogenated organic compounds are present or suspected, a second extraction method was developed. This method utilizes a similar aqueous-organic solvent followed by a Florisil cleanup column. The Florisil cleanup column removes common non-PCB organic chloride compounds such as pentachlorophenol from the solvent extract. PCBs are not lost on the Florisil cleanup column during the filtration process. Inorganic salts associated with sampled soil cause no interference with PCB quantification by the L2000 after extraction with either solvent system.⁵

The soil samples collected by GZA were extracted as received using the novel solvent systems and analyzed with Dexsil's L2000 to determine the PCB Aroclor 1248 concentration. The data generated using the new solvent systems and L2000 showed an excellent correlation when compared with the results from split samples analyzed in accordance with U.S. EPA SW-846 Method 8080 and Method 3540.

SAMPLING and ANALYSIS

For this study, GZA utilized a Geoprobe to bore approximately 45 soil borings at the industrial property. The objective of the soil-boring program was to evaluate PCB contaminated areas and define the extent of PCBs in the soil. Soil samples were collected continuously at 2-foot intervals through the end of boring at average depths of 12 feet below ground surface. A Site Plan showing the layout of the soil borings is presented as Figure No. 1. Precautions were taken during sampling to prevent cross contamination by cleaning the Geoprobe® sampling tools with a Citrisolv detergent solution. The samples were kept on ice and delivered to Dexsil within 48 hours of collection under chain-of-custody documentation. Dexsil homogenized then analyzed the samples using the L2000 in accordance with U.S. EPA SW-846 Draft Method 9078 and GC in accordance with Method 8080 following Soxhlet extraction in accordance with U.S. EPA Method 3540.

PCB Aroclor 1248 concentrations were determined in the soil samples using the L2000 and both extraction methods, the aqueous-organic solvent system and the aqueous-organic solvent system followed by filtering through a Florisil cleanup column. The solvents do not contain chlorofluorocarbons and are therefore ozone-friendly. After the chlorinated organic compounds were extracted from the soil samples into the solvent using the aqueous-organic system, or modified solvent followed by the Florisil cleanup, the compounds were reacted with organometallic sodium to strip away the chloride. The resulting chloride ions were then quantified using the chloride specific electrode in the L2000. The L2000 converts the chloride content to the equivalent amount of PCB Aroclor (specified by the user) and displays the value on a digital readout. Samples can also be quantified with the total chloride setting. When the chloride setting is used, the chloride reading is converted to a specific PCB Aroclor concentration using the chloride content in the identified Aroclor.

A portion of each soil sample was weighed into a tray and dried overnight. The calculated water content was used to adjust the L2000 results for the wet soil to the PCB concentration in an equivalent amount of dry soil. The clumps of dried soil samples were broken up then extracted with both solvent systems and re-analyzed using the L2000. Based on the results of the soil samples analyzed using the L2000, 10 percent of the samples where PCBs were not detected and all samples testing positive (>2 ppm) were analyzed using U.S. EPA SW-846 Methods 8080/3540 (GC with Soxhlet extraction).

RESULTS and DISCUSSION

As summarized in Table 1, the average water content of 71 clay samples collected from the soil borings was 13%. Also summarized in Table 1 are the PCB Aroclor 1248 concentrations detected in 71 wet soil samples after extraction using the aqueous-organic solvent extraction method and L2000 analysis, the fraction of solids in the soil, calculated concentrations of PCB Aroclor 1248 in an equivalent amount of dry soil, and the PCB Aroclor 1248 concentration determined by GC after Soxhlet extraction.

Summarized in Table 2 are the PCB Aroclor 1248 concentrations of 16 dry soil samples determined using GC following Soxhlet extraction and the L2000 following extraction with the aqueous-organic system.

Table 3 summarizes the PCB Aroclor 1248 concentrations detected in 42 wet and dry soil samples after extraction using the aqueous-organic solvent extraction method with Florisil cleanup column and L2000 analysis. Included on the Table 2 are the fraction of solids in the soil, calculated concentration of PCB Aroclor 1248 in an equivalent amount of dry soil, and the PCB Aroclor 1248 concentration determined by GC.

