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Wisconsin Groundwater Management Practice Monitoring Project No. 5

GROUNDWATER
Wisconsin's
buried treasure

Wisconsin Department of Natural Resources

VOC Contamination at Selected Wisconsin Landfills — Sampling Results and Policy Implications

Janet R. Battista
Hydrogeologist

Johnston P. Connelly
Groundwater Assessment Unit Leader

Wisconsin Department of Natural Resources
P.O. Box 7921
Madison, Wisconsin 53707

June, 1989

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Authors: Janet R. Battista, Hydrogeologist

Johnston P. Connelly, Groundwater Assessment Unit Leader,
Bureau of Solid and Hazardous Waste Management

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VOC CONTAMINATION AT SELECTED WISCONSIN LANDFILLS-
SAMPLING RESULTS AND POLICY IMPLICATIONS

Janet R. Battista
Hydrogeologist

Johnston P. Connelly
Groundwater Assessment Unit Leader

Wisconsin Department of Natural Resources
P.O.Box 7921
Madison, Wisconsin 53707

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State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Carroll D. Besadny
Secretary

BOX 7921
MADISON, WISCONSIN 53707

IN REPLY REFER TO: 4400

Open Letter to DNR Staff, Consulting Firms,
Other State Agencies and Interested Individuals:

SUBJECT: Volatile Organic Compounds in Groundwater at Wisconsin Landfills

This document is intended to be used by Department staff and others concerned with groundwater contamination from volatile organic compounds (VOCs) originating at landfills. It summarizes the second part of a two part VOC study. In the initial study (Friedman, 1988) the Department found VOC contamination primarily at unlined municipal landfills. As a result, we did follow-up VOC sampling at 19 additional unlined municipal landfills. To increase our data on VOCs at industrial landfills we also sampled for VOCs at six additional industrial sites. The executive summary presents the conclusions and recommendations of the follow-up study.

If you have any questions about the report, please contact Janet Battista at (608) 267-3533 or Jack Connelly at (608) 267-7574.

Sincerely,

Lyman F. Wible

Lyman F. Wible, Administrator
Division for Environmental Quality

LFW:JC

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- the landfill owners and consultants who cooperated in this study

- the Solid Waste District staff for collecting the groundwater samples and for providing landfill site information

- the Wisconsin State Laboratory of Hygiene staff for analyzing the groundwater samples

- the Solid Waste Bureau staff for providing site information and for contributing valuable suggestions and criticism.

This study was funded cooperatively through the Bureau of Water Resources Management using groundwater monitoring monies from the State Groundwater Fund.

EXECUTIVE SUMMARY

The Wisconsin Department of Natural Resources, Bureau of Solid and Hazardous Waste Management (BSHWM) has completed the second part of a two part study to evaluate the need for routine volatile organic compound (VOC) sampling at Wisconsin landfills. As part of the initial study (Friedman, 1988) Department staff sampled monitoring wells for VOCs at 26 municipal and industrial landfills constructed with various designs from 1985 to 1987. We determined from the initial study that unlined municipal landfills had the most VOC contamination and that industrial landfills in Wisconsin had very little. This report summarizes our findings from the follow-up VOC study. We're also reporting the findings from a survey we did of 48 states and two Canadian provinces on what type of VOC sampling they are requiring. Finally, we make VOC sampling recommendations for all types of solid waste landfills in Wisconsin.

CONCLUSIONS

1. Landfills with natural attenuation designs are more likely to have VOC contaminated groundwater than those designed with containment and leachate collection.

2. Landfills taking municipal solid waste are more likely to have VOC contamination than those taking industrial solid waste.

   NOTE: The industrial sites we reviewed were primarily papermill sludge landfills, these being the most common industrial solid waste sites in Wisconsin. Industrial solid waste in other states may have substantially different chemical composition.

3. Landfills with waste volumes of less than 50,000 cubic yards are less likely to have VOC contamination than those with larger volumes.

4. VOC monitoring in other states and provinces ranges from no sampling requirements to quarterly sampling required at regulated landfill sites.

5. Inorganic parameters are useful in predicting VOC contamination.

RECOMMENDATIONS

Based on the conclusions from this study and the Friedman (1988) study, we recommend that the BSHWM require facilities to do the following.

1. Establish background VOC levels at all groundwater monitoring wells.
2. Monitor leachate for VOCs annually.
3. Monitor collection lysimeter samples for VOCs annually.
4. Monitor selected groundwater points at the following frequencies:
   a. every five years for landfills with containment and leachate collection
   b. for landfills without containment and leachate collection:

      -annually at landfills with capacities greater than 500,000 cubic yards

      -biannually at landfills with capacities less than 500,000 cubic yards
   c. for all landfills, regardless of design, waste type, or approval date, where inorganic parameters are elevated or where VOCs have been detected in groundwater--at an increased frequency based on degree and extent of contamination.
5. Monitor for VOCs at an increased frequency (monthly or quarterly) at any landfill for a limited time period to define contamination or to confirm questionable VOC data.
6. Continue sampling for inorganic indicator parameters.
7. When evaluating possible groundwater contamination at a landfill, consider increases in chloride above background rather than only those values above the secondary drinking-water standard or other set standards.
8. Add the first 6 compounds listed in Table 2B to WDNR's list of compounds required for laboratory VOC quantification.

I. INTRODUCTION

This report presents the results of a study of volatile organic compound (VOC) contamination at 25 solid waste landfills in Wisconsin. The study represents continuing interest by the Bureau of Solid and Hazardous Waste Management in the problem of groundwater contamination originating at landfills. This project complements and expands on an earlier Bureau study (Friedman, 1988) which focused on VOCs in leachate and groundwater at landfills of various designs. For this study, we concentrate on those sites found by Friedman to be the most vulnerable to groundwater contamination--natural attenuation, or unengineered sites. Of these sites, we chose 19 municipal, solid waste landfills most containing less than 500,000 cubic yards of waste. Landfills in this size class comprise the vast majority of Wisconsin's approximately 850 licensed solid waste facilities. We also chose six industrial solid waste landfills to add to our data pool on Wisconsin industrial sites.

In the following sections, we evaluate the laboratory results which detail the VOC content of groundwater samples collected at these 25 sites. The evaluation emphasizes the extent of VOC contamination, the reliability of the data, and the occurrence of individual VOCs. For policy purposes, the study continues an earlier assessment of inorganic parameters in predicting VOC presence, and summarizes results of a survey of VOC sampling requirements in other states. Finally, the authors make recommendations for VOC monitoring at all types of municipal and industrial landfills in Wisconsin.

A. BACKGROUND

VOCs are potentially toxic, synthetic compounds found in widely used household, institutional, commercial and industrial products. As their containers decompose, these products release VOCs into a landfill or dump site. In the subsoil where light and oxygen are limited, VOCs resist biological and chemical decay. In addition, because they resist adsorption by fine-sized particles, VOCs are highly mobile and can easily migrate through soil and sediment to groundwater. The belief that soil readily attenuates or destroys pollutants does not hold for VOCs.

Our study shows that VOCs have reached groundwater beneath many Wisconsin landfills where no leachate barriers or leachate collection systems are in place. This poses severe problems for communities with landfills which do not have leachate collection systems. These landfill owners must balance the risks of groundwater contamination with financial constraints. Many communities cannot afford expensive well installation and VOC sampling and analysis. We hope that this project will help department staff and others to prioritize susceptible landfills for further evaluation, will help them better interpret the groundwater data they receive, and will provide support in communications with landfill owners, consulting firms, and community planners.

B. OBJECTIVES

In the following paragraphs, we first describe our procedures, then present our results and conclusions by addressing the study's objectives:

Research Objectives

Our research objectives include evaluating the following:

1. the extent of VOC contamination at 19 small- to medium-sized municipal and six industrial landfills
2. the occurrence of individual VOCs, including how often each exceeds Wisconsin standards
3. the reliablility of the data
4. the relationship between site conditions and VOC contamination
5. the usefulness of inorganic parameters in predicting VOC presence.

Policy Objectives

Our policy objectives include:

1. summarizing other states' requirements for VOC monitoring at solid waste landfills
2. proposing policy recommendations for VOC monitoring at Wisconsin solid waste landfills.

II. PROCEDURES

A. LANDFILL SELECTION

The Wisconsin Department of Natural Resources (WDNR) central office staff, district solid waste specialists, and district hydrogeologists, jointly selected the landfill sites used in this study. These sites include 19 small to medium-sized municipal landfills and 6 industrial solid waste landfills. All but one of the municipal landfills contain less than 500,000 cubic yards of waste. We selected the 19 municipal sites to represent as many different kinds of natural attenuation solid waste landfill as possible across the state. In addition to location, we chose particular sites because either they had a history of inorganic groundwater contamination, or they were of concern for other reasons, such as proximity to private wells.

The six industrial landfills were selected to represent several kinds of industrial waste, primarily papermill sludge generated by various processes. Except for one sludge lined site, the industrial landfills are also located at unengineered, natural-attenuation sites. Figure 1 shows the location of the chosen industrial and municipal landfills, and Table 1 lists the site conditions they represent.

Because the landfills represented in this study do not represent a random selection, our evaluation does not attempt to characterize the overall extent of VOC contamination in Wisconsin. Rather, we designed the study to reveal as much information as possible about VOC occurrence based on a limited number of selected sites to aid the bureau staff in prioritizing other similar sites for further evaluation.

B. GROUNDWATER SAMPLING

The district staff chose at least one well thought to be upgradient to groundwater flow, and two or more downgradient wells at each site. Independent consulting firms had previously installed these wells to WDNR specifications. The wells, constructed of 1 1/2 to 2 inch polyvinylchloride pipe, represent a mix--those most recently installed were constructed using flush threaded joints while older wells were often constructed using couplings and glue. We have noted in the report those cases where we suspected that glue may have contributed to VOC presence in the groundwater samples. Most wells sampled for contaminant analysis in this study are water table observation wells with 10 to 15 foot screens intersecting the water table.

Ten out of the 103 total municipal and industrial wells sampled are piezometers with 2 to 5 foot screens sealed below the water table. Almost all wells occur within 50 to 150 lateral feet of the landfill waste.

Although many different staff personnel sampled the wells, they each followed established WDNR protocol for VOC sampling (Lindorff et al, 1984) which includes the following:

-purging each well to remove a quantity of water equal to four well volumes

-using teflon sampling bailers

-rinsing the bailers three times with laboratory grade distilled water between samples

-filling four vials from each bailer sample, with minimum disturbance and leaving no air space.

For quality control, the sampling crew brought a trip blank on each trip, and collected a duplicate sample and field blank at almost all sites. We describe and interpret the results from analysis of these samples in the section below on data reliability.

C. LABORATORY ANALYSIS

The Wisconsin State Laboratory of Hygiene (WSLH) analyzed each groundwater sample and each field and trip blank following an established two-step procedure for VOCs. The following several paragraphs summarize this procedure and examine its bearing on this study.

Procedure: The first procedural step includes a cryogenic-headspace technique for removing volatiles from a sample vial followed by gas chromatography/mass spectroscopy to screen for VOCs present (EPA method 624). Any VOCs present in concentrations above the WSLH reporting limit are recorded by the laboratory staff. However, only selected compounds (Table 2A) are quantified in the second procedural step. This next step includes quantifying the VOCs discovered during the screening process: it follows EPA methods 601 and 602 whereby nitrogen gas purge-and-trap of VOCs preceeds gas chromatography. To quantify each VOC, the staff compares a computer generated curve calibrated using a laboratory grade standard VOC with a known retention time, to a curve produced for the unknown VOC. The laboratory keeps a library of standards-curves and only quantifies those VOCs in the library.

Cautionary Note: In general, proper interpretation of VOC data requires an understanding of the methods involved, as well as knowledge of the laboratory's capacity to quantify all compounds of concern. Confusion may result from data comparisons among various studies unless laboratory variation is considered. For example, Minnesota (1983) found the commonly used solvent acetone, in leachate at 100% of solid waste sites, and in groundwater samples at 46% of the sites they studied. However, the Wisconsin State Laboratory does not quantify the acetone content of samples.

In addition to acetone, a number of VOCs commonly found at solid waste landfills are neither quantified nor verified to be present by the WSLH (Table 2B). This laboratory does, however, indicate in a report letter (Appendix H) those cases in which unquantified VOCs are detected in the screening process. As Table 2B shows the WSLH did not quantify at least 6 VOCs detected in numerous samples collected at a high percentage of the sites. Although we assume that these unquantified VOCs are present at the study's landfills, without a specific quantity or final verification we weren't able to include them in our tables.

Precision and Accuracy: Specific information on the precision and accuracy of the data for each VOC is available on request.

III. RESEARCH OBJECTIVES: RESULTS AND DISCUSSION

A. HOW EXTENSIVE IS THE VOC CONTAMINATION?

Although the landfills analyzed in this study do not represent a random sampling of municipal landfills in the state, we were interested in the extent of the VOC groundwater contamination at the selected sites for several reasons. First, these sites are typical of many other natural attenuation landfills in Wisconsin, some of which are monitored for VOCs, but many of which are not. Second, we hoped that our study would help district and central office staff better review existing and proposed monitoring at these particular sites. Finally, we planned to use the information on the extent of VOC contamination in conjunction with landfill site characteristics in order to better structure monitoring requirements for all municipal and industrial solid waste sites in Wisconsin.

Municipal Landfill Sites: We asked several questions concerning the extent of VOC contamination:

1. How many sites have contaminated wells?

2. How many wells at these sites have VOC detects?

3. Where are the wells located in relation to groundwater flow direction?

4. Is there a difference between the extent of contamination found in the water table observation wells compared to piezometers?

The district staff sampled groundwater at 19 preselected small to medium-sized municipal solid waste landfills. We found VOC concentrations above the WSLH reporting limit in groundwater at 15 of them. At these landfills the staff sampled a total of 79 monitoring wells of which 32 had VOC detects. To characterize the position of contaminated wells with respect to groundwater flow direction we analyzed site reports and groundwater head data. Of the 79 wells, 18 occur upgradient to groundwater flow, 51 occur down- or sidegradient to flow and 10 occur at sites where groundwater flow patterns are difficult to define. Flow patterns at sites having unknown gradients were influenced by groundwater mounding beneath the landfill or by seasonal fluctuations. VOCs were detected in 24 of the 51 down- or side-gradient wells, and in one of the 18 up-gradient wells. The question of VOC presence in relation to groundwater flow is not trivial. Because VOCs exhibit solubilities and density patterns distinct from the bulk of groundwater, their flow patterns may be equally distinct. These data, however, suggest that almost all the VOC contamination does in fact occur downgradient. Included in the 79 total wells were four piezometers finished below the water table; none of the samples from the piezometers contained VOC detects.

The data indicate that VOCs do migrate to groundwater at unengineered small- to medium-sized municipal solid waste landfills. As indicated in correspondence on file, only two of the sampled sites have histories of suspected large scale hazardous waste dumping (#130 and #057). As far as is known the rest have accepted only household, commercial, and institutional waste. However, hazardous substances do exist in these waste types, as part of many small-sized solvent, fuel, paint and refinishing containers, for example.

Industrial Landfill Sites: The district staff sampled groundwater at six preselected industrial solid waste landfills: four containing pulp and papermill sludge, one containing automobile shredder waste, and one containing demolition waste, foundry sand, and unidentified industrial waste (Table 3). Two of the six industrial landfill sites had VOC detects; these detects occurred in a total of three monitoring wells--one of the wells is at a papermill sludge landfill, and the other two are at the landfill which has accepted unidentified industrial solid waste. Besides its history of accepting unknown waste, this site may be influenced by groundwater contamination originating at two nearby municipal landfills.

A comparison between the number of VOCs per well at the municipal sites and the number of VOCs per well at the industrial sites (Table 1) indicates that the industrial landfills have fewer contaminated wells than the municipal landfills, as well as having fewer VOCs in each well.

Papermill-Sludge Landfills: In the previous WDNR VOC study, Friedman (1988) found that only one of four papermill sludge landfills had VOC detects. We identified the pulp-generating process which produced the sludge in this landfill, and chose four addditional sites with similarly generated sludge for our follow-up study. At these additional papermill sites, only one well had any VOC detects; this well contained only one detect--380 ug/l of tetrahydrofuran. Although the construction history of this well is unknown, tetrahydrofuran is a frequent component of the glue once used to install monitoring wells in Wisconsin. Because tetrahydrofuran is the only VOC found at this site, we attribute its presence to the pipe bonding glue.

In general, when compared to monitoring wells at the municipal sites we studied, few of the wells at the industrial sites, contained VOCs in groundwater. Table 3 summarizes this data, including waste type and extent of the contamination, at the six industrial landfill sites we sampled. When combined with Friedman's data on industrial sites, only one of eight total papermill sludge landfills had VOCs clearly attributable to the landfill waste. It should be noted that papermill sludge is the most common industrial solid waste in Wisconsin.

B. HOW OFTEN ARE INDIVIDUAL VOCs DETECTED AND HOW OFTEN DO THEY EXCEED WISCONSIN GROUNDWATER STANDARDS?

We were interested in determining which individual VOCs were detected in our study samples for several reasons. First, some VOCs have more serious health and environmental effects than others. Identifying how frequently, and where, these VOCs occur can help us prioritize landfill cleanup efforts. Second, laboratory analysis of VOCs may one day evolve to the point at which individual VOCs can be identified, rather than the entire suite of VOCs by GC/MS, as is now the case. The present financial burden associated with VOC monitoring may be lessened, if only a few VOCs need be found. Third, knowing which are the most prevalent, and the most toxic VOCs could help in managing the waste stream entering solid waste landfills.