The PCB concentration detected in each wet and dry soil sample as quantified by L2000 (with and without the Florisil cleanup column) was plotted against data obtained using U.S. EPA SW-846 Method 8080. Standard residual analyses were done on the data to identify outliers. Linear regression analysis yielded a value for the slope, intercept, and regression coefficient (R^2). The slope of each plot is an indication of the extraction efficiency of the solvent system in wet and dry clay; and a non-zero intercept would indicate any systematic bias. The correlation between the L2000 and GC data was represented by the R^2 value. Data plots for soil samples collected during this study are shown in Graphs 1 through 4.

Graph 1 is a plot of PCB Aroclor 1248 concentrations of the 71 wet soil analyses determined using the L2000 following extraction with the aqueous-organic solvent system versus the PCB Aroclor 1248 concentration quantified by Soxhlet extraction and GC. Four outliers (GP104-S2, GP106-S4, GP130-S4, and GP140-S5) were excluded from the plot based on results from standard residual analysis. Despite the rather high water content, the aqueous-organic solvent system (without the Florisil cleanup column) yielded a 78% PCB extraction efficiency. The correlation between the GC and L2000 field methods was 0.93.

Regression analysis of the data shown in Graph 1 using a 95% confidence level illustrates the intercept of the plot is statistically equivalent to zero. The slope, however, is not statistically equal to one. Since solvent extraction systems generally cannot achieve the same efficiency as the laboratory Soxhlet extraction method, the “non-one” slope was not surprising. The high correlation with the reference method indicates that the extraction efficiency is repeatable. The L2000 result can, therefore, be corrected using the known extraction efficiency. Furthermore, if an environmental professional establishes that the extraction efficiency of PCBs from their particular soil is significantly different from the value presented here, the L2000 results can be corrected using a site-specific correction.

Graph 2 is a plot of the 16 dry soil analyses summarized in Table 2. Plotted in Graph 2 are the Aroclor 1248 concentrations determined using the L2000 following extraction using the aqueous-organic solvent system; versus the Aroclor 1248 concentration quantified by GC following Soxhlet extraction. One outlier (GP103-S4) was excluded from the plot based on results from standard residual analysis. The aqueous-organic solvent system (without the Florisil cleanup column) yielded a 77% PCB extraction efficiency.

Regression analysis of the data shown in Graph 2, results in an intercept that is statistically equivalent to zero at a 95% confidence level, indicating insignificant bias. As with the wet soil, and for the same reasons, the slope is not statistically equal to one. The regression coefficient of 0.97 demonstrates an excellent correlation between the data

generated using the L2000 and GC.

Graphs 3 and 4 are plots of the 42 wet and dry soil analyses summarized in Table 3. Plotted in Graph 3, for the wet soil samples, and Graph 4, for the dry soil samples, are the Aroclor 1248 concentrations determined using the L2000 following extraction using the aqueous-organic solvent system and Florisil cleanup column versus the Aroclor 1248 concentration quantified by GC following Soxhlet extraction. There were no outliers in the resulting data set. The aqueous-organic solvent system with the Florisil cleanup column yielded a 73% PCB extraction efficiency.

Regression analysis of the data shown in Graphs 3 and 4 using a 95% confidence level illustrates that the intercept of the plots are statistically equivalent to zero. As with Graphs 1 and 2, and for the same reasons, the slopes are not statistically equal to one. The regression value of 0.88 for the wet soil samples and 0.91 for the dry soil samples demonstrates a good correlation between the data generated using the L2000 and GC.

CONCLUSION

Although the PCBs present in the soil at the industrial property were associated with diesel range organics, the PID used to identify hydrocarbon-contaminated soil during excavation did not detect the co-contaminating PCBs. Further laboratory analysis, established the presence of Aroclor 1248. Recognizing that the PCBs, in addition to the diesel range organics, would need to be delineated in the excavated soil, GZA researched the feasibility of utilizing different PCB field screening techniques. Few field screening methods were found to have a reputation of being capable of quantifying PCBs in real-time in complex, co-contaminated matrices such as the red clay soil found at the industrial site.

Prior to this study, the L2000 was demonstrated to be an effective PCB field-screening tool in a variety of soil types including sand and several different clay soils. This particular study illustrates the use of two novel solvent systems to extract PCBs from complex clay matrices. Both solvent systems demonstrated highly efficient (>73%) extraction efficiencies of PCBs from lacustrine red clay soil when compared with the Soxhlet extraction method. The extraction efficiencies reported using the new solvent systems are greater than the extraction percentages reportedly achievable by other field screening methods.

The L2000, in previous studies, has also been shown to reliably quantify PCBs in the presence of co-contaminating hydrocarbons. With the new modified solvent system and Florisil column, the user can efficiently extract and reliably quantify PCB Aroclors in the presence of some non-PCB halogenated solvents.

The information gained by this study indicates that the L2000 can be used as a valuable PCB field-screening tool in a variety of difficult matrices and situations. This should heighten environmental engineers confidence in field data.

Table 1: Quantification of Aroclor 1248 in Wet Soils by USEPA Methods 8080/3540 Compared to Extraction by Aqueous-Organic System and L2000 Analysis				
Sample ID	as 1248 Wet Weight L2000(ppm)	Fraction Solid	as 1248 Dry Weight (Calc) L2000(ppm)	Soxhlet GC 8080 1248 (ppm)
GP101-S2	1.05	0.87	1.21	0.19
GP103-S2	1065.75	0.87	1224.50	1450.00
GP103-S3	970.38	0.88	1102.79	1320.00
GP103-S4	437.50	0.87	501.35	682.00
GP103-S5	137.81	0.87	159.31	252.00
GP104-S2	1190.88	0.88	1360.13	3540.00
GP104-S3	712.25	0.88	811.02	1096.00
GP104-S4	615.13	0.87	707.24	613.00
GP104-S6	1.84	0.88	2.09	0.41
GP105-S3	70.79	0.87	81.74	114.00
GP105-S4	389.38	0.87	449.71	466.00
GP105-S6	1.93	0.87	2.21	1.20
GP106-S3	148.75	0.86	172.87	334.00
GP106-S4	93.98	0.88	106.23	734.00
GP106-S5	259.00	0.87	299.10	429.00
GP107-S2	238.88	0.88	271.75	518.00
GP107-S3	156.54	0.88	177.76	292.00
GP107-S4	136.15	0.86	157.48	163.00
GP108-S2	142.36	0.85	168.42	288.00
GP110-S2	1.14	0.86	1.32	0.31
GP113-S1	9.01	0.93	9.66	4.10
GP113-S2	23.54	0.86	27.39	22.00
GP114-S1	15.66	0.96	16.31	1.30
GP114-S2	20.13	0.88	22.97	0.17
GP115-S2	2.01	0.85	2.35	9.20
GP117-S2	2.01	0.86	2.34	3.00
GP117-S3	369.25	0.88	419.71	451.00
GP117-S4	232.75	0.89	261.75	344.00
GP117-S5	138.16	0.87	158.63	307.00
GP118-S3	62.74	0.88	71.21	63.00
GP118-S4	33.08	0.88	37.79	128.00
GP118-S5	147.61	0.88	167.77	40.00
GP119-S2	10.33	0.89	11.55	11.00
GP119-S4	81.81	0.88	93.15	180.00
GP120-S5	12.69	0.87	14.57	100.00
GP121-S2	2.45	0.86	2.86	0.07
GP123-S2	2.36	0.87	2.71	0.40
GP124-S2	5.60	0.88	6.37	11.00
GP124-S4	238.00	0.88	271.99	396.00
GP125-S2	140.35	0.85	165.31	159.00
GP127-S4	1.84	0.88	2.10	0.11
GP128-S6	2.71	0.87	3.11	0.03
GP129-S4	771.75	0.87	891.88	1113.00
GP129-S6	3.85	0.87	4.44	0.67