The WSLH found 18 different VOCs among the 113 samples they analyzed from our 19 selected municipal landfill sites. Tables 4A, 4B, and 4C list these VOCs and rank their frequency-of-occurrence as a percentage of the total number of groundwater samples, monitoring wells, and landfill sites, respectively, as well as by percentage of the contaminated samples, wells, and sites. Table 4D ranks the VOCs by maximum concentration.

Table 4A shows, for example, that only one sample out of 113 contained 1,2-Dichloropropane. Similarly, Table 4B indicates, for example, that more than two-thirds (67.9%) of the monitoring wells having any VOC detects contained 1,2-Dichloroethylene, and that 25% of all wells contained 1,1-Dichloroethane. According to Table 4C, there were 10 VOCs which occurred at over 60% of all of the municipal landfills with VOC contaminated groundwater. Table 4D ranks the VOC parameters according to the maximum concentrations found in any of the 113 samples. Four compounds, ethylbenzene, toluene, tetrahydrofuran, vinyl chloride, and 1,2-Dichloroethylene occurred in concentrations greater than 100 ug/l.

We determined which VOCs exceeded their Wisconsin groundwater standards because these standards reflect the potential for public health injury. Although the sampled wells are too close to the landfill waste to be used for drinking water, we wanted to know whether the VOCs commonly found at municipal landfills have potential health risks.

The monitoring wells occur within the state's legally defined landfill design-management-zone (DMZ). The state permits wells within this zone to exceed some of the state's groundwater standards.

Wisconsin has developed a two-tiered system of groundwater standards. The upper tier, called the enforcement standard is similar to federal maximum contaminant levels. This level is only enforced beyond the DMZ. The lower tier, which is set at a percentage of the enforcement standard, is designed to trigger a response before the enforcement standard is reached. Wisconsin takes less severe action if a groundwater standard is exceeded at wells within the DMZ than at wells beyond this limit.

Table 5 ranks those VOCs which have Wisconsin groundwater standards. Since not all the VOCs found at the study sites had Wisconsin standards at the time of writing, several VOCs which we found to occur frequently, do not appear on this list. The ranking in Table 5 is based on the number of monitoring wells which had VOCs detected in concentrations equaling or exceeding their Wisconsin standards--both enforcement standard (ES) and preventive action limit (PAL) (NR 140 Wis. Adm. Code). The table indicates, for example, that benzene exceeded its enforcement standard in 41% of all wells containing any detects, and that whenever it was detected benzene exceeded both its ES and PAL.

Comparisons between the Wisconsin groundwater standards and the laroratory reporting limits, indicate that whenever benzene, vinyl chloride, tetrachloroethylene, and trichloroethylene were detected, their concentrations exceeded the standards. Comparisons between the standards ranking (Table 5), and the frequency rankings (Tables 4A, 4B, and 4C), indicate that the most toxic VOC compounds were also among the most frequently occurring. For example, benzene and vinyl chloride, the two compounds which exceeded Wisconsin groundwater standards most often, were also among the four most frequently occurring compounds at all the municipal sites. Since the standards are an indication of human toxicity, this comparison shows which VOCs are most likely to pose health risks from landfill contamination.

C. HOW RELIABLE ARE THE DATA?

Assessment of data reliability is necessary to answer several crucial questions about any VOC study. These questions include the following:

1. Do the reported VOCs represent true constituents of goundwater or do they have a different source?

2. How reliable are the concentrations found?

3. Have we found all the VOCs present?

To determine whether the VOCs reported to be present by the laboratory were true groundwater constituents, we analyzed the results from trip blanks and field bailer blanks. A trip blank is a laboratory grade distilled water sample which accompanies the sample bottle to the field and back to the laboratory. The purpose of the trip blank is to determine if any of the sample bottles or collected samples have been contaminated with VOCs before or during sampling or shipping. VOC detects found in these blanks would indicate contamination from automobile exhaust or from contaminated distilled water, for example. None of the trip blanks supplied during this study had VOC detects.

A field bailer blank is a sample of laboratory grade distilled water which is processed through the sampling equipment in the same manner as the actual groundwater sample to determine if field cleaning procedures are adequate. VOC detects in the field bailer blanks would indicate inadequate bailer rinsing between collected field samples, or contaminated distilled water. Of 28 bailer blank samples representing 23 landfills, two samples had VOC detects. We suspect that the two contaminated samples came from contaminated distilled water used in the bailer rinsing procedure at sites #108 and #1751 only.

To determine how reliable the detected VOC concentrations were, we analyzed the results from duplicate samples. Duplicate samples are two separately labelled samples taken from the same bailer filled with groundwater at one time. Table 6 lists results from analysis of 15 duplicate samples collected for this and for the previous WDNR VOC sudy. While sample sizes were too low to do a complete statistical analysis, we found close correspondence when comparing the duplicate samples qualitatively. For example, only two of 79 paired VOCs had detects in one, but not in the other sample. Thus, even though many of the VOC concentrations present are close to their detection limits, their presence in groundwater was verified.

To determine whether all the VOCs present in the groundwater samples were actually detected, we studied the laboratory VOC-analysis procedures (see section on procedures). As discussed earlier, these procedures indicate that several VOCs detected in the screening process did not receive follow-up quantification. These VOCs are not included in the library of standards which the laboratory uses to quantify the compounds present.

Based on the data for trip blanks, field blanks and duplicate samples we believe that the VOCs detected in the monitoring well samples represent substances found in groundwater at the landfills, and that their concentrations reliably reflect groundwater concentrations. Solid waste staff are often questioned about the validity of low-level VOC data. Our results indicate that with adequate quality control, low-level VOC concentrations can be trusted.

NOTE TO VOC RESEARCHERS: Few of the published VOC studies reviewed by the authors gave any indication that quality control was considered; we find this to be a serious flaw and suggest that future studies contain quality control information.

D. <u>DO SITE CONDITIONS AFFECT VOC CONTAMINATION?</u>

To determine relationships between VOC presence and site conditions, we selected several site properties most likely to influence groundwater contamination. We selected these particular properties because they are widely known to influence leachate and groundwater flow rates. In addition, we had information about these site properties from soil boring logs, site investigators' direct experience, engineering plans, and monitoring well data. We could not so easily identify the exact waste composition at the sites, although clearly, the nature of the fill would have significant bearing on which and how many VOCs are found. Table 1 lists site properties for each municipal site while Table 7 summarizes the results. The properties selected include the following:

- -dominant surficial deposits, including USCS soil type
- -average depth to the water table in wells
- -approximate cubic yards of waste in place
- -approximate depth to bedrock and bedrock type

<u>Surficial Deposits</u>

We grouped the municipal landfill sites into categories according to the dominant surficial deposits and USCS soil type. The surficial deposits comprise outwash sand and gravel, sandstone residuum, till, ice contact stratified deposits (ICSD), glaciolacustrine sediment, and loess. We combined sites where the dominant surficial deposits were outwash sand and gravel and sandstone residuum, into a "coarse" group. Sites of dominantly glaciolacustrine or loess deposits, we called "fine," and sites where the surficial deposits were dominantly sandy till or ice contact stratified deposits we called "mixed." The USCS soil types ranged from poorly graded sand and gravel (SP and GP), mostly at the "coarse" sites, to low plasticity c (CL) at the "fine" sites. Table 1 lists the specific USCS type dominant at each site.

The data in Table 7 indicate that more sites with dominantly "coarse" and "mixed" surficial deposits had VOCs in groundwater, than sites with "fine" deposits, as might be expected. In addition, more wells were contaminated on average, and more different kinds of VOCs were found at the "coarse" and "mixed" sites than at the "fine" sites. Some of the "coarse" group sites did not have VOC detects, however, while all of the "fine" group did.

Depth to the Water Table

The municipal landfill sites were grouped into classes of 0-10', 11-20', 21-30', and >30' based on the average depth to the water table found in wells. Because the depth to groundwater in monitoring wells does not necessarily indicate the distance between the landfill waste itself and the water table, this grouping is only a crude approximation of the distance between waste and groundwater. As Table 7 indicates the average depth-to-groundwater groupings show no correlation with VOC presence. In addition each grouping contains sites with VOC-contaminated groundwater and sites without any VOC detects.

Waste Volume

Finally, the municipal landfills were grouped according to the approximate volume of waste in place. These groups comprised classes of 0-50,000, 50,000-100,000 and >100,000 cubic yards of waste. We estimated the waste volume from billing data, from calculations by site engineers, or from information provided by district solid waste specialists. Landfill groupings based on volume of fill indicate that sites with less then 50,000 cubic yards of waste are less likely to have VOCs in groundwater than sites with larger volumes of fill. Only one of the four smallest sites had VOC detects, while 14 of the 15 larger sites did. In addition, more contaminated wells, on average, were found at the sites with more than 50,000 cubic yards of waste than at smaller sites.

Depth to Bedrock and Bedrock Type

Table 1 indicates that VOCs occurred at sites above sandstone, dolomite, and igneous/metamorphic rock, and that VOCs occurred at sites both shallow and deep to bedrock. No correlation existed between either bedrock type or depth to bedrock, and VOC contamination of groundwater.

In addition to the above site properties, we attempted to relate landfill age to contamination. Although WDNR had formally licensed all of the study sites between the years 1969 and 1976, we discovered that almost every sites had accepted waste before its formal opening date. We could not consistently determine how long waste had accumulated at each site before it officially opened. Therefore, we were unable to correlate landfill age with groundwater contamination.

Overall, the data indicate that VOCs occurred in every category we selected of unengineered, municipal solid-waste sites in the small- to medium-size class. Moreover, almost every category contained at least one site which did not have VOCs. We found no infallible correlations between site conditions and VOC presence. However, the group of sites containing less than 50,000 cubic yards of waste had proportionately fewer contaminated sites than did the other groups.

E. HOW USEFUL ARE INORGANIC PARAMETERS IN PREDICTING VOC PRESENCE?

Historically, the WDNR has relied on inorganic indicator parameters to detect contamination arising from landfills. In the early 1980's we learned that leachate generated at Wisconsin solid waste landfills had significant levels of both inorganic and organic compounds (McGinley and Kmet, 1984). Then, the preceeding VOC study (Friedman, 1988) established that VOCs do enter groundwater at landfills, as well as contaminate leachate. However, before requiring VOC monitoring on a routine basis, we wanted to know whether inorganic parameters could be used to predict the presence of VOCs. Because VOC analyses are so much more expensive than inorganic analyses site owners could save significant amounts of money by relying on inorganic parameters should they prove to be reliable indicators of VOC presence.

To evaluate how well elevated inorganic parameters predict VOC presence in groundwater, we analyzed data from 16 sites chosen from both this and the earlier VOC study. We chose sites for this analysis because they had clearly defined upgradient wells which we then used to establish background levels of inorganic parameters. The inorganic parameters used were chemical oxygen demand (COD), specific conductance, chloride, alkalinity and hardness. Background levels were calculated by averaging the parameter concentrations for all upgradient wells at a site, and then adding three standard deviations to the mean. We considered a well to have elevated inorganic parameters if any one of the five parameters had levels above background at the sampling date closest to the date of VOC sampling. These dates were generally within three months of each other.

Figure 6 groups the results for 49 downgradient wells into four correspondence classes based on whether or not VOCs were detected when inorganic parameters were elevated, and whether or not VOCs were detected when inorganic parameters were at background levels.

The groups are as follows:

- those wells with elevated inorganic parameters and VOCs detected

- those wells with elevated inorganic parameters but no VOCs detected

- those wells with background levels of inorganic parameters and no VOCs detected

- those wells with background levels of inorganic parameters and VOCs detected.

Results indicate that inorganic parameters were elevated and VOCs were detected at approximately the same time, in 20 of the 49 wells. In 11 of the 49 wells inorganic parameters were elevated, but no VOCs were detected. When inorganic parameters were at background levels, 15 wells contained no VOCs. Finally, and most importantly, when inorganic parameters were at background levels three of the 49 wells (6%) had VOC detects. This is the most critical case for management purposes because when inorganic parameters are at background levels, a reviewer might miss the VOC contamination. Considering that almost all sites have more than one downgradient well, the proportion of sites where VOCs would be missed by relying on inorganic indicators to predict VOC presence is small, according to this data.

However, the correspondence data for inorganic parameters and VOCs can be viewed in other ways as well. For example, if only those wells with background levels of inorganic parameters are considered the failure rate in predicting VOCs increases. Similarly, if only those wells with VOCs present are considered the predictive value of inorganic parameters decreases. Thus, inorganic parameters are useful in predicting most VOC contamination, but care should be taken in relying on them to detect all VOC contamination.

Table 8 lists the wells which had VOC detects, and indicates specifically which inorganic parameters were above background levels. It includes the number of VOCs detected, and the number of VOCs detected above 10 ug/l. We arbitrarily selected 10 ug/l to try to establish correspondence between high and low concentrations of VOCs and the various inorganic parameters. We found no clear correspondences among them. As Table 8 indicates chloride levels are reported in two ways: (1) >P and <P for concentrations above or below the Wisconsin statute preventive action limit (PAL) of 125 ug/l, and (2) "X" or "B" for concentrations above or at background levels. We calculated the background chloride levels in the same manner that we calculated background levels for the other inorganic indicator parameters (see above). Results indicate that chloride becomes a better indicator of VOC presence in groundwater when background chloride levels are calculated on a site-by-site basis, rather than when the uniform Wisconsin statute PAL is used.

IV. POLICY OBJECTIVES: RESULTS AND DISCUSSION

Wisconsin has approximately 850 licensed solid waste landfills of which 340 have monitoring wells in place. Because the vast majority of these are at natural attenuation sites, they are especially vulnerable to groundwater contamination. The expense involved in monitoring for VOCs at every site on a routine basis may not be justified if other inexpensive means are available for groundwater monitoring and protection. This creates the need for policy which prioritizes the sites and provides for efficient monitoring schedules. To help formulate policy, we first conducted a survey of other states' policy requirements. The next few paragraphs summarize the results of this survey. Following the survey summary, we present the conclusions from all aspects of this study and submit preliminary recommendations for VOC monitoring in Wisconsin.

What are Other States' Requirements for VOC Monitoring?

To provide informational background to state policy makers, we contacted solid waste managers in 48 states and two Canadian provinces (referred to as "states" below), and asked them for details about their regulations concerning VOC monitoring at solid-waste landfills. Figure 7 depicts how many of the 50 states have routine, case-by-case, mixed, or no VOC monitoring required at solid waste landfills. Table 9 lists the states surveyed individually, and indicates which plan to initiate VOC sampling. We include the frequency of VOC sampling for those states requiring, or planning routine VOC sampling.

The survey results show that 19 of the 50 states require sampling on a case-by-case basis. Many of the respondents from the 19 case-by-case states indicated that they considered elevated inorganic parameters and a history of hazardous waste dumping to be the most important factors in deciding when to require VOC sampling. Thirteen states indicated that they require routine VOC sampling, however we did not receive enough data to evaluate specifically how many landfills are sampled routinely in each state. Five of the 50 states responded that they monitor under a mixed strategy of routine sampling at some, and case-by-case sampling at other landfills. No VOC sampling is required at solid waste sites in 13 of the 50 states, but two of these plan to initiate case-by-case VOC sampling soon. Of the states that require, or plan to require routine sampling, one-third require sampling annually, approximately one-third quarterly, and the remaining third require sampling semi-annually, tri-annually, under a variable time-table, or have not decided on their sampling frequency yet.

Additionally, Maryland and Minnesota responded that they plan to use VOCs as primary indicators of groundwater contamination, phasing out reliance on inorganic indicator parameters for VOC contamination.

The map in Figure 8 locates the individual states and identifies their policy requirements.

V. CONCLUSIONS

There has been increasing interest across the country in recent years in sampling for VOCs at solid waste landfills. The Bureau of Solid and Hazardous Waste Management (BSHWM) began a study in 1985 to determine whether the state should start sampling for VOCs on a routine basis at solid waste landfills. From the study reported here, and from the previous study by Friedman (1988) we obtained VOC sampling results for a total of 51 Wisconsin solid waste landfills, and contacted 48 states and two Canadian provinces for information on what type of sampling they were requiring.

Results from these studies indicate the following:

A. Landfills with natural attenuation designs are more likely to have VOC contaminated groundwater than those designed with containment and leachate collection.

B. Landfills taking municipal solid waste are more likely to have VOC contamination than those taking industrial solid waste.

NOTE: The industrial sites we reviewed were primarily papermill sludge landfills, these being the most common industrial solid waste sites in Wisconsin. Industrial solid waste in other states may have substantially different chemical composition.

C. Landfills with waste volumes of less than 50,000 cubic yards are less likely to have VOC contamination than those with larger volumes.

D. VOC monitoring in other states and provinces ranges from no sampling requirements to quarterly sampling required at regulated landfill sites.

E. Inorganic parameters are useful in predicting VOC contamination.

VI. RECOMMENDATIONS

Based on the conclusions from this study and the Friedman (1988) study, we recommend that the BSHWM require solid waste facilities to do the following.

A. Establish background VOC levels at all groundwater monitoring wells.

B. Monitor leachate for VOCs annually.

C. Monitor collection lysimeter samples for VOCs annually.

D. Monitor selected groundwater points at the following frequencies:

1. every five years for landfills with containment and leachate collection

2. for landfills without containment and leachate collection:

   -annually at landfills with capacities greater than 500,000 cubic yards

   -biannually at landfills with capacities less than 500,000 cubic yards

3. for all landfills, regardless of design, waste type, or approval date, where inorganic parameters are elevated or where VOCs have been detected in groundwater--at an increased frequency based on degree and extent of contamination.

E. Monitor for VOCs at an increased frequency (monthly or quarterly) at any landfill for a limited time period to define contamination or to confirm questionable VOC data.