Table 1: Quantification of Aroclor 1248 in Wet Soils by USEPA Methods 8080/3540 Compared to Extraction by Aqueous-Organic System and L2000 Analysis				
Sample ID	as 1248 Wet Weight L2000(ppm)	Fraction Solid	as 1248 Dry Weight (Calc) L2000(ppm)	Soxhlet GC 8080 1248 (ppm)
GP130-S2	4.81	0.87	5.55	26.10
GP130-S4	735.88	0.87	843.94	542.00
GP131-S1	2.63	0.85	3.07	2.40
GP132-S4	0.70	0.87	0.81	0.06
GP134-S2	3.33	0.87	3.81	0.72
GP136-S2	3.06	0.92	3.33	1.30
GP137-S2	4.99	0.85	5.86	2.30
GP138-S3	54.25	0.87	62.37	45.00
GP138-S5	210.88	0.89	236.29	119.00
GP139-S2	1.23	0.87	1.41	0.55
GP139-S5	46.73	0.87	53.52	42.00
GP139-S6	142.45	0.87	163.51	445.00
GP140-S3	4.64	0.87	5.30	12.00
GP140-S4	280.88	0.86	324.76	116.00
GP140-S5	954.63	0.87	1096.68	760.00
GP140-S6	52.68	0.88	60.03	70.00
GP141-S1	35.70	0.88	40.58	27.00
GP141-S3	8.31	0.88	9.43	9.10
GP141-S4	5.86	0.86	6.81	3.10
GP141-S5	12.60	0.87	14.52	20.00
GP142-S4	4.03	0.88	4.60	12.00
GP143-S2	20.56	0.87	23.69	38.00
GP143-S3	102.03	0.87	116.86	374.00
GP143-S4	339.50	0.88	386.57	646.00
GP144-S4	54.43	0.87	62.44	97.00
SQ110896-2	15.93	0.83	19.15	19.20
SQ110896-3	3.24	0.94	3.46	3.40

Table 2: L2000 Analysis Using Aqueous-Organic Extraction in Dry Soil Compared to GC 8080 Analysis

Sample ID	Aroclor 1248 in Dry Soil L2000(ppm)	Aroclor 1248 Soxhlet w/ GC 8080 (ppm)
GP101-S2	1.575	0.19
GP103-S4	880.25	682
GP104-S3	776.125	1096
GP104-S6	0.6125	0.41
GP105-S3	32.55	114
GP105-S6	0.9625	1.2
GP106-S4	678.125	734
GP107-S3	253.75	292
GP108-S2	139.65	288
GP110-S2	0.175	0.31
GP113-S2	16.7125	22
GP114-S2	1.6625	0.17
GP115-S2	7.7875	9.2
GP117-S2	4.2	3
GP117-S4	307.125	344
GP118-S5	43.4	40