F. Continue sampling for inorganic indicator parameters.

G. When evaluating possible groundwater contamination at a landfill, consider increases in chloride above background rather than only those values above the secondary drinking-water standard or other set standards.

H. Add the first 6 compounds listed in Table 2B to WDNR's list of compounds required for laboratory VOC quantification.

VIII. SUGGESTIONS FOR FURTHER RESEARCH

This study has shown the need for further research in the following areas:

A. Statistical analysis of duplicate samples. Combining duplicate sample data from many studies should provide sufficient information to calculate confidence intervals for each VOC.

B. Relationships between inorganic parameters and VOCs. Inorganic parameters other than those used in this study may also have predictive value.

C. VOC presence at industrial solid waste sites.

D. The need for repeat sampling for verification of VOC presence.

E. Relationships between VOC concentrations in up versus down gradient wells and at various depths.

F. Groundwater contamination from landfills based on a random selection of sites.

The following should be a part of any groundwater contamination study:

A. Quality control (include bailer blanks, trip blanks and duplicate samples in the analysis).

B. Determination of laboratory analysis procedures (record detection limits, and consider which VOCs the laboratory cannot identify).

REFERENCES

Friedman, M. A. 1988. Volatile Organic Compounds in Groundwater and Leachate at Wisconsin Landfills. Wisconsin Department of Natural Resources Publication WR-193-88. 79 pp.

Lindorff, D. E., J. Feld, and J. P. Connelly. 1987. Groundwater Sampling Procedures and Guidelines. Wisconsin Department of Natural Resources Publication WR-153-87. 91 pp.

McGinley, P. M., and P. Kmet. 1984. Formation, Characteristics, Treatment and Disposal of Leachate from Municipal Solid Waste Landfills. Wisconsin Department of Natural Resources Special Report SW-003-85. 288 pp.

Sabel, G. V. and T. P. Clark. 1983. Volatile Organic Compounds as Indicators of Municipal Solid Waste Leachate Contamination pp. 108-125 in proceedings of the Sixth Annual Madison Conference on Municipal and Industrial Waste.

DEFINITIONS

Design Management Zone (DMZ) - a regulatory boundary defined in the Wisconsin Groundwater Quality Rules (NR 140). For new landfills, the DMZ is located 150 feet from the waste or at the property boundary, whichever is less. For old landfills, the DMZ is located 300 feet from the waste or at the property boundary, whichever is less.

Bailer Blank (Field Blank) - a sample of laboratory grade distilled water which is processed through the sampling equipment in the same manner as the actual groundwater sample to determine if field cleaning procedures are adequate.

Duplicate Sample - two separately labelled samples taken from the same bailer filled with groundwater at one time.

Glaciolacustrine Sediment - silt and clay sized laminated sediment which originates in proglacial lakes.

Ice Contact Stratified Deposits (ICSD) - stratified but sometimes poorly-sorted sediment deposited in contact with melting glacial ice.

Indicator Parameters - parameters which are monitored to indicate the presence of leachate. They commonly include specific conductance, pH, hardness, alkalinity, dissolved iron, chloride and sulfate. Note: Indicator parameter has a more narrow definition in NR 140 Wis. Adm. Code.

Leachate Collection System - a system which collects and removes leachate from a solid waste facility. Generally, such a system is composed of a series of interconnected PVC pipes, manholes and pumping stations.

Loess - unstratified deposits of windblown glacial sediment, usually silt but sometimes fine sand or clay.

Natural Attenuation Landfill - an unlined landfill constructed on native soils with no leachate collection system or imported lining material. Natural attenuation landfills exist in all soil environments ranging from coarse to fine.

NR 140 Wis. Adm. Code - Wisconsin Groundwater Quality Rules. NR 140 establishes two sets of standards for given parameters, including VOCs, that are applied to groundwater. Enforcement standards (ES) are based on federally supplied concentrations, and preventive action limits (PALs) are set at a certain percentage of the enforcement standards. Enforcement standards only apply at wells beyond a certain distance from the waste while PALs apply at all wells. NR 140 describes action which should be taken if groundwater exceeds either of these standards.

Residuum - untransported sediment derived from weathered bedrock.

Trip blank - a sample of laboratory grade distilled water which accompanies the sample bottle to the field and back to the laboratory. The purpose of the trip blank is to determine if any of the sample bottles or collected samples have been contaminated with VOCs before or during sampling or shipping.

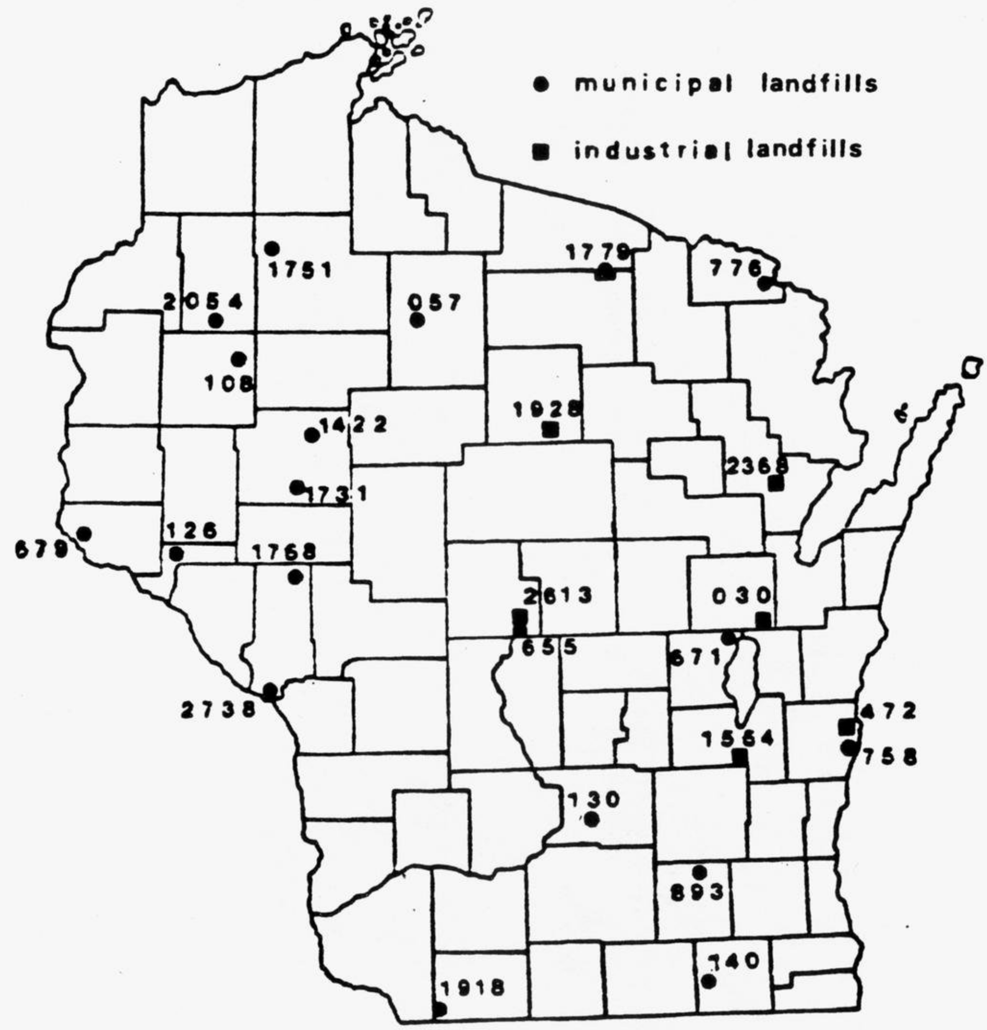


FIGURE 1. LOCATION OF MUNICIPAL AND INDUSTRIAL SITES SAMPLED FOR VOLATILE ORGANIC COMPOUNDS.

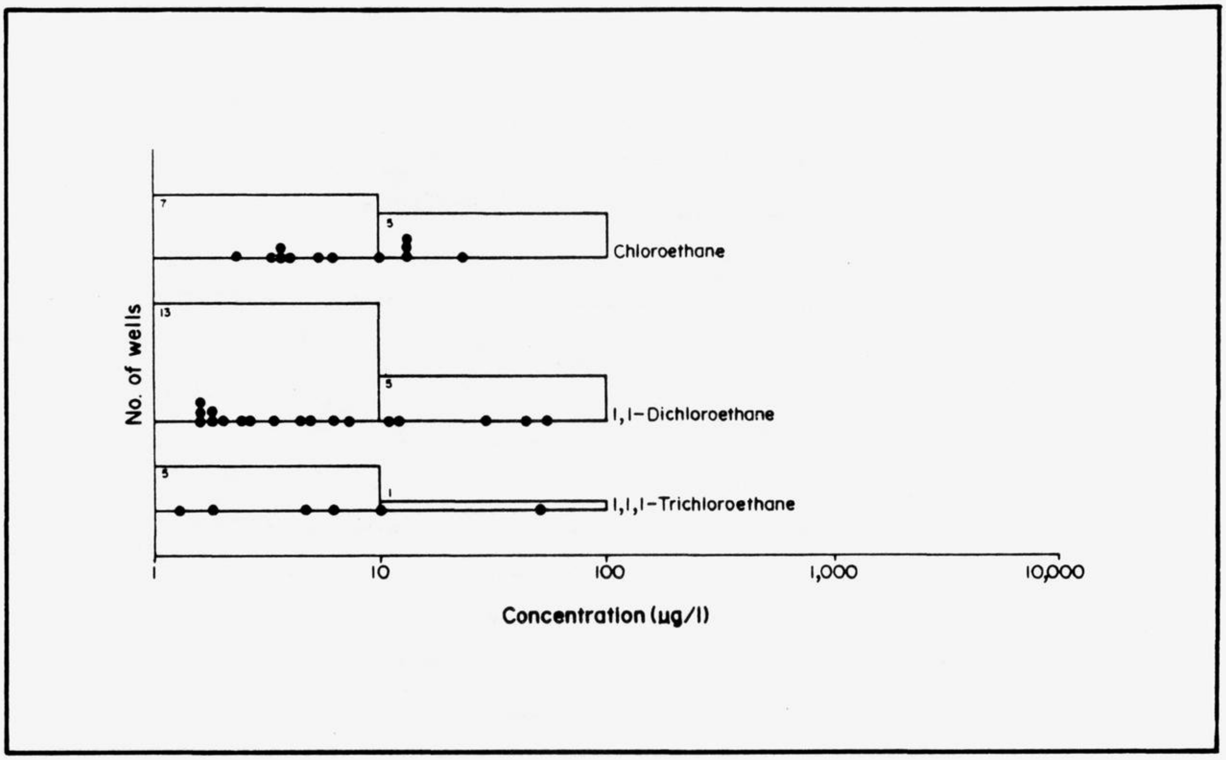


Figure 2. Distribution of chlorinated ethanes in groundwater.

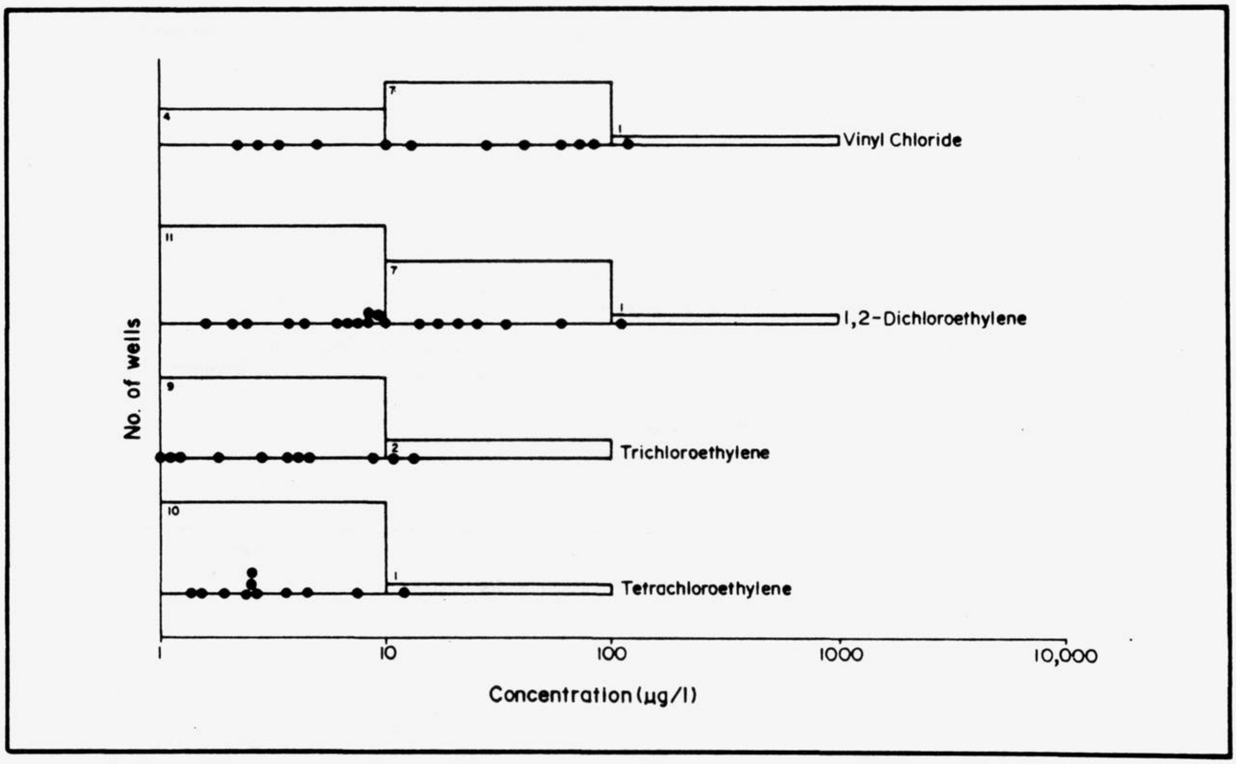


Figure 3. Distribution of chlorinated ethylenes in groundwater.

* The height of the bar corresponds to the number in the left hand corner. This is the number of wells which had the indicated compound detected.

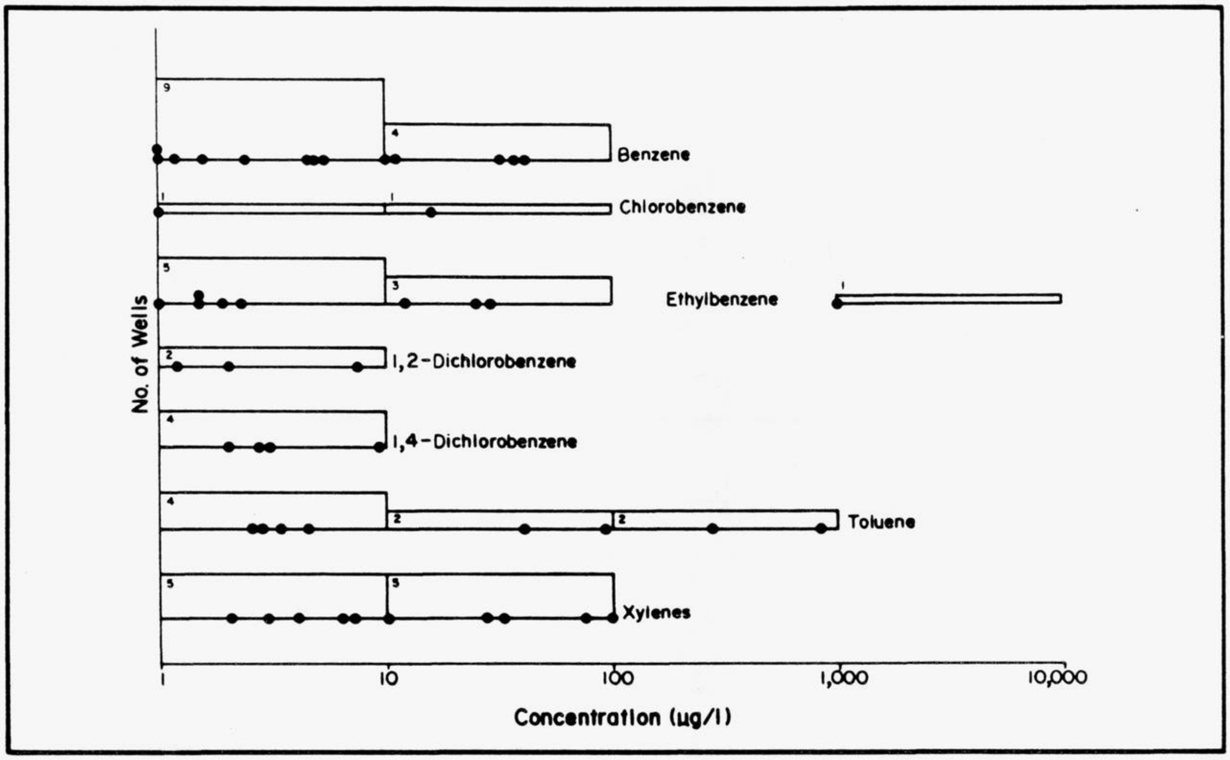


Figure 4. Distribution of aromatic and chlorinated aromatic hydrocarbons in groundwater.

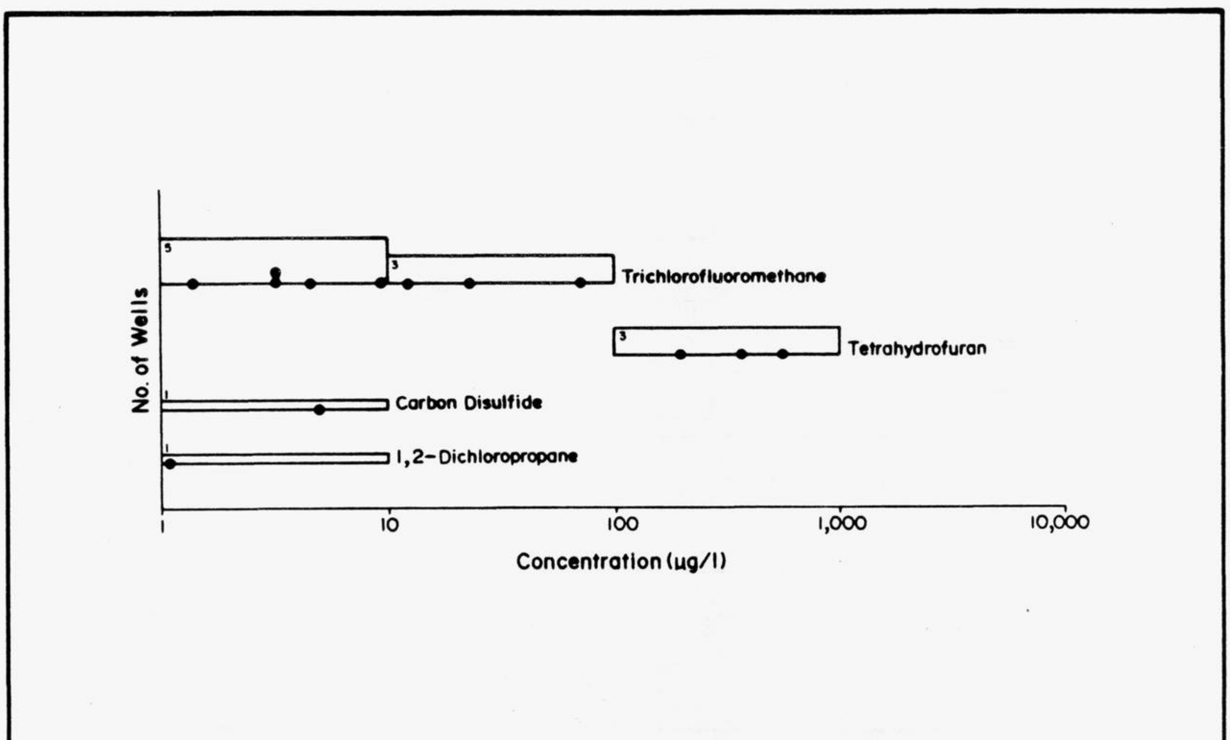


Figure 5. Distribution of miscellaneous VOCs in groundwater.

* The height of the bar corresponds to the number in the left hand corner. This is the number of wells which had the indicated compound detected.

FIGURE 6. CORRESPONDENCES BETWEEN ELEVATED INORGANIC PARAMETERS AND VOCs DETECTED IN DOWNGRADIENT MONITORING WELLS

(One or more inorganic parameters* elevated at last sampling date)

		VOCs DETECTED? YES	VOCs DETECTED? NO
ELEVATED INORGANIC PARAMETERS?	YES	20 (41%)	11 (22%)
	NO	3 (6%)	15 (31%)

Total wells**: 49

Elevated inorganics, VOCs present: 20 (41%)

Elevated inorganics, no VOCs present: 11 (22%)

Background inorganics, VOCs present: 3 (6%)

Background inorganics, no VOCs present: 15 (31%)

*Inorganic parameters used: COD, specific conductance, chloride ion, alkalinity, hardness

**16 sites represented

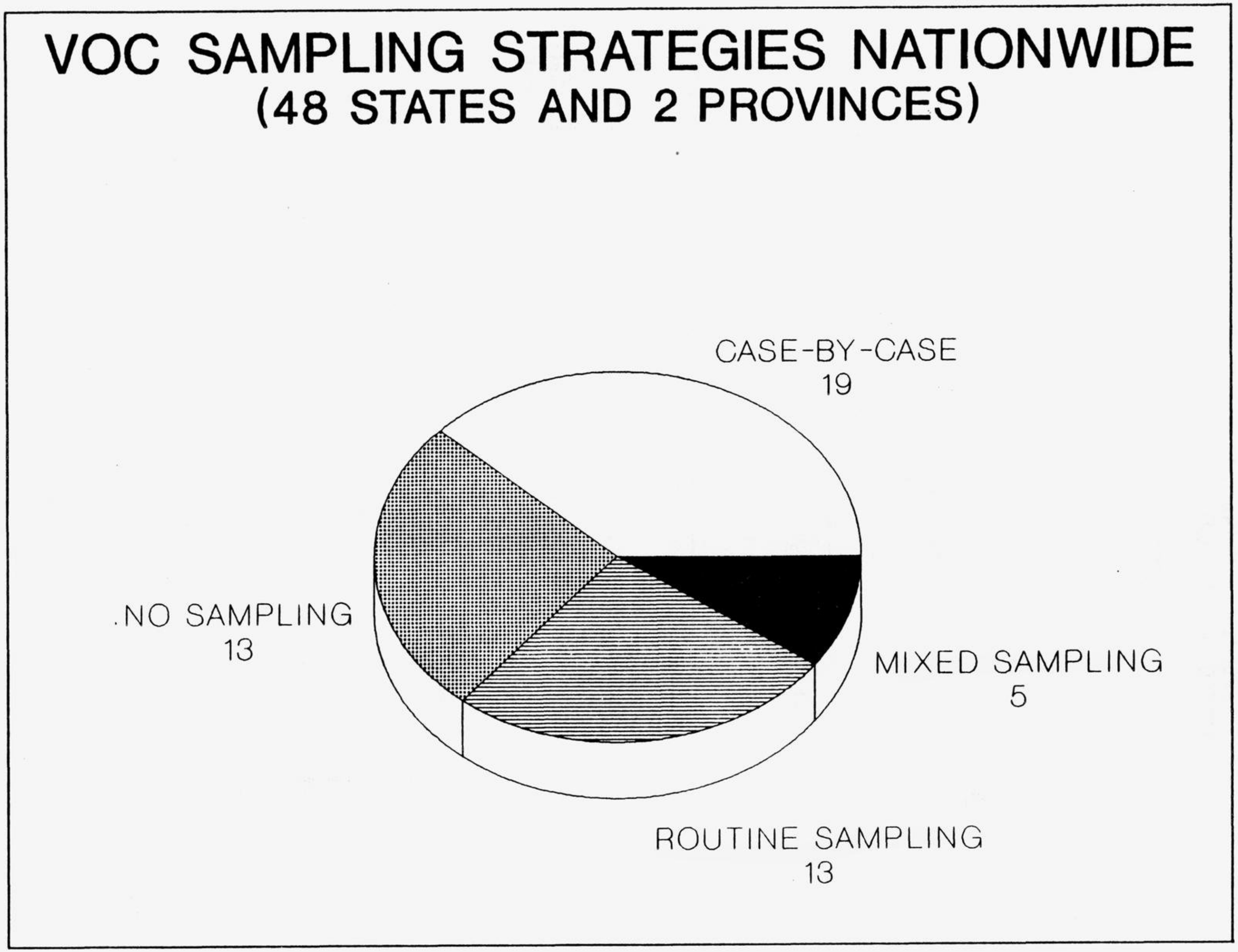


FIGURE 7: VOC SAMPLING STRATEGIES IN 48 STATES AND 2 CANADIAN PROVINCES.

FIGURE 8. VOC MONITORING STRATEGIES NATIONWIDE (BY STATES).

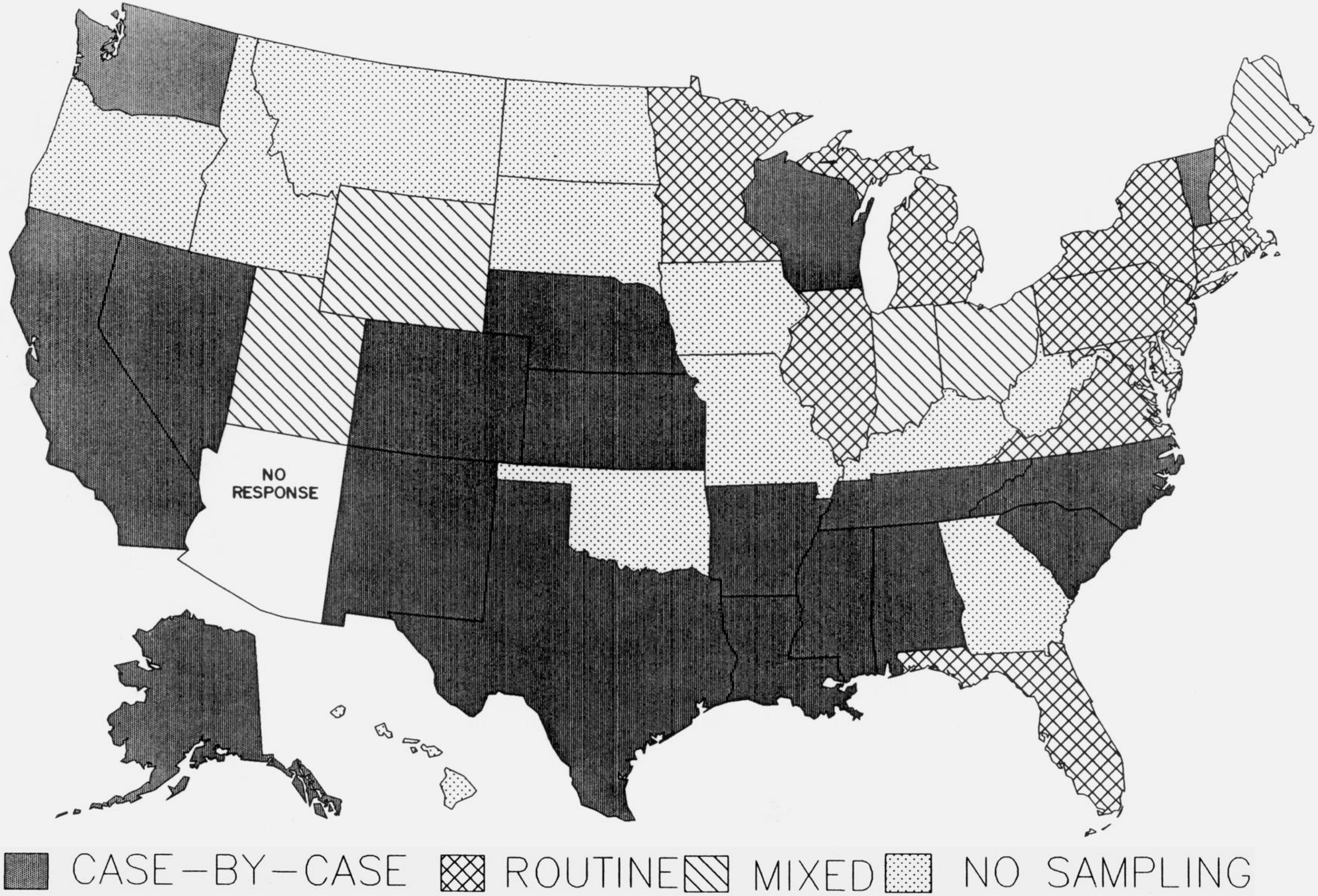


TABLE 1. SITE CHARACTERISTICS

I. SMALL MUNICIPAL LANDFILLS

Facility Name	License Number	Dominant Surficial Deposits	Dominant USCS Soil Type	Depth to Water Table (in wells)	Depth to Bedrock	Bedrock Type	Waste Cu. yds. (1000's)	# Contam. Wells	# Wells Sampled	# VOCs Detected	Max. Conc. [ug/l]	# VOCs >PAL
1. Area Sanitary	1768	Ss. residuum	SP-SM	14-32'	4-15'	Sandstone	112	2	7	13	270	5
2. Cty Cornell	1422	Outwash S&G	SP	15-20'	50-100'	Ign./meta.	27	2	3	9	59	3
3. Cty Durand	126	Outwash S&G	SP	86-89'	>100'	Sandstone	75	4	5	8	28	5
4. Cty Galesville	2738	Outwash S&G	SP	69-74'	100-200'	Sandstone	44	0	2	0	ND	0
5. Cty Hayward	1751	Outwash S&G	SP-SM	20-32'	Unknown	Sandstone	70	2	5	9	92	3
6. Cty Phillips	57	Outwash S&G	SP-GP	14-22'	Unknown	Sandstone	80	0	5	0	ND	0
7. Cty Rice Lake	108	Outwash S&G	SP-SM	18-24'	~30'	Sandstone	60	3	3	4	41	1
8. Cty River Falls	679	SS residuum	SM	49-72'	13-21'	Dolomite	75	3	3	9	120	4
9. Cty Watertown	893	Sandy till	SM	4-22'	40-60'	Dolomite	120	3	4	13	1000	7
10. Greidanus	140	Till	SC-SM	55-74'	150-200'	Dolomite	640	2	3	6	55	4
11. Lake Area	2054	ICSD	SP-SM	51-74'	100-300'	Sandstone	250	3	5	5	66	3
12. Tn Aurora	776	ICSD	SM	0-16'	0-20'	Ign./meta.	30	0	4	0	ND	0
13. Tn Dekorra	130	Outwash sand	SP-SM	Unknown	~30	Unknown	80	2	2	10	32	1
14. Tn Lafayette	1731	Outwash S&G	SM	16-32'	23-38'	Sandstone	60	1	5	4	13	1
15. Tn Lincoln	1779	Outwash sand	SP-SM	4-7'	~150'	Ign./meta.	474	1	3	6	59	3
16. Tn Menasha	671	Glaciolacustrine	CL	5-32'	25-35'	Dolomite	90	1	6	2	13	1
17. Tn Saratoga	655	Outwash Sand	SP	12-44'	~100'	Sandstone	34	0	5	0	ND	0
18. Tn Wilson	758	Glaciolacustrine	CL-SM	3-12'	109-164'	Dolomite	59	2	6	3	10	1
19. Wiederholt	1918	Loess	ML-CL	7-14'	6.5-25.5'	Dolomite	373	1	3	6	11	3
II. INDUSTRIAL LANDFILL SITES												
1. Appleton Papers	30	Glaciolacustrine	CL	5-70'	25-60'	Dolomite	330	0	4	0	ND	0
2. Merrill Gravel	1928	ICSD	SP	5-28'	80-100'	Ign./meta.	75	0	3	0	ND	0
3. Nekoosa Paper	2613	Outwash/residuum	SP,ML	3-35'	15-25'	Ign./meta.	350	1	2	1	380	1
4. Sadoff & Rudoy	1554	Till&ICSD	SM	No data	8-31'	Dolomite	56	0	6	0	ND	0
5. Scott Paper	2368	Outwash S&G/Till	SM,CL	5-21'	100-200'	Dolomite	90	0	4	0	ND	0
6. Spielvogel	472	Glaciolacustrine	SP,CL	15-33'	120-130'	Dolomite	30	2	5	2	2.6	1

TABLE 2A. VOLATILE ORGANIC COMPOUNDS SCREENED FOR AND QUANTIFIED BY THE WISCONSIN STATE LAB OF HYGIENE [REPORTING LIMITS IN UG/L]

1. Benzene [1.0]
2. Bromobenzene [4.0]
3. Bromodichloromethane [2.0]
4. Bromoform [5.0]
5. Carbon Disulfide [5.0]
6. Carbon Tetrachloride [2.0]
7. Chlorobenzene [2.0]
8. Chloroethane [2.0]
9. 2-Chloroethylvinyl ether [4.0]
10. Chloroform [1.0]
11. o-Chlorotoluene [1.0]
12. p-Chlorotoluene [1.0]
13. Dibromomethane [2.0]
14. Dibromochloromethane [2.0]
15. 1,2-Dibromo-3-Chloropropane [7.0]
16. 1,2-Dichlorobenzene [2.0]
17. 1,3-Dichlorobenzene [2.0]
18. 1,4-Dichlorobenzene [2.0]
19. 1,1-Dichloroethane [1.0]
20. 1,2-Dichloroehtane [1.0]
21. 1,1-Dichloroethylene [1.0]
22. 1,2-Dichloroethylene cis [1.0]
23. 1,2-Dichloroethylene trans [1.0]
24. 1,2-Dichloropropane [1.0]
25. 1,3-Dichloropropane [1.0]
26. 2,2-Dichloropropane [2.0]
27. 1,1-Dichloropropene [2.0]
28. 1,3-Dichloropropene, cis [2.5]
29. 1,3-Dichloropropene, trans [2.5]
30. Ethylbenzene
31. Ethylene Dibromide [1.0]
32. Methylethylketone [12]
33. Methylene Chloride [5.0]
34. Styrene [2.0]
35. 1,1,1,2-Tetrachloroethane [3.0]
36. 1,1,2,2-Tetrachloroethane [3.0]
37. Tetrachloroethylene [1.0]
38. Tetrahydrofuran (THF) [200]
39. Toluene [1.0]
40. 1,2,4-Trichlorobenzene [1.0]
41. 1,1,1-Trichloroethane [1.0]
42. 1,1,2-Trichloroethane [2.0]
43. Trichloroethylene [1.0]
44. Trichlorofluoromethane [1.0]
45. Trichlorotrifluoroethane [3.0]
46. 1,2,3-Trichloropropane [2.0]
47. Vinyl Chloride [1.0]
48. Xylenes [2.0]

TABLE 2B. ADDITIONAL VOLATILE ORGANIC COMPOUNDS DETECTED (NOT QUANTIFIED) BY THE WISCONSIN STATE LAB OF HYGIENE

	Number of Sites
1. Napthalene	6
2. Methyl napthalene	3
3. Chlorofluoromethane	6
4. Dichlorofluoromethane	5
5. Acetone	2
6. Thiobismethane	2
7. Alkylated benzenes (undifferentiated)	8
8. Hydrocarbons (undifferentiated)	8