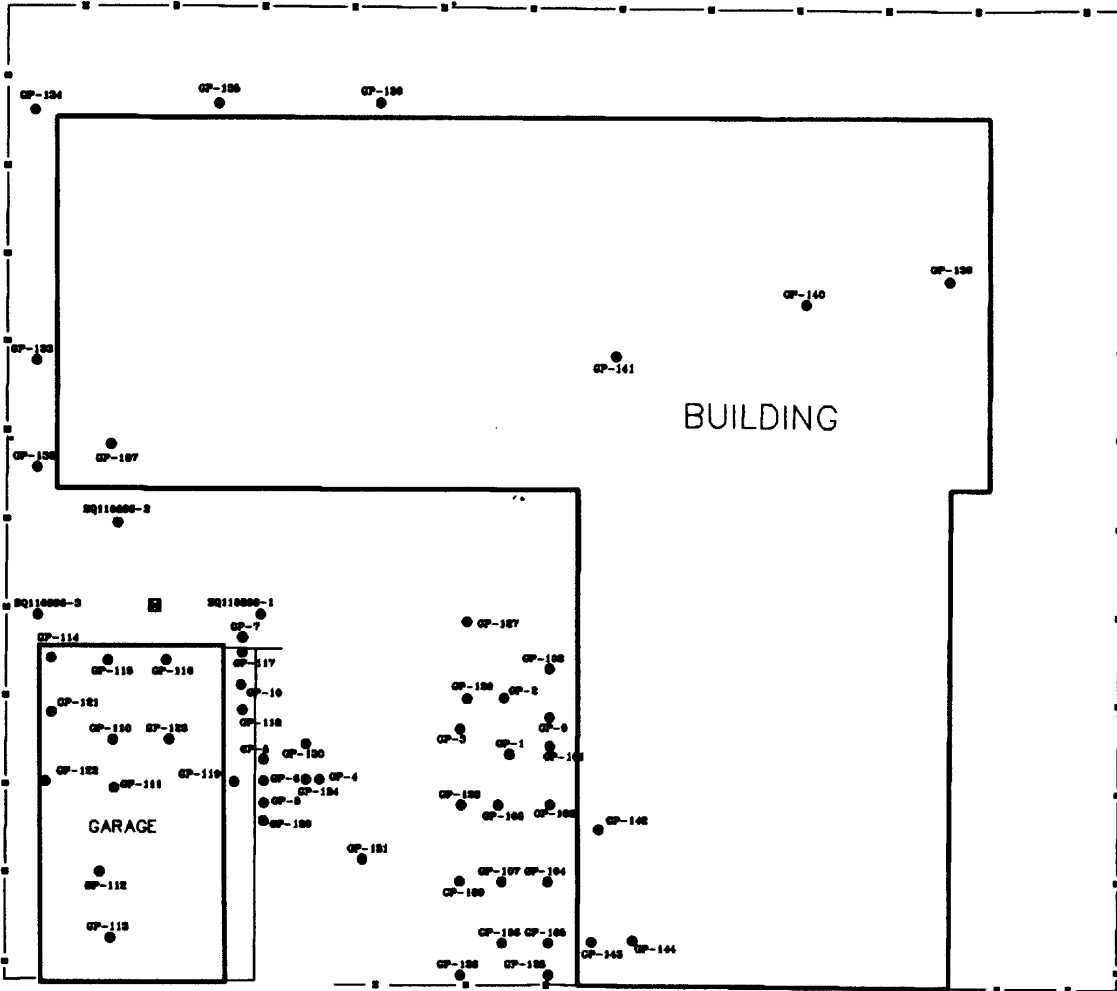
Table 3: L2000 Analysis Using Modified Extraction/Florisil Filter Compared to GC Method 8080 in Wet and Dry Soils					
Sample ID	Aroclor 1248 Wet Weight L2000 (ppm)	Fraction Solid	Aroclor 1248 Dry Weight (Calc) L2000 (ppm)	Aroclor 1248 in Dry Soil L2000 (ppm)	Aroclor 1248 Soxhlet w/ GC 8080 (ppm)
GP103-S2	407.2	0.86	520.9	1058.8	1450.0
GP103-S3	721.4	0.87	912.1	1029.9	1320.0
GP103-S5	50.2	0.87	63.5	157.9	252.0
GP104-S2	5884.4	0.86	8601.8	>2000	3540.0
GP104-S4	539.4	0.87	681.9	586.2	1096.0
GP106-S5	27.2	0.87	34.4	143.4	429.0
GP107-S2	352.6	0.88	440.8	637.2	518.0
GP107-S3	204.8	0.88	255.9	316.7	292.0
GP107-S4	52.6	0.86	67.3	75.6	163.0
GP108-S2	67.8	0.83	89.9	48.1	288.0
GP113-S2	3.1	0.85	4.0	3.4	22.0
GP117-S3	344.2	0.86	440.3	370.6	451.0
GP117-S4	306.6	0.87	387.7	273.4	344.0
GP117-S5	88.3	0.87	111.6	263.7	307.0
GP118-S4	52.5	0.89	64.9	75.4	128.0
GP118-S5	13.0	0.88	18.5	9.1	40.0
GP119-S4	112.2	0.87	141.8	148.2	180.0
GP120-S5	17.4	0.71	27.0	9.2	100.0
GP124-S2	5.3	0.85	6.8	9.4	11.0
GP125-S2	5.8	0.87	7.3	69.3	159.0
GP127-S2	14.8	0.87	18.7	0.3	
GP128-S2	2.6	0.87	3.3	0.5	
GP129-S4	797.5	0.87	1008.3	962.5	1113.0
GP129-S6	1.9	0.84	2.5	0.1	0.7
GP130-S2	1.5	0.88	1.9	1.7	26.1
GP130-S4	396.7	0.87	501.6	371.5	542.0
GP131-S4	0.3	0.87	0.3	1.4	
GP133-S4	0.3	0.85	0.3	0.4	
GP136-S2	2.1	0.93	2.5	12.5	1.3
GP137-S2	2.3	0.86	2.9	3.4	2.3
GP138-S3	71.8	0.84	94.1	101.7	45.0
GP139-S1	0.4	0.94	0.4	0.8	
GP139-S4	0.3	0.86	0.3	0.5	
GP139-S5	11.2	0.87	14.2	47.4	42.0
GP139-S6	268.6	0.88	335.8	463.0	445.0
GP140-S4	36.2	0.86	53.0	54.9	116.0
GP140-S5	290.5	0.87	419.8	436.0	760.0
GP140-S6	60.2	0.87	87.0	26.6	70.0
GP143-S2	44.0	0.86	56.3	138.6	38.0
GP143-S3	100.1	0.88	125.1	269.5	374.0
GP143-S4	296.6	0.86	433.6	847.0	646.0
GP144-S4	70.3	0.87	88.8	128.5	97.0