TABLE 3. CHARACTERIZATION OF INDUSTRIAL LANDFILLS

FACILITY NAME	LICENSE NUMBER	WASTE SOURCE	SITE TYPE	SLUDGE-GENERATING PROCESS/ WASTE COMPOSITION	# Cont. Wells	# Wells Sampled	# VOCs Detected	Max. Conc. [ug/l]	# VOCs >PALs
Appleton Paper Co.	030	Papermill	Natural atten.	Semi-chemical, deinking, bleaching	0	4	0	-	0
Merrill Gravel Co.	1928	Papermill	Natural atten.	Deinking	0	3	0	-	0
Nekoosa Paper Co.	2316	Papermill	Sludge-liner	Magnefite, sulfate, bleaching	1	2	1	380	1
Sadoff & Rudoy	1554	Shredder Waste	Natural atten.	Automobile shredder waste	0	6	0	-	0
Scott Paper Co.	2368	Papermill	Natural atten.	Sulfite, bleaching	0	4	0	-	0
Spielvogel	472	Mixed	Natural atten.	Demolition, foundry sand, misc.	2	4	2	2.6	1

TABLE 4A. VOC OCCURRENCE IN GROUNDWATER SAMPLES FROM SMALL-MEDIUM SIZED MUNICIPAL LANDFILLS

RANK	VOC PARAMETER	GROUNDWATER SAMPLES: # WITH VOC PARAMETER DETECTED	TOTAL GW SAMPLES: % WITH VOC PARAMETER DETECTED	CONTAM. GW SAMPLES: % WITH VOC PARAMETER DETECTED
1	1,2-DICHLOROETHYLENE	29	28.2	65.9
2	1,1-DICHLOROETHANE	21	20.4	47.7
3	BENZENE	18	17.5	40.0
4	VINYL CHLORIDE	17	16.5	38.6
5	TRICHLOROETHYLENE	16	15.5	36.4
6	TETRACHLOROETHYLENE	16	15.5	36.4
7	CHLOROETHANE	16	15.5	36.4
8	XYLENE (TOTAL)	15	14.6	34.1
9	ETHYL BENZENE	14	13.6	31.8
10	TOLUENE	13	12.6	29.6
11	TRICHLOROFLUOROMETHANE	13	12.6	29.6
12	1,1,1-TRICHLOROETHANE	12	11.7	27.3
13	1,4-DICHLOROBENZENE	6	5.8	13.6
14	CHLOROBENZENE	5	4.9	11.4
15	1,2-DICHLOROBENZENE	4	3.9	9.1
16	TETRAHYDROFURAN	3	2.9	6.8
17	CARBON DISULFIDE	2	1.9	4.6
18	1,2-DICHLOROPROPANE	1	1.0	2.3

TABLE 4B. VOC OCCURRENCE IN MONITORING WELLS AT SMALL-MEDIUM SIZED MUNICIPAL LANDFILLS

RANK	VOC PARAMETER	MONITORING WELLS: # WITH VOC PARAMETER DETECTED	TOTAL WELLS: % WITH VOC PARAMETER DETECTED	CONTAM. WELLS: % WITH VOC PARAMETER DETECTED
1	1,2-DICHLOROETHYLENE	19	26.4	67.9
2	1,1-DICHLOROETHANE	18	25	64.3
3	BENZENE	13	18.1	46.4
4	VINYL CHLORIDE	12	16.7	42.9
5	CHLOROETHANE	12	16.7	42.9
6	TETRACHLOROETHYLENE	11	15.3	39.3
7	TRICHLOROETHYLENE	11	15.3	39.3
8	XYLENE (TOTAL)	10	13.9	35.7
9	ETHYL BENZENE	9	12.5	32.1
10	TOLUENE	8	11.1	28.6
11	TRICHLOROFLUOROMETHANE	8	11.1	28.6
12	1,1,1-TRICHLOROETHANE	6	8.3	21.4
13	1,4-DICHLOROBENZENE	4	5.6	14.3
14	TETRAHYDROFURAN	3	4.2	10.7
15	1,2-DICHLOROBENZENE	2	2.8	7.1
16	CHLOROBENZENE	2	2.8	7.1
17	1,2-DICHLOROPROPANE	1	1.4	3.6
18	CARBON DISULFIDE	1	1.4	3.6

TOTAL GROUNDWATER SAMPLES:	113
TOTAL CONTAMINATED GROUNDWATER SAMPLES:	49
TOTAL WELLS SAMPLED:	79
TOTAL CONTAMINATED WELLS:	32
TOTAL SITES REPRESENTED:	19
TOTAL SITES WITH CONTAMINATED WELLS:	15

TABLE 4C. VOC OCCURRENCE AT SMALL-MEDIUM SIZED MUNICIPAL LANDFILL SITES

RANK	VOC PARAMETER	TOTAL SITES: # WITH VOC PARAMETER DETECTED	TOTAL SITES: % WITH VOC PARAMETER DETECTED	CONTAM. SITES: % WITH VOC PARAMETER DETECTED
1	1,1-DICHLOROETHANE	11	65.7	84.6
2	1,2-DICHLOROETHYLENE	10	58.8	76.9
3	VINYL CHLORIDE	9	52.9	69.2
4	BENZENE	9	52.9	69.2
5	TETRACHLOROETHYLENE	8	47.1	61.5
6	TRICHLOROETHYLENE	8	47.1	61.5
7	TOLUENE	8	47.1	61.5
8	ETHYL BENZENE	8	47.1	61.5
9	XYLENE (TOTAL)	8	47.1	61.5
10	CHLOROETHANE	8	47.1	61.5
11	TRICHLOROFLUOROMETHANE	5	29.4	38.5
12	1,1,1-TRICHLOROETHANE	4	23.5	30.8
13	1,4-DICHLOROBENZENE	4	23.5	30.8
14	CHLOROBENZENE	2	11.8	15.4
15	1,2-DICHLOROBENZENE	2	11.8	15.4
16	1,2-DICHLOROPROPANE	1	5.9	7.7
17	TETRAHYDROFURAN	1	5.9	7.7
18	CARBON DISULFIDE	1	5.9	7.7

TABLE 4D. RANKING BASED ON MAXIMUM CONCENTRATIONS FOUND

RANK	VOC PARAMETER	GW SAMPLE MAXIMUM UG/L DETECTED
1	ETHYL BENZENE	1000
2	TOLUENE	820
3	TETRAHYDROFURAN	560
4	VINYL CHLORIDE	120
5	1,2-DICHLOROETHYLENE	110
6	XYLENE (TOTAL)	98
7	TRICHLOROFLUOROMETHANE	66
8	1,1 DICHLOROETHANE	55
9	1,1,1-TRICHLOROETHANE	51
10	BENZENE	43
11	CHLOROETHANE	23
12	CHLOROBENZENE	16
13	TRICHLOROETHYLENE	13
14	TETRACHLOROETHYLENE	12
15	1,4-DICHLOROBENZENE	9.2
16	1,2-DICHLOROBENZENE	7.4
17	CARBON DISULFIDE	>5
18	1,2-DICHLOROPROPANE	1.1

TOTAL GROUNDWATER SAMPLES:	113
TOTAL CONTAMINATED GROUNDWATER SAMPLES:	49
TOTAL WELLS SAMPLED:	79
TOTAL CONTAMINATED WELLS:	32
TOTAL SITES REPRESENTED:	19
TOTAL SITES WITH CONTAMINATED WELLS:	15

TABLE 5. RANKING BASED ON HOW OFTEN VOC EXCEEDS WISCONSIN GROUNDWATER STANDARDS

RANK	VOC PARAMETER*	ENFORCE-MENT STANDARD (ES) (A) [UG\L]	PREVENTIVE ACTION LIMIT (PAL) (B) [UG\L]	WSLH REPORTING LIMIT [UG\L]	# WELLS WITH VOC DETECTED	# OF WELLS EXCEEDING: ES (A)	# OF WELLS EXCEEDING: PAL (B)	% ALL WELLS: VOC> ES (A)	% ALL CONTAM. WELLS: VOC> ES (A)	% ALL WELLS: VOC> PAL (B)	% ALL CONTAM. WELLS: VOC> PAL (B)	% WELLS WITH VOC: VOC> ES (A)	% WELLS WITH VOC: VOC> PAL (B)
1	BENZENE	0.67	0.067	1	13	13	13	16.5	40.6	16.5	40.6	100	100
2	VINYL CHLORIDE	0.015	0.0015	1	12	12	12	15.2	37.5	15.2	37.5	100	100
3	TETRACHLOROETHYLENE	1	0.1	1	11	11	11	13.9	34.4	13.9	34.4	100	100
4	TRICHLOROETHYLENE	1.8	0.18	1	11	8	11	10.1	25.0	13.9	34.4	72.7	100
5	TETRAHYDROFURAN	50	10	200	3	3	3	3.8	9.4	3.8	9.4	100	100
6	1,2-DICHLOROETHYLENE	100	10	1	19	1	8	1.3	3.1	10.1	25.0	5.3	42.1
7	TOLUENE	343	68.6	1	8	1	3	1.3	3.1	3.8	9.4	12.5	37.5
8	ETHYLBENZENE	1360	272	1	9	1	1	1.3	3.1	1.3	3.1	11.1	11.1
9	1,1,1-TRICHLOROETHANE	200	40	1	6	0	1	0	0	1.3	3.1	0	16.7
10	1,1 DICHLOROETHANE	850	85	1	18	0	0	0	0	0	0	0	0
11	XYLENES (TOTAL)	620	124	2	10	0	0	0	0	0	0	0	0
12	1,2-DICHLOROBENZENE	1250	125	2	2	0	0	0	0	0	0	0	0
13	1,4-DICHLOROBENZENE	750	150	2	4	0	0	0	0	0	0	0	0
14	TRICHLOROFLUOROMETHANE	3490	689	3	8	0	0	0	0	0	0	0	0

TOTAL WELLS SAMPLED: 79
TOTAL CONTAMINATED WELLS: 32

* VOC PARAMETERS HAVING WISCONSIN GROUNDWATER STANDARDS
(A) = NR 140 WIS. ADM. CODE ENFORCEMENT STANDARD
(B) = NR 140 WIS. ADM. CODE PREVENTIVE ACTION LIMIT

TABLE 6. DUPLICATE SAMPLE COMPARISONS [UG/L]

LICENSE NUMBER	WELL NAME	SAMPLING DATE	Tri-chloro-fluro-methane	Chloro-ethane	1,1-Di-chloro-ethane	1,2-Di-chloro-ethane	1,1,1-Tri-chloro-ethane	Vinyl Chloride	1,1-Di-chloro-ethylene	1,2-Di-chloro-ethylene	Tri-chloro-ethylene	Tetra-chloro-ethylene	Benzene	Toluene	Xylene	Ethyl-benzene	Chloro-benzene	1,2-Di-chloro-benzene	1,4-Di-chloro-benzene	Tetra-hydro-furan
1768	MW-3	7/6/87			44		4.9			97	2.6		20	180	45	13	12	5.7	2.2	
	MW-3d	7/6/87			42		4.3			110	2.8		31	270	75	23	16	7.4	3	
1422	MW-3	3/29/88	11									5.7								
	MW-3d	3/29/88	13									6.6								
126	MW-4	6/24/87								9.4	2.7									
	MW-4d	6/24/87								9	2.7									
2054	MW-4	12/10/85	36				23													
	MW-4d	12/10/85	55				34													
2051	MW-25	11/28/85		340	94	4.4			2.9	41	2.5	1.4	31	2400	160	74	4.8		5	
	MW-25d	11/28/85		420	110	6.8			3.9	43	4.0	4.3	32	2600	140	71	7.6		6.2	
130	MW-3	6/8/88	3.4	3.6	6.6		4.7			6.2		4.2								
	MW-3d	6/8/88	3.4	3.9	7.2		4.5			7.3		4.5								
1731	MW-2	3/22/88		2.8				10		1.8					4.0					
	MW-2d	3/22/88		5.3				13		2.1										
1779	MW-2	9/28/87						2.7		59			5.3	1.5	6.3	2.3				
	MW-2d	9/28/87						1.3		58			3.1	4.4	3.1	1.1				
758	DG-4	5/16/88		2.8																
	DG-4d	5/16/88																		
472	MW-1	5/09/88										1.4								
	MW-1d	5/09/88										1.5								

TABLE 6. DUPLICATE SAMPLE COMPARISONS [UG/L] (CONTINUED)

LICENSE NUMBER	WELL NAME	SAMPLING DATE	Trichlorofluromethane	Chloroethane	1,1-Dichloroethane	1,2-Dichloroethane	1,1,1-Trichloroethane	Vinyl Chloride	1,1-Dichloroethylene	1,2-Dichloroethylene	Trichloroethylene	Tetrachloroethylene	Benzene	Toluene	Xylene	Ethylbenzene	Chlorobenzene	1,2-Dichlorobenzene	1,4-Dichlorobenzene	Tetrahydrofuran
2484	P-6B	12/02/68		26	52	7.5		160		3600	480	59	15	3500	120	34	110			
	P-6Bd	12/02/68		23	47	8.1		190		3900	470	60	12	3300	120	39	110			
2568	MW-7C	12/10/85																		980
	MW-7Cd	12/10/85																		1000
2637	MW-12	11/20/85			85		7.3			28	35	30		10	71	29				
	MW-12d	11/20/85			64		7.1			24	28	23		4	55	24				
2680	MW-29	11/26/85	17		56		22			15	72	740	4.9	5.1	6.3					
	MW-29d	11/26/85	13		48		25			16	74	660	3.6	5.2	6.4					
2695	DH-17A	6/16/86												5.3						
	DH-17Ad	6/16/86												5.2						

TABLE 7. SUMMARY OF LANDFILL SITE CONDITIONS AND VOC PRESENCE AT SMALL-MEDIUM SIZED MUNICIPAL LANDFILLS IN WISCONSIN

	TOTAL LAND-FILLS	SURFICIAL DEPOSITS			AVE. DEPTH TO WATER TABLE				CUBIC YARDS WASTE (1000'S)		
		COARSE	MIXED	FINE	0-10'	11-20'	21-30'	>30'	0-50'	50-100'	>100'
# OF LANDFILLS	19	12	4	3	3	5	5	5	4	9	6
# OF LANDFILLS WITH VOC DETECTS	15	9	3	3	2	4	4	4	1	8	6
MEAN # VOCs DETECTED (AT SITES)	5.6	6.0	6.0	3.7	3.0	6.0	6.0	5.6	2.2	5.4	8.2
MEAN # VOCs DETECTED (AT VOC SITES)	7.1	8	8	3.7	4.5	7.5	7.5	7	9	6.1	8.2
MEAN # CHLORIN-ATED ALIPHATICS (AT VOC SITES)	4.3	4.6	4.7	3	2.5	3.7	4.2	5.2	5	4	5.3
MEAN # AROMATIC AND CHLORIN-ATED AROMATICS (AT VOC SITES)	2.7	3.4	2.7	0.7	2.0	3.2	3.2	1.7	4	2.1	2.8
AV. % CONTAM. GW WELLS AT EACH SITE	45%	47%	50%	28%	22%	38%	38%	61%	17%	54%	50%

TABLE 8. VOC DETECTIONS AND COMPARISON BETWEEN VOCS AND INDICATOR PARAMETER LEVELS.

SITE # **	WELL NAME	# VOCs DETECTED	# VOCs >10 UG/L	CHLORIDE (1)	CHLORIDE (2)	ALKALINITY	HARDNESS	SPECIFIC CONDUCTANCE	COD
108	W-1	1	0	<P	B	B	B	B	B
	W-2	2	1	<P	B	B	B	X	B
	W-3	2	0	<P	X	X	B	X	B
126	MW-2	6	1	<P	X	X	X	X	B
	MW-3	8	2	<P	X	X	X	X	B
	MW-4	5	2	<P	X	X	X	X	B
	MW-5	2	1	<P	X	B	B	B	B
140	W-22	4	1	<P	B	B	B	B	B
	W-54	6	4	<P	X	X	X	X	B
671	N-2	2	1	<P	X	-	-	X	B
758	DG-3	3	0	<P	X	X	X	X	B
	DG-4	3	0	<P	X	X	X	X	B
1422	W-2	7	3	-	-	X	X	X	X
	W-3	2	2	<P	X	X	X	X	X
1731	MW-2	4	1	<P	X	X	B	X	X
1768	W-3	12	8	<P	X	B	B	B	X
	W-4	2	0	<P	B	B	B	B	B
1779	MW-2	6	1	<P	X	-	-	X	X
2051	TW-25	15	9	>P	X	X	X	X	X
	TW-26	7	2	<P	B	X	X	X	B
	TW-26A	11	4	<P	B	X	X	X	B
2054	W-3	3	1	<P	B	X	X	X	B
	W-4	2	2	<P	B	X	X	X	B
	W-5	4	0	<P	B	X	X	X	X

KEY:
B = BACKGROUND OR BELOW CALCULATED PREVENTIVE ACTION LIMIT (PAL)
X = >CALCULATED BACKGROUND LEVEL
>P = >WISCONSIN STATUTE PAL VALUE*
<P = <WISCONSIN STATUTE PAL VALUE*
- = NO DATA

*PAL = Wisconsin Administrative Code NR 140 Prevention Action Limit

** Sites include only those where background levels of inorganic parameters could be determined.

TABLE 9. VOLATILE ORGANIC COMPOUND MONITORING REGULATIONS IN 48 STATES AND 2 PROVINCES

STATE OR PROVINCE	CASE-BY-CASE ONLY	ROUTINE SAMPLING REQUIRED	CASE-BY-CASE & ROUTINE SAMPLING	ROUTINE SAMPLING FREQUENCY	NO VOC SAMPLING REQUIRED	CASE-BY-CASE PLANNED	ROUTINE SAMPLING PLANNED	PLANNED SAMPLING FREQUENCY	LANDFILLS SAMPLED FOR VOCs	NUMBER OF REGULATED LANDFILLS
ALABAMA	X								22	111
ALASKA	X								15	200
ARKANSAS	X								10	130
CALIFORNIA	X								212	600
COLORADO			X	Quarterly						
CONNECTICUT		X		Quarterly					90	140
DELAWARE					X				0	
FLORIDA		X		Quarterly						
GEORGIA					X				0	
HAWAII					X				0	4
IDAHO					X				0	
ILLINOIS		X		Variable						
INDIANA			X	Annually						
IOWA					X	X			0	
KANSAS	X								100	235
KENTUCKY					X	X				
LOUISIANA	X								25	250
MAINE			X	Quarterly			X	Unknown		
MARYLAND		X		Semi-ann.					51	51
MASSACHUSETTS		X		Variable						
MICHIGAN		X		Annually						
MINNESOTA		X		Variable			X	Tri-ann.	87	
MISSISSIPPI	X								9	120
MISSOURI					X				0	
MONTANA					X				0	
NEBRASKA	X						X	Annually		
NEVADA	X									
NEW HAMPSHIRE		X		Quarterly						
NEW JERSEY		X		Annually					400	400
NEW MEXICO	X								3	
NEW YORK		X		Annually						
NORTH CAROLINA	X								1-3	155
NORTH DAKOTA					X				0	75

TABLE 9. VOLATILE ORGANIC COMPOUND MONITORING REGULATIONS IN 48 STATES AND 2 PROVINCES

STATE OR PROVINCE	CASE-BY-CASE-ONLY	ROUTINE SAMPLING REQUIRED	CASE-BY-CASE & ROUTINE SAMPLING	ROUTINE SAMPLING FREQUENCY	NO VOC SAMPLING REQUIRED	CASE-BY-CASE-PLANNED	ROUTINE SAMPLING PLANNED	PLANNED SAMPLING FREQUENCY	LANDFILLS SAMPLED FOR VOCs	NUMBER OF REGULATED LANDFILLS
OHIO			X	Annually						
OKLAHOMA					X				0	178
ONTARIO	X									
OREGON					X				0	
PENNSYLVANIA		X		Annually						
QUEBEC	X									
RHODE ISLAND		X		Quarterly					12	12
SOUTH CAROLINA	X									70-80
SOUTH DAKOTA					X				0	
TENNESSEE	X						X	Annually		
TEXAS	X									
UTAH			X						5	31
VERMONT	X						X	Unknown		
VIRGINIA		X		Quarterly						
WASHINGTON	X									
WEST VIRGINIA					X				0	49
WYOMING	X								6-8	300
TOTAL: 50	19	13	5		13	2	5			

APPENDIX A. VOC DATA FOR 19 MUNICIPAL LANDFILLS IN WISCONSIN
(in ug/l)

FACILITY NAME	LICENSE NUMBER	WELL NAME	SAMPLING DATE	Tri-chloro-fluro-methane	Chloro-ethane	1,1-Di-chloro-ethane	1,1,1-Tri-chloro-ethane	Vinyl Chloride	1,2-Di-chloro-ethyl-ene	Tri-chloro-ethyl-ene	Tetra-chloro-ethyl-ene	1,2-Di-chloro-propane	Benzene	Toluene	Xylene	Ethyl-benzene	Chloro-benzene	1,2-Di-chloro-benzene	1,4-Di-chloro-benzene	Tetra-hydro-furan	Carbon Di-sulfide
Area Sanitary (Osseo)	1768	MW-1	7/6/87																		
		MW-3	7/6/87			44	4.9		97	2.6			20	180	45	13	12	5.7	2.2		
		MW-3d	7/6/87			42	4.3		110	2.8			31	270	75	23	16	7.4	3.0		
		MW-4	7/6/87			2.5			8.1												
		MW-4P	7/6/87																		
		BB	7/6/87																		
		MW-1	9/14/87																		
		MW-2	9/14/87																		
		MW-3	9/14/87			42	6.2	73	31	2.1	2.4		32	170	73	25	5.0	2.4			
		BB	9/14/87																		
		MW-4	9/14/87																		
		MW-4A	9/14/87																		
		MW-5	9/14/87																		
Cty Cornell	1422	MW-1	12/15/87																		
		MW-2	12/15/87		18			36					1.6	3.3	10	29	18				
		BB	12/15/87																		
		MW-3	12/15/87								12										
		MW-1	3/29/88																		
		MW-2	3/29/88		23	1.6		59						2.5	6.8	20					
		BB	3/29/88																		
		MW-3	3/29/88	11							5.7										
		MW-3d	3/29/88	13							6.6										
Cty Dekorra/ Vil Poynette	130	MW-3	6/8/88	3.4	3.6	6.6	4.7		6.2		4.2										
		MW-3d	6/8/88	3.4	3.9	7.2	4.5		7.3		4.5										
		BB	6/8/88																		
		MW-4	6/8/88						1.6					2.5	32	1.9			9.2		

APPENDIX A. VOC DATA FOR 19 MUNICIPAL LANDFILLS IN WISCONSIN
(in ug/l)

FACILITY NAME	LICENSE NUMBER	WELL NAME	SAMPLING DATE	Trichlorofluromethane	Chloroethane	1,1-Dichloroethane	1,1,1-Trichloroethane	Vinyl Chloride	1,2-Dichloroethylene	Trichloroethylene	Tetrachloroethylene	1,2-Dichloropropane	Benzene	Toluene	Xylene	Ethylbenzene	Chlorobenzene	1,2-Dichlorobenzene	1,4-Dichlorobenzene	Tetrahydrofuran	Carbon Disulfide
Area Sanitary (Osseo)	1768	MW-1	7/6/87																		
		MW-3	7/6/87			44	4.9		97	2.6			20	180	45	13	12	5.7	2.2		
		MW-3d	7/6/87			42	4.3		110	2.8			31	270	75	23	16	7.4	3		
		MW-4	7/6/87			2.5			8.1												
		MW-4P	7/6/87																		
		BB	7/6/87																		
		MW-1	9/14/87																		
		MW-2	9/14/87																		
		MW-3	9/14/87			42	6.2	73	31	2.1	2.4		32	170	73	25	5	2.4			
		BB	9/14/87																		
		MW-4	9/14/87																		
		MW-4A	9/14/87																		
		MW-5	9/14/87																		
Cty Cornell	1422	MW-1	12/15/87																		
		MW-2	12/15/87		18			36					1.6	3.3	10	29	18				
		BB	12/15/87																		
		MW-3	12/15/87								12										
		MW-1	3/29/88																		
		MW-2	3/29/88		23	1.6		59						2.5	6.8	20					
		BB	3/29/88																		
		MW-3	3/29/88	11							5.7										
		MW-3d	3/29/88	13							6.6										
Cty Dekorra/ Vil Poynette	130	MW-3	6/8/88	3.4	3.6	6.6	4.7		6.2		4.2										
		MW-3d	6/8/88	3.4	3.9	7.2	4.5		7.3		4.5										
		BB	6/8/88																		
		MW-4	6/8/88						1.6					2.5	32	1.9			9.2		

APPENDIX A. VOC DATA FOR 19 MUNICIPAL LANDFILLS IN WISCONSIN (CONTINUED)
(in ug/l)

FACILITY NAME	LICENSE NUMBER	WELL NAME	SAMPLING DATE	Trichlorofluromethane	Chloroethane	1,1-Dichloroethane	1,1,1-Trichloroethane	Vinyl Chloride	1,2-Dichloroethylene	Trichloroethylene	Tetrachloroethylene	1,2-Dichloropropane	Benzene	Toluene	Xylene	Ethylbenzene	Chlorobenzene	1,2-Dichlorobenzene	1,4-Dichlorobenzene	Tetrahydrofuran	Carbon Disulfide
Cty Durand	126	MW-1	6/24/87																		
		MW-2	6/24/87		3.6	1.6		7.3	19	1	2.6										
		MW-3	6/24/87		13	4.1		27	6.2	4.1			1.2	2.7							
		MW-4	6/24/87						9.4	2.7											
		MW-4d	6/24/87						9	2.7											
		BB	6/24/87																		
		MW-5	6/24/87						12		2.5										
		MW-1	9/22/87																		
		MW-2	9/22/87					10	21		2.1										
		MW-3	9/22/87		2.6	6.2		28	6.8	3.4	1.4										
		MW-4	9/22/87		2.3	4.5		2.2	25	11											
		BB	9/22/87																		
		MW-5	9/22/87						14		1.6										
Cty Galesville	2738	MW-1	12/8/87																		
		MW-2	12/8/87						<no detects>												
		BB	12/8/87																		
Cty Hayward	1751	MW-1	2/7/88	3.5					4.4												
		MW-2	2/7/88																		
		MW-3	2/7/88																		
		MW-4	2/7/88	4.8	6.1	4.9			8	1.1			2.4	92	27	12					
		BB	2/7/88										1.1	2.4							
		MW-5	2/7/88																		
Cty Phillips	057	UG-1	9/17/85																		
		MW-2	9/17/85																		
		MW-3	9/17/85						<no detects>												
		MW-4	9/17/85																		
		MW-5	9/17/85																		
		BB	9/17/85																		

APPENDIX A. VOC DATA FOR 19 MUNICIPAL LANDFILLS IN WISCONSIN (CONTINUED)
(in ug/l)

FACILITY NAME	LICENSE NUMBER	WELL NAME	SAMPLING DATE	Trichlorofluromethane	Chloroethane	1,1-Dichloroethane	1,1,1-Trichloroethane	Vinyl Chloride	1,2-Dichloroethylene	Trichloroethylene	Tetrachloroethylene	1,2-Dichloropropane	Benzene	Toluene	Xylene	Ethylbenzene	Chlorobenzene	1,2-Dichlorobenzene	1,4-Dichlorobenzene	Tetrahydrofuran	Carbon Disulfide
Cty Rice Lake	108	W-1	3/29/88	1.4																	
		W-2	3/29/88		3.3			41													
		BB	3/29/88											2.7							
		W-3	3/29/88		3.6											1.5					
Cty River Falls	679	MW-1	8/25/87			1.6			3.7				37		2.9						
		MW-3	8/25/87					120	9.8				4.9								
		MW-5	8/25/87			1.8			2.4	1.8	3.6		43	40	7	1.5					
Cty Watertown	893	MW-2	8/4/87										>1		>2	>1	>2		>2	>200	>5
		MW-2d	8/4/87										>1		>2	>1	>2	>2	>2	>200	>5
		MW-3	8/4/87																	560	
		BB	8/4/87																		
		MW-5	8/4/87			12		82	34	3.7			9.8	820	98	1000					
		MW-6	8/4/87																		
Greidanus	140	W-7	7/9/86																		
		W-7d	7/9/86																		
		W-22	7/9/86			29			6.1	8.9			1.1								
		W-54	7/9/86			55	9.9		17	13	7.3		11								
		BB	7/9/86																		
Lake Area	2054	MW-2	9/23/85																		
		MW-3	9/23/85	15		3.4	1.8				1.7										
		MW-4	9/23/85	66			51														
		MW-5	9/23/85	9.4			1.3			1.2											
		MW-2	12/10/85																		
		MW-3	12/10/85	24			1.8				2.5										
		MW-4	12/10/85	36			23														
		MW-4d	12/10/85	55			34														
		MW-5	12/10/85																		
		MW-20	12/10/85																		

APPENDIX A. VOC DATA FOR 19 MUNICIPAL LANDFILLS IN WISCONSIN (CONTINUED)
(in ug/l)

FACILITY NAME	LICENSE NUMBER	WELL NAME	SAMPLING DATE	Tri-chloro-fluro-methane	Chloro-ethane	1,1-Di-chloro-ethane	1,1,1-Tri-chloro-ethane	Vinyl Chloride	1,2-Di-chloro-ethyl-ene	Tri-chloro-ethyl-ene	Tetra-chloro-ethyl-ene	1,2-Di-chloro-propane	Benzene	Toluene	Xylene	Ethyl-benzene	Chloro-benzene	1,2-Di-chloro-benzene	1,4-Di-chloro-benzene	Tetra-hydro-furan	Carbon Di-sulfide
Tn Aurora	776	MW-1	11/24/87																		
		MW-2	11/24/87						<no detects>												
		MW-3	11/24/87																		
		MW-3d	11/24/87																		
		BB	11/24/87																		
		MW-4	11/24/87																		
Tn Lafayette	1731	MW-1	3/22/88																		
		MW-2	3/22/88		2.8			10	1.8						4						
		MW-2d	3/22/88		5.3			13	2.1												
		BB	3/22/88																		
		MW-3	3/22/88																		
		MW-4	3/22/88																		
		MW-5	3/22/88																		
Tn Lincoln	1779	MW-1	9/28/87																		
		BB	9/28/87																		
		MW-2	9/28/87					2.7	59				5.3	1.5	6.3	2.3					
		MW-2d	9/28/87					1.3	58				3.1	4.4	3.1	1.1					
		MW-3C	9/28/87																		
Tn Menasha	671	N-2	12/8/87		13								4.8								
		BB	12/8/87																		
		N-9	12/8/87																		
		N-10	12/8/87																		
		N-11	12/8/87																		
		N-11d	12/8/87																		
		N-8A	4/20/88																		
		N-10	4/20/88																		
		N-11	4/20/88																		
		BB	4/20/88																		
		N-12	4/20/88																		
		N-12d	4/20/88																		

APPENDIX A. VOC DATA FOR 19 MUNICIPAL LANDFILLS IN WISCONSIN (CONTINUED)
(in ug/l)

FACILITY NAME	LICENSE NUMBER	WELL NAME	SAMPLING DATE	Trichlorofluromethane	Chloroethane	1,1-Dichloroethane	1,1,1-Trichloroethane	Vinyl Chloride	1,2-Dichloroethylene	Trichloroethylene	Tetrachloroethylene	1,2-Dichloropropane	Benzene	Toluene	Xylene	Ethylbenzene	Chlorobenzene	1,2-Dichlorobenzene	1,4-Dichlorobenzene	Tetrahydrofuran	Carbon Disulfide
Tn Saratoga	655	MW-1	3/16/88																		
		MW-2	3/16/88																		
		MW-3	3/16/88						<no detects>												
		MW-4	3/16/88																		
		MW-4d	3/16/88																		
		BB	3/16/88																		
		MW-5	3/16/88																		
Tn Wilson	758	UG-1	11/24/87																		
		SG-2	11/24/87																		
		DG-3	11/24/87		10	2		3.4													
		DG-4	11/24/87		13	1.8		4.9													
		DG-5	11/24/87																		
		DG-6	11/24/87																		
		UG-1	5/16/88																		
		SG-2	5/16/88																		
		DG-3	5/16/88		5.1	1.7															
		DG-4	5/16/88		2.8																
		DG-4d	5/16/88																		
		BB	5/16/88																		
		DG-5	5/16/88																		
		DG-6	5/16/88																		
Wiederholt	1918	MW-2	9/29/87																		
		MW-3	9/29/87			11			10	4.6	1.9	1.1							2.7		
		BB	9/29/87																		
		MW-4	9/29/87																		
		MW-4d	9/29/87																		

NOTE: Monitoring well names ending in "d" indicate duplicate samples.
"BB" indicates a bailer blank sample.

APPENDIX B. VOC DATA FOR 6 INDUSTRIAL LANDFILLS IN WISCONSIN
(in ug/l)

FACILITY NAME	LICENSE NUMBER	WELL NAME	SAMPLING DATE	Tri-chloro-fluro-methane	Chloro-ethane	1,1-Di-chloro-ethane	1,1,1-Tri-chloro-ethane	Vinyl Chloride	1,2-Di-chloro-ethyl-ene	Tri-chloro-ethyl-ene	Tetra-chloro-ethyl-ene	1,2-Di-chloro-propane	Benzene	Toluene	Xylene	Ethyl-benzene	Chloro-benzene	1,2-chloro-benzene	1,4-chloro-benzene	Tetra-hydro-furan	Carbon Di-sulfide
Appleton	3036																				
		16A	4/20/88																		
		B-34A	4/20/88																		
		B-34Ad	4/20/88					<no detects>													
		BB	4/20/88																		
	30																				
		B-37D	4/20/88																		
		B-49A	4/20/88																		
Merrill Sand & Gravel	1928																				
		B-1	10/07/87																		
		B-2	10/07/87					<no detects>													
		B-3	10/07/87																		
		B-3d	10/07/87																		
		BB	10/07/87																		
Nekoosa Paper	2613																				
		MW-34	10/26/87																		
		MW-21	10/26/87																	380	
		CB-7	10/26/87																		
		CB-8	10/26/87																		
		LC-1	10/26/87																		
		BB	10/26/87																		
Sadoff & Rudoy	1554																				
		MW-6	9/21/87																		
		MW-7	9/21/87																		
		MW-7d	9/21/87					<no detects>													
		MW-7A	9/21/87																		
		MW-8	9/21/87																		
		BB	9/21/87																		
		MW-9	9/21/87																		
		MW-9A	9/21/87																		

APPENDIX B. VOC DATA FOR 6 INDUSTRIAL LANDFILLS IN WISCONSIN (CONTINUED)
(in ug/l)

FACILITY NAME	LICENSE NUMBER	WELL NAME	SAMPLING DATE	Trichlorofluromethane	Chloroethane	1,1-Dichloroethane	1,1,1-Trichloroethane	Vinyl Chloride	1,2-Dichloroethylene	Trichloroethylene	Tetrachloroethylene	1,2-Dichloropropane	Benzene	Toluene	Xylene	Ethylbenzene	Chlorobenzene	1,2-chlorobenzene	1,4-chlorobenzene	Tetrahydrofuran	Carbon Disulfide
Scott	2368																				
Paper		B-24	10/13/87																		
		B-24d	10/13/87																		
		B-8AR	10/13/87																		
		BB	10/13/87																		
	2846							<no detects>													
		B-15	10/13/87																		
		B-26	10/13/87																		
Spielvogel	472																				
		BB	11/23/87																		
		MW-1	11/23/87								1										
		MW-2	11/23/87																		
		MW-3A	11/23/87																		
		MW-4	11/23/87																		
		MW-5	11/23/87			2.6															
		MW-1	5/09/88								1.4										
		BB	5/09/88																		
		MW-1d	5/09/88								1.5										
		MW-2	5/09/88																		
		MW-3A	5/09/88																		
		MW-4	5/09/88																		
		MW-5	5/09/88			2.3															

NOTE: Monitoring well names ending in "d" indicate duplicate samples.
"BB" indicates a bailer blank sample.