NORTH STREET

GRAVEL ROAD

EAST AVENUE



SOUTH STREET

LEGEND

- GEOPROBE BORINGS COMPLETED BY OTHERS
- GEOPROBE BORING COMPLETED BY GZA
- - - FENCE

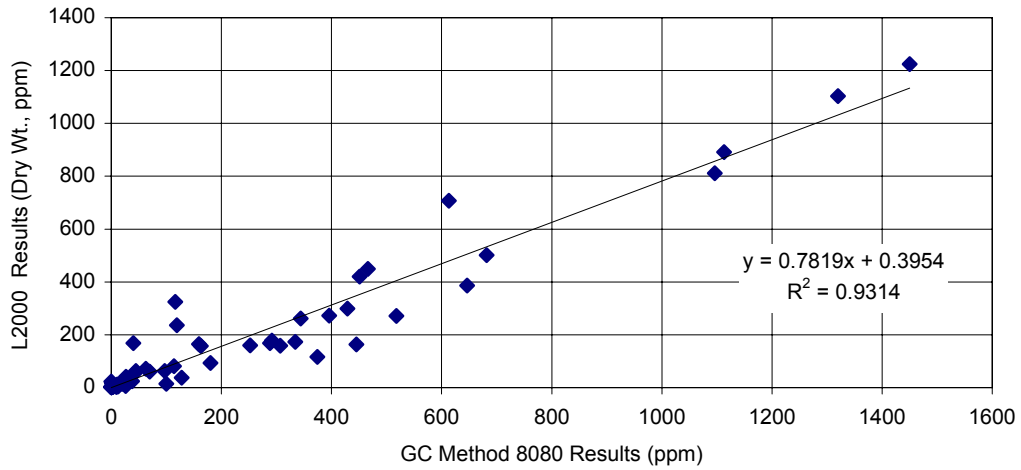
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SITE PLAN
INDUSTRIAL PROPERTY
MIDWEST USA

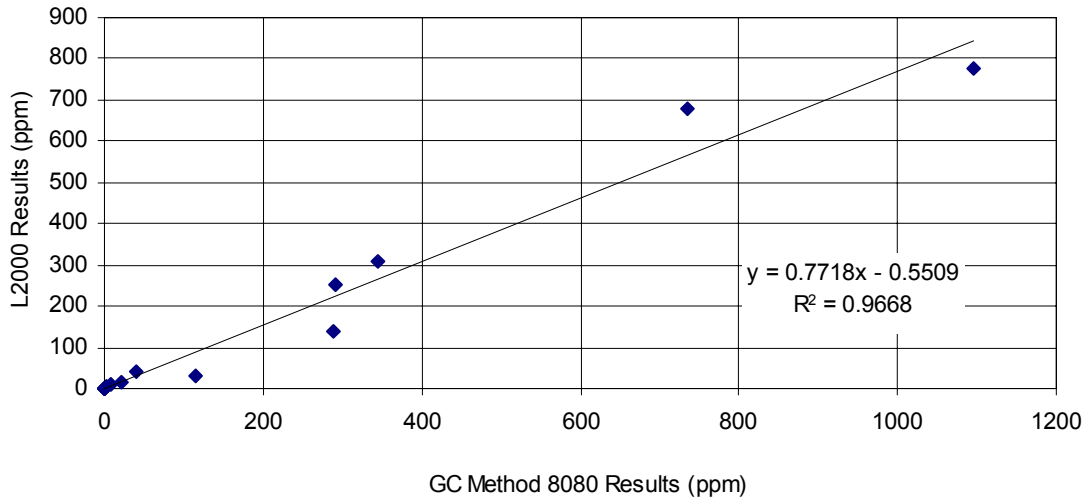
SCALE IN FEET
 0 20 40
 APPROXIMATE
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FIGURE NO.
 1