APPENDIX C. GROUNDWATER MONITORING DATA SORTED BY PARAMETER AND VALUE.

LICENSE #	WELL #	WELL NAME	DATE	DUPLICATE #	PARAMETER	[UG/L]
126	004	MW-4	09/22/87	1	CHLOROETHANE	2.3
126	003	MW-3	09/22/87	1	CHLOROETHANE	2.6
1731	002	MW-2	03/22/88	1	CHLOROETHANE	2.8
108	802	W-2	03/29/88	1	CHLOROETHANE	3.3
126	002	MW-2	06/24/87	1	CHLOROETHANE	3.6
130	103	MW-3	06/08/88	1	CHLOROETHANE	3.6
108	803	W-3	03/29/88	1	CHLOROETHANE	3.6
130	103	MW-3	06/08/88	1	CHLOROETHANE	3.9
1731	002	MW-2	03/22/88	2	CHLOROETHANE	5.3
1751	804	MW-4	06/07/88	1	CHLOROETHANE	6.1
758	203	DG-3	11/24/87	1	CHLOROETHANE	10.0
126	003	MW-3	06/24/87	1	CHLOROETHANE	13.0
758	204	DG-4	11/24/87	1	CHLOROETHANE	13.0
671	001	N-2	12/08/87	1	CHLOROETHANE	13.0
1422	602	MW-2	12/15/87	1	CHLOROETHANE	18.0
1422	602	MW-2	03/09/88	1	CHLOROETHANE	23.0
1422	602	MW-2	03/09/88	1	1,1-DICHLOROETHANE	1.6
679	001	MW-1	08/25/87	1	1,1-DICHLOROETHANE	1.6
126	002	MW-2	06/24/87	1	1,1-DICHLOROETHANE	1.6
758	204	DG-4	11/24/87	1	1,1-DICHLOROETHANE	1.8
679	007	MW-5	08/25/87	1	1,1-DICHLOROETHANE	1.8
758	203	DG-3	11/24/87	1	1,1-DICHLOROETHANE	2.0
472	005	MW-5	05/09/88	1	1,1-DICHLOROETHANE	2.3
1768	104	MW-4	07/06/87	1	1,1-DICHLOROETHANE	2.5
472	005	MW-5	11/23/87	1	1,1-DICHLOROETHANE	2.6
2054	805	MW-5	09/23/85	1	1,1-DICHLOROETHANE	3.4
126	003	MW-3	06/24/87	1	1,1-DICHLOROETHANE	4.1
126	004	MW-4	09/22/87	1	1,1-DICHLOROETHANE	4.5
1741	804	MW-4	06/07/88	1	1,1-DICHLOROETHANE	4.9
126	003	MW-3	09/22/87	1	1,1-DICHLOROETHANE	6.2
130	103	MW-3	06/08/88	1	1,1-DICHLOROETHANE	6.6
130	103	MW-3	06/08/88	2	1,1-DICHLOROETHANE	7.2
1918	108	MW-3	09/29/87	1	1,1-DICHLOROETHANE	11.0
893	111	MW-5	08/04/87	1	1,1-DICHLOROETHANE	12.0
140	211	W-22	07/09/86	1	1,1-DICHLOROETHANE	29.0
1768	103	MW-3	09/14/87	1	1,1-DICHLOROETHANE	42.0
1768	103	MW-3	07/06/87	2	1,1-DICHLOROETHANE	42.0
1768	103	MW-3	07/06/87	1	1,1-DICHLOROETHANE	44.0
140	214	W-54	07/09/86	1	1,1-DICHLOROETHANE	55.0
2054	805	MW-5	09/23/85	1	1,1,1-TRICHLOROETHANE	1.3
2054	803	MW-3	09/23/85	1	1,1,1-TRICHLOROETHANE	1.8
2054	803	MW-3	12/10/85	1	1,1,1-TRICHLOROETHANE	1.8
1768	103	MW-3	07/06/87	2	1,1,1-TRICHLOROETHANE	4.3
130	103	MW-3	06/08/88	2	1,1,1-TRICHLOROETHANE	4.5
130	103	MW-3	06/08/88	1	1,1,1-TRICHLOROETHANE	4.7
1768	103	MW-3	07/06/87	1	1,1,1-TRICHLOROETHANE	4.9

APPENDIX C. GROUNDWATER MONITORING DATA SORTED BY PARAMETER AND VALUE (CONTINUED).

LICENSE #	WELL #	WELL NAME	DATE	DUPLICATE #	PARAMETER	[UG/L]
1768	103	MW-3	09/14/87	1	1,1,1-TRICHLOROETHANE	6.2
140	214	W-54	07/09/86	1	1,1,1-TRICHLOROETHANE	9.9
2054	804	MW-4	12/10/85	1	1,1,1-TRICHLOROETHANE	23.0
2054	804	MW-4	12/10/85	2	1,1,1-TRICHLOROETHANE	34.0
2054	804	MW-4	09/23/85	1	1,1,1-TRICHLOROETHANE	51.0
1779	002	MW-2	09/28/87	2	VINYL CHLORIDE	1.3
126	004	MW-4	09/22/87	1	VINYL CHLORIDE	2.2
1779	002	MW-2	09/28/87	1	VINYL CHLORIDE	2.7
758	203	DG-3	11/24/87	1	VINYL CHLORIDE	3.4
758	204	DG-4	11/24/87	1	VINYL CHLORIDE	4.9
126	002	MW-2	06/24/87	1	VINYL CHLORIDE	7.3
126	002	MW-2	09/22/87	1	VINYL CHLORIDE	10.0
1731	002	MW-2	03/22/88	1	VINYL CHLORIDE	10.0
1731	002	MW-2	03/22/88	2	VINYL CHLORIDE	13.0
126	003	MW-3	06/24/87	1	VINYL CHLORIDE	27.0
126	003	MW-3	09/22/87	1	VINYL CHLORIDE	28.0
1422	602	MW-2	12/15/87	1	VINYL CHLORIDE	36.0
108	802	W-2	03/29/88	1	VINYL CHLORIDE	41.0
1422	602	MW-2	03/09/88	1	VINYL CHLORIDE	59.0
1768	103	MW-3	09/14/87	1	VINYL CHLORIDE	73.0
893	111	MW-5	08/04/87	1	VINYL CHLORIDE	82.0
679	005	MW-3	08/25/87	1	VINYL CHLORIDE	120.0
130	104	MW-4	06/08/88	1	1,2-DICHLOROETHYLENE	1.6
1731	002	MW-2	03/22/88	1	1,2-DICHLOROETHYLENE	1.8
1731	002	MW-2	03/22/88	2	1,2-DICHLOROETHYLENE	2.1
679	007	MW-5	08/25/87	1	1,2-DICHLOROETHYLENE	2.4
679	001	MW-1	08/25/87	1	1,2-DICHLOROETHYLENE	3.7
1751	801	MW-1	06/07/88	1	1,2-DICHLOROETHYLENE	4.4
140	211	W-22	07/09/86	1	1,2-DICHLOROETHYLENE	6.1
126	003	MW-3	06/24/87	1	1,2-DICHLOROETHYLENE	6.2
130	103	MW-3	06/08/88	1	1,2-DICHLOROETHYLENE	6.2
126	003	MW-3	09/22/87	1	1,2-DICHLOROETHYLENE	6.8
130	103	MW-3	06/08/88	2	1,2-DICHLOROETHYLENE	7.3
1751	804	MW-4	06/07/88	1	1,2-DICHLOROETHYLENE	8
1768	104	MW-4	07/06/87	1	1,2-DICHLOROETHYLENE	8.1
126	004	MW-4	06/24/87	2	1,2-DICHLOROETHYLENE	9.0
126	004	MW-4	06/24/87	1	1,2-DICHLOROETHYLENE	9.4
679	005	MW-3	08/25/87	1	1,2-DICHLOROETHYLENE	9.8
1918	108	MW-3	09/29/87	1	1,2-DICHLOROETHYLENE	10.0
126	005	MW-5	06/24/87	1	1,2-DICHLOROETHYLENE	12.0
126	005	MW-5	09/22/87	1	1,2-DICHLOROETHYLENE	14.0
140	214	W-54	07/09/86	1	1,2 DICHLOROETHYLENE	17.0
126	002	MW-2	06/24/87	1	1,2-DICHLOROETHYLENE	19.0
126	002	MW-2	09/22/87	1	1,2-DICHLOROETHYLENE	21.0
126	004	MW-4	09/22/87	1	1,2-DICHLOROETHYLENE	25.0
1768	103	MW-3	09/14/87	1	1,2-DICHLOROETHYLENE	31.0

APPENDIX C. GROUNDWATER MONITORING DATA SORTED BY PARAMETER AND VALUE (CONTINUED).

LICENSE #	WELL #	WELL NAME	DATE	DUPLICATE #	PARAMETER	[UG/L]
893	111	MW-5	08/04/87	1	1,2-DICHLOROETHYLENE	34.0
1779	002	MW-2	09/28/87	2	1,2-DICHLOROETHYLENE	58.0
1779	002	MW-2	09/28/87	1	1,2-DICHLOROETHYLENE	59.0
1768	103	MW-3	07/06/87	1	1,2-DICHLOROETHYLENE	97.0
1768	103	MW-3	07/06/87	2	1,2-DICHLOROETHYLENE	110.0
126	002	MW-2	06/24/87	1	TRICHLOROETHYLENE	1.0
1751	804	MW-4	06/07/88	1	TRICHLOROETHYLENE	1.1
2054	805	MW-5	09/23/85	1	TRICHLOROETHYLENE	1.2
679	007	MW-5	08/25/87	1	TRICHLOROETHYLENE	1.8
1768	103	MW-3	09/14/87	1	TRICHLOROETHYLENE	2.1
1768	103	MW-3	07/06/87	1	TRICHLOROETHYLENE	2.6
126	004	MW-4	06/24/87	2	TRICHLOROETHYLENE	2.7
126	004	MW-4	06/24/87	1	TRICHLOROETHYLENE	2.7
1768	103	MW-3	07/06/87	2	TRICHLOROETHYLENE	2.8
126	003	MW-3	09/22/87	1	TRICHLOROETHYLENE	3.4
893	111	MW-5	08/04/87	1	TRICHLOROETHYLENE	3.7
126	003	MW-3	06/24/87	1	TRICHLOROETHYLENE	4.1
1918	108	MW-3	09/29/87	1	TRICHLOROETHYLENE	4.6
140	211	W-22	07/09/86	1	TRICHLOROETHYLENE	8.9
126	004	MW-4	09/22/87	1	TRICHLOROETHYLENE	11.0
140	214	W-54	07/09/86	1	TRICHLOROETHYLENE	13.0
472	001	MW-1	11/23/87	1	TETRACHLOROETHYLENE	1.0
126	003	MW-3	09/22/87	1	TETRACHLOROETHYLENE	1.4
472	001	MW-1	05/09/88	1	TETRACHLOROETHYLENE	1.4
472	001	MW-1	05/09/88	2	TETRACHLOROETHYLENE	1.5
126	005	MW-5	09/22/87	1	TETRACHLOROETHYLENE	1.6
2054	803	MW-3	09/23/85	1	TETRACHLOROETHYLENE	1.7
1918	108	MW-3	09/29/87	1	TETRACHLOROETHYLENE	1.9
126	002	MW-2	09/22/87	1	TETRACHLOROETHYLENE	2.1
1768	103	MW-3	09/14/87	1	TETRACHLOROETHYLENE	2.4
126	005	MW-5	06/24/87	1	TETRACHLOROETHYLENE	2.5
2054	803	MW-3	12/10/85	1	TETRACHLOROETHYLENE	2.5
126	002	MW-2	06/24/87	1	TETRACHLOROETHYLENE	2.6
679	007	MW-5	08/25/87	1	TETRACHLOROETHYLENE	3.6
130	103	MW-3	06/08/88	1	TETRACHLOROETHYLENE	4.2
130	103	MW-3	06/08/88	2	TETRACHLOROETHYLENE	4.5
1422	603	MW-3	03/09/88	1	TETRACHLOROETHYLENE	5.7
1422	603	MW-3	03/09/88	2	TETRACHLOROETHYLENE	6.6
140	214	W-54	07/09/86	1	TETRACHLOROETHYLENE	7.3
1422	603	MW-3	12/15/87	1	TETRACHLOROETHYLENE	12.0
893	107	MW-2	08/04/87	1	BENZENE	>1
893	107	MW-2	08/04/87	2	BENZENE	>1
140	211	W-22	07/09/86	1	BENZENE	1.0
1751		BB	06/07/88	1	BENZENE	1.1
126	003	MW-3	06/24/87	1	BENZENE	1.2

APPENDIX C. GROUNDWATER MONITORING DATA SORTED BY PARAMETER AND VALUE (CONTINUED).

LICENSE #	WELL #	WELL NAME	DATE	DUPLICATE #	PARAMETER	[UG/L]
1422	602	MW-2	12/15/87	1	BENZENE	1.6
1751	804	MW-4	06/07/88	1	BENZENE	2.4
1779	002	MW-2	09/28/87	2	BENZENE	3.1
671	001	N-2	12/08/87	1	BENZENE	4.8
679	005	MW-3	08/25/87	1	BENZENE	4.9
1779	002	MW-2	09/28/87	1	BENZENE	5.3
893	111	MW-5	08/04/87	1	BENZENE	9.8
140	214	W-54	07/09/86	1	BENZENE	11.0
1768	103	MW-3	07/06/87	1	BENZENE	20.0
1768	103	MW-3	07/06/87	2	BENZENE	31.0
1768	103	MW-3	09/14/87	1	BENZENE	32.0
679	001	MW-1	08/25/87	1	BENZENE	37.0
679	007	MW-5	08/25/87	1	BENZENE	43.0
893	107	MW-2	08/04/87	1	CHLOROBENZENE	>2
893	107	MW-2	08/04/87	2	CHLOROBENZENE	>2
1768	103	MW-3	09/14/87	1	CHLOROBENZENE	5.0
1768	103	MW-3	07/06/87	1	CHLOROBENZENE	12.0
1768	103	MW-3	07/06/87	2	CHLOROBENZENE	16.0
893	107	MW-2	08/04/87	2	ETHYLBENZENE	>1
893	107	MW-2	08/04/87	1	ETHYLBENZENE	>1
1779	002	MW-2	09/28/87	2	ETHYLBENZENE	1.1
679	007	MW-5	08/25/87	1	ETHYLBENZENE	1.5
108	803	W-3	03/29/88	1	ETHYLBENZENE	1.5
130	104	MW-4	06/08/88	1	ETHYLBENZENE	1.9
1779	002	MW-2	09/28/87	1	ETHYLBENZENE	2.3
1751	804	MW-4	06/07/88	1	ETHYLBENZENE	12
1768	103	MW-3	07/06/87	1	ETHYLBENZENE	13.0
1422	602	MW-2	03/09/88	1	ETHYLBENZENE	20.0
1768	103	MW-3	07/06/87	2	ETHYLBENZENE	23.0
1768	103	MW-3	09/14/87	1	ETHYLBENZENE	25.0
1422	602	MW-2	12/15/87	1	ETHYLBENZENE	29.0
893	111	MW-5	08/04/87	1	ETHYLBENZENE	1000.0
893	107	MW-2	08/04/87	2	1,2-DICHLOROBENZENE	>2
1768	103	MW-3	09/14/87	1	1,2-DICHLOROBENZENE	2.4
1768	103	MW-3	07/06/87	1	1,2-DICHLOROBENZENE	5.7
1768	103	MW-3	07/06/87	2	1,2-DICHLOROBENZENE	7.4
893	107	MW-2	08/04/87	2	1,4-DICHLOROBENZENE	>2
893	107	MW-2	08/04/87	1	1,4-DICHLOROBENZENE	>2
1768	103	MW-3	07/06/87	1	1,4-DICHLOROBENZENE	2.2
1918	108	MW-3	09/29/87	1	1,4-DICHLOROBENZENE	2.7
1768	103	MW-3	07/06/87	2	1,4-DICHLOROBENZENE	3.0
130	104	MW-4	06/08/88	1	1,4-DICHLOROBENZENE	9.2
1779	002	MW-2	09/28/87	1	TOLUENE	1.5

APPENDIX C. GROUNDWATER MONITORING DATA SORTED BY PARAMETER AND VALUE (CONTINUED).