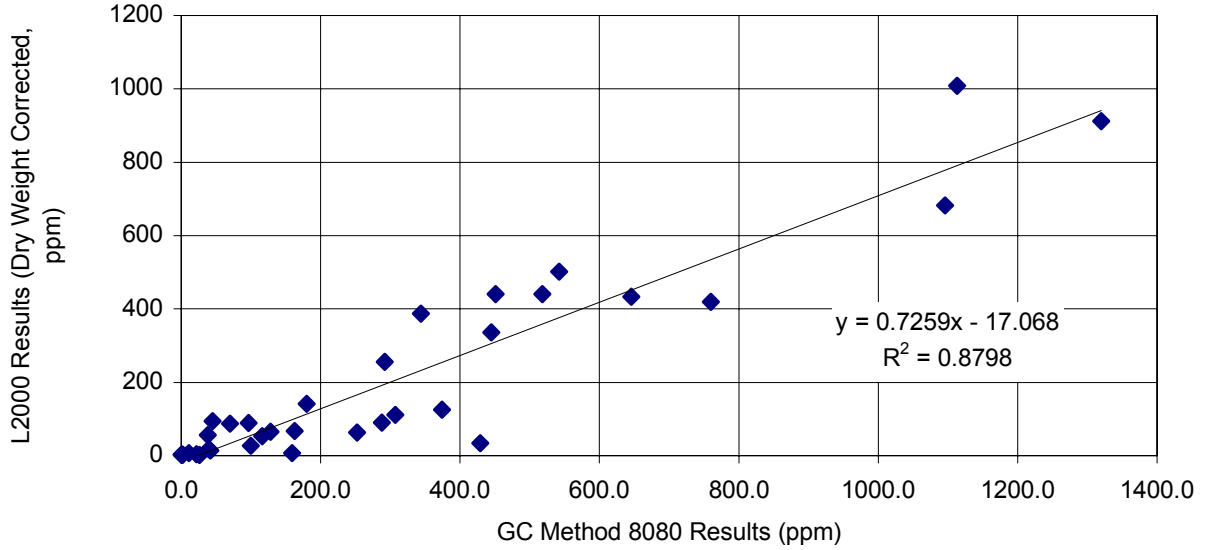
Graph 1: L2000* versus GC Method 8080 Quantification of Aroclor 1248 in Wet Soils
(*These samples were extracted with the aqueous-organic solvent)



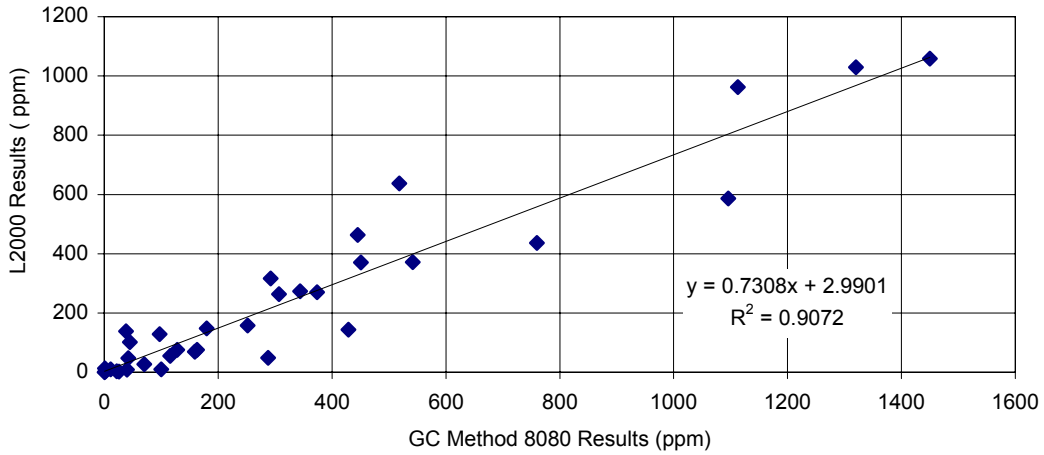
Graph 2: L2000* versus GC Method 8080 Quantification of Aroclor 1248 in Dry Soils
(*These samples were extracted with the aqueous-organic solvent)



Graph 3: L2000* versus GC Method 8080 Quantification of Aroclor 1248 in Wet Soils
(*These samples were extracted with the modified solvent and filtered through a florasil column)



Graph 4: L2000* versus GC Method 8080 Quantification of Aroclor 1248 in Dry Soils
(*These samples were extracted with the modified solvent and filtered through a florasil column)



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