LICENSE #	WELL #	WELL NAME	DATE	DUPLICATE #	PARAMETER	[UG/L]
1751		BB	06/07/88	1	TOLUENE	2.4
1422	602	MW-2	03/09/88	1	TOLUENE	2.5
130	104	MW-4	06/08/88	1	TOLUENE	2.5
108		BB	03/29/88	1	TOLUENE	2.7
126	003	MW-3	06/24/87	1	TOLUENE	2.7
1422	602	MW-2	12/15/87	1	TOLUENE	3.3
1779	002	MW-2	09/28/87	2	TOLUENE	4.4
679	007	MW-5	08/25/87	1	TOLUENE	40.0
1751	804	MW-4	06/07/88	1	TOLUENE	92
1768	103	MW-3	09/14/87	1	TOLUENE	170.0
1768	103	MW-3	07/06/87	1	TOLUENE	180.0
1768	103	MW-3	07/06/87	2	TOLUENE	270.0
893	111	MW-5	08/04/87	1	TOLUENE	820.0
893	107	MW-2	08/04/87	2	XYLENE (TOTAL)	>2
893	107	MW-2	08/04/87	1	XYLENE (TOTAL)	>2
679	001	MW-1	08/25/87	1	XYLENE (TOTAL)	2.9
1779	002	MW-2	09/28/87	2	XYLENE (TOTAL)	3.1
1731	002	MW-2	03/22/88	1	XYLENE (TOTAL)	4.0
1779	002	MW-2	09/28/87	1	XYLENE (TOTAL)	6.3
1422	602	MW-2	03/09/88	1	XYLENE (TOTAL)	6.8
679	007	MW-5	08/25/87	1	XYLENE (TOTAL)	7.0
1422	602	MW-2	12/15/87	1	XYLENE (TOTAL)	10.0
1751	804	MW-4	06/07/88	1	XYLENE (TOTAL)	27
130	104	MW-4	06/08/88	1	XYLENE (TOTAL)	32
1768	103	MW-3	07/06/87	1	XYLENE (TOTAL)	45.0
1768	103	MW-3	09/14/87	1	XYLENE (TOTAL)	73.0
1768	103	MW-3	07/06/87	2	XYLENE (TOTAL)	75.0
893	111	MW-5	08/04/87	1	XYLENE (TOTAL)	98.0
108	801	W-1	03/29/88	1	TRICHLOROFLUOROMETHANE	1.4
130	103	MW-3	06/08/88	1	TRICHLOROFLUOROMETHANE	3.4
130	103	MW-3	06/08/88	1	TRICHLOROFLUOROMETHANE	3.4
1751	801	MW-1	06/07/88	1	TRICHLOROFLUOROMETHANE	3.5
1751	804	MW-4	06/07/88	1	TRICHLOROFLUOROMETHANE	4.8
2054	805	MW-5	09/23/85	1	TRICHLOROFLUOROMETHANE	9.4
1422	603	MW-3	03/09/88	1	TRICHLOROFLUOROMETHANE	11.0
1422	603	MW-3	03/09/88	2	TRICHLOROFLUOROMETHANE	13.0
2054	803	MW-3	09/23/85	1	TRICHLOROFLUOROMETHANE	15.0
2054	803	MW-3	12/10/85	1	TRICHLOROFLUOROMETHANE	24.0
2054	804	MW-4	12/10/85	1	TRICHLOROFLUOROMETHANE	36.0
2054	804	MW-4	12/10/85	2	TRICHLOROFLUOROMETHANE	55.0
2054	804	MW-4	09/23/85	1	TRICHLOROFLUOROMETHANE	66.0
893	107	MW-2	08/04/87	2	TETRAHYDROFURAN	>200
893	107	MW-2	08/04/87	1	TETRAHYDROFURAN	>200
2613	079	MW-21	10/26/87	1	TETRAHYDROFURAN	380.0
893	108	MW-3	08/04/87	1	TETRAHYDROFURAN	560.0

APPENDIX C. GROUNDWATER MONITORING DATA SORTED BY PARAMETER AND VALUE (CONTINUED).

LICENSE #	WELL #	WELL NAME	DATE	DUPLICATE #	PARAMETER	[UG/L]
893	107	MW-2	08/04/87	1	CARBON DISULFIDE	>5
893	107	MW-2	08/04/87	2	CARBON DISULFIDE	>5
1918	108	MW-3	09/29/87	1	1,2-DICHLOROPROPANE	1.1

APPENDIX D. GROUNDWATER MONITORING DATA SORTED BY LANDFILL AND PARAMETER.

LICENSE #	WELL #	WELL NAME	DATE	DUPLICATE #	VOC PARAMETER	[UG/L]
108	802	W-2	03/29/88	1	CHLOROETHANE	3.3
108	803	W-3	03/29/88	1	CHLOROETHANE	3.6
108	802	W-2	03/29/88	1	VINYL CHLORIDE	41.0
108	803	W-3	03/29/88	1	ETHYL BENZENE	1.5
108		BB	03/29/88	1	TOLUENE	2.7
108	801	W-1	03/29/88	1	TRICHLOROFLUOROMETHANE	1.4
126	004	MW-4	09/22/87	1	CHLOROETHANE	2.3
126	003	MW-3	09/22/87	1	CHLOROETHANE	2.6
126	002	MW-2	06/24/87	1	CHLOROETHANE	3.6
126	003	MW-3	06/24/87	1	CHLOROETHANE	13.0
126	002	MW-2	06/24/87	1	1,1-DICHLOROETHANE	1.6
126	003	MW-3	06/24/87	1	1,1-DICHLOROETHANE	4.1
126	004	MW-4	09/22/87	1	1,1-DICHLOROETHANE	4.5
126	003	MW-3	09/22/87	1	1,1-DICHLOROETHANE	6.2
126	004	MW-4	09/22/87	1	VINYL CHLORIDE	2.2
126	002	MW-2	06/24/87	1	VINYL CHLORIDE	7.3
126	002	MW-2	09/22/87	1	VINYL CHLORIDE	10.0
126	003	MW-3	06/24/87	1	VINYL CHLORIDE	27.0
126	003	MW-3	09/22/87	1	VINYL CHLORIDE	28.0
126	003	MW-3	06/24/87	1	1,2-DICHLOROETHYLENE	6.2
126	003	MW-3	09/22/87	1	1,2-DICHLOROETHYLENE	6.8
126	004	MW-4	06/24/87	2	1,2-DICHLOROETHYLENE	9.0
126	004	MW-4	06/24/87	1	1,2-DICHLOROETHYLENE	9.4
126	005	MW-5	06/24/87	1	1,2-DICHLOROETHYLENE	12.0
126	005	MW-5	09/22/87	1	1,2-DICHLOROETHYLENE	14.0
126	002	MW-2	06/24/87	1	1,2-DICHLOROETHYLENE	19.0
126	002	MW-2	09/22/87	1	1,2-DICHLOROETHYLENE	21.0
126	004	MW-4	09/22/87	1	1,2-DICHLOROETHYLENE	25.0
126	002	MW-2	06/24/87	1	TRICHLOROETHYLENE	1.0
126	004	MW-4	06/24/87	2	TRICHLOROETHYLENE	2.7
126	004	MW-4	06/24/87	1	TRICHLOROETHYLENE	2.7
126	003	MW-3	09/22/87	1	TRICHLOROETHYLENE	3.4
126	003	MW-3	06/24/87	1	TRICHLOROETHYLENE	4.1
126	004	MW-4	09/22/87	1	TRICHLOROETHYLENE	11.0
126	003	MW-3	09/22/87	1	TETRACHLOROETHYLENE	1.4
126	005	MW-5	09/22/87	1	TETRACHLOROETHYLENE	1.6
126	002	MW-2	09/22/87	1	TETRACHLOROETHYLENE	2.1
126	005	MW-5	06/24/87	1	TETRACHLOROETHYLENE	2.5
126	002	MW-2	06/24/87	1	TETRACHLOROETHYLENE	2.6
126	003	MW-3	06/24/87	1	BENZENE	1.2
126	003	MW-3	06/24/87	1	TOLUENE	2.7
130	103	MW-3	06/08/88	1	CHLOROETHANE	3.6
130	103	MW-3	06/08/88	2	CHLOROETHANE	3.9
130	103	MW-3	06/08/88	1	1,1-DICHLOROETHANE	6.6
130	103	MW-3	06/08/88	2	1,1-DICHLOROETHANE	7.2
130	103	MW-3	06/08/88	2	1,1,1-TRICHLOROETHANE	4.5

APPENDIX D. GROUNDWATER MONITORING DATA SORTED BY LANDFILL AND PARAMETER (CONTINUED).

LICENSE #	WELL #	WELL NAME	DATE	DUPLICATE #	VOC PARAMETER	[UG/L]
130	103	MW-3	06/08/88	1	1,1,1-TRICHLOROETHANE	4.7
130	103	MW-3	06/08/88	1	TRICHLOROFLUOROMETHANE	3.4
130	103	MW-3	06/08/88	2	TRICHLOROFLUOROMETHANE	3.4
130	103	MW-3	06/08/88	1	1,2-DICHLOROETHYLENE	1.6
130	103	MW-3	06/08/88	1	1,2-DICHLOROETHYLENE	6.2
130	104	MW-4	06/08/88	2	1,2-DICHLOROETHYLENE	7.3
130	103	MW-3	06/08/88	1	TETRACHLOROEHTYLENE	4.2
130	103	MW-3	06/08/88	2	TETRACHLOROETHYLENE	4.5
130	104	MW-4	06/08/88	1	1,4-DICHLOROBENZENE	9.2
130	104	MW-4	06/08/88	1	ETHYLBENZENE	1.9
130	104	MW-4	06/08/88	1	TOLUENE	2.5
130	104	MW-4	06/08/88	1	XYLENE (TOTAL)	32.0
140	211	W-22	07/09/86	1	1,1-DICHLOROETHANE	29.0
140	214	W-54	07/09/86	1	1,1-DICHLOROETHANE	55.0
140	214	W-54	07/09/86	1	1,1,1-TRICHLOROETHANE	9.9
140	211	W-22	07/09/86	1	1,2-DICHLOROETHYLENE	6.1
140	214	W-54	07/09/86	1	1,2-DICHLOROETHYLENE	17.0
140	211	W-22	07/09/86	1	TRICHLOROETHYLENE	8.9
140	214	W-54	07/09/86	1	TRICHLOROETHYLENE	13.0
140	214	W-54	07/09/86	1	TETRACHLOROETHYLENE	7.3
140	211	W-22	07/09/86	1	BENZENE	1.0
140	214	W-54	07/09/86	1	BENZENE	11.0
472	005	MW-5	05/09/88	1	1,1-DICHLOROETHANE	2.3
472	005	MW-5	11/23/87	1	1,1-DICHLOROETHANE	2.6
472	001	MW-1	11/23/87	1	TETRACHLOROETHYLENE	1.0
472	001	MW-1	05/09/88	1	TETRACHLOROETHYLENE	1.4
472	001	MW-1	05/09/88	2	TETRACHLOROETHYLENE	1.5
671	001	N-2	12/08/87	1	CHLOROETHANE	13.0
671	001	N-2	12/08/87	1	BENZENE	4.8
679	001	MW-1	08/25/87	1	1,1-DICHLOROETHANE	1.6
679	007	MW-5	08/25/87	1	1,1-DICHLOROETHANE	1.8
679	005	MW-3	08/25/87	1	VINYL CHLORIDE	120.0
679	007	MW-5	08/25/87	1	1,2-DICHLOROETHYLENE	2.4
679	001	MW-1	08/25/87	1	1,2-DICHLOROETHYLENE	3.7
679	005	MW-3	08/25/87	1	1,2-DICHLOROETHYLENE	9.8
679	007	MW-5	08/25/87	1	TRICHLOROETHYLENE	1.8
679	007	MW-5	08/25/87	1	TETRACHLOROETHYLENE	3.6
679	005	MW-3	08/25/87	1	BENZENE	4.9
679	001	MW-1	08/25/87	1	BENZENE	37.0
679	007	MW-5	08/25/87	1	BENZENE	43.0
679	007	MW-5	08/25/87	1	ETHYL BENZENE	1.5
679	007	MW-5	08/25/87	1	TOLUENE	40.0
679	001	MW-1	08/25/87	1	XYLENE (TOTAL)	2.9
679	007	MW-5	08/25/87	1	XYLENE (TOTAL)	7.0

?. GROUNDWATER MONITORING DATA SORTED BY LANDFILL AND PARAMETER (CONTINUED).

LICENSE #	WELL #	WELL NAME	DATE	DUPLICATE #	VOC PARAMETER	[UG/L]
758	203	DG-3	11/24/87	1	CHLOROETHANE	10.0
758	204	DG-4	11/24/87	1	CHLOROETHANE	13.0
758	204	DG-4	11/24/87	1	1,1-DICHLOROETHANE	1.8
758	203	DG-3	11/24/87	1	1,1-DICHLOROETHANE	2.0
758	203	DG-3	11/24/87	1	VINYL CHLORIDE	3.4
758	204	DG-4	11/24/87	1	VINYL CHLORIDE	4.9
893	107	MW-2	08/04/87	1	CARBON DISULFIDE	>5
893	107	MW-2	08/04/87	2	CARBON DISULFIDE	>5
893	111	MW-5	08/04/87	1	1,1-DICHLOROETHANE	12.0
893	111	MW-5	08/04/87	1	VINYL CHLORIDE	82.0
893	111	MW-5	08/04/87	1	1,2-DICHLOROETHYLENE	34.0
893	111	MW-5	08/04/87	1	TRICHLOROETHYLENE	3.7
893	107	MW-2	08/04/87	2	BENZENE	>1
893	107	MW-2	08/04/87	1	BENZENE	>1
893	111	MW-5	08/04/87	1	BENZENE	9.8
893	107	MW-2	08/04/87	1	CHLOROBENZENE	>2
893	107	MW-2	08/04/87	2	CHLOROBENZENE	>2
893	107	MW-2	08/04/87	2	ETHYL BENZENE	>1
893	107	MW-2	08/04/87	1	ETHYL BENZENE	>1
893	111	MW-5	08/04/87	1	ETHYL BENZENE	1000.0
893	107	MW-2	08/04/87	2	1,2-DICHLOROBENZENE	>2
893	107	MW-2	08/04/87	2	1,4-DICHLOROBENZENE	>2
893	107	MW-2	08/04/87	1	1,4-DICHLOROBENZENE	>2
893	111	MW-5	08/04/87	1	TOLUENE	820.0
893	107	MW-2	08/04/87	1	XYLENE (TOTAL)	>2
893	107	MW-2	08/04/87	2	XYLENE (TOTAL)	>2
893	111	MW-5	08/04/87	1	XYLENE (TOTAL)	98.0
893	107	MW-2	08/04/87	1	TETRAHYDROFURAN	>200
893	107	MW-2	08/04/87	2	TETRAHYDROFURAN	>200
893	108	MW-3	08/04/87	1	TETRAHYDROFURAN	560.0
1422	602	MW-2	12/15/87	1	CHLOROETHANE	18.0
1422	602	MW-2	03/09/88	1	CHLOROETHANE	23.0
1422	602	MW-2	03/09/88	1	1,1-DICHLOROETHANE	1.6
1422	602	MW-2	12/15/87	1	VINYL CHLORIDE	36.0
1422	602	MW-2	03/09/88	1	VINYL CHLORIDE	59.0
1422	603	MW-3	03/09/88	1	TETRACHLOROETHYLENE	5.7
1422	603	MW-3	03/09/88	2	TETRACHLOROETHYLENE	6.6
1422	603	MW-3	12/15/87	1	TETRACHLOROETHYLENE	12.0
1422	602	MW-2	12/15/87	1	BENZENE	1.6
1422	602	MW-2	03/09/88	1	ETHYL BENZENE	20.0
1422	602	MW-2	12/15/87	1	ETHYL BENZENE	29.0
1422	602	MW-2	03/09/88	1	TOLUENE	2.5
1422	602	MW-2	12/15/87	1	TOLUENE	3.3
1422	602	MW-2	03/09/88	1	XYLENE (TOTAL)	6.8
1422	602	MW-2	12/15/87	1	XYLENE (TOTAL)	10.0
1422	603	MW-3	03/09/88	1	TRICHLOROFLUOROMETHANE	11.0

APPENDIX D. GROUNDWATER MONITORING DATA SORTED BY LANDFILL AND PARAMETER (CONTINUED).

LICENSE #	WELL #	WELL NAME	DATE	DUPLICATE #	VOC PARAMETER	[UG/L]
1422	603	MW-3	03/09/88	2	TRICHLOROFLUOROMETHANE	13.0
1731	002	MW-2	03/22/88	1	CHLOROETHANE	2.8
1731	002	MW-2	03/22/88	2	CHLOROETHANE	5.3
1731	002	MW-2	03/22/88	1	VINYL CHLORIDE	10.0
1731	002	MW-2	03/22/88	2	VINYL CHLORIDE	13.0
1731	002	MW-2	03/22/88	1	1,2-DICHLOROETHYLENE	1.8
1731	002	MW-2	03/22/88	2	1,2-DICHLOROETHYLENE	2.1
1731	002	MW-2	03/22/88	1	XYLENE (TOTAL)	4.0
1751	804	MW-1	06/07/88	1	CHLOROETHANE	6.1
1751	804	MW-1	06/07/88	1	1,1-DICHLOROETHANE	4.9
1751	801	MW-4	06/07/88	1	1,2-DICHLOROETHYLENE	4.4
1751	804	MW-4	06/07/88	1	1,2-DICHLOROETHYLENE	8
1751	804	MW-4	06/07/88	1	TRICHLOROETHYLENE	1.1
1751	801	MW-4	06/07/88	1	TRICHLOROFLUOROMETHANE	3.5
1751	804	MW-4	06/07/88	1	TRICHLOROFLUOROMETHANE	4.8
1751	804	MW-4	06/07/88	1	BENZENE	1.1
1751	804	MW-4	06/07/88	1	BENZENE	2.4
1751	804	MW-4	06/07/88	1	ETHYLBENZENE	12
1751		BB	06/07/88	1	TOLUENE	2.4
1751	804	MW-4	06/07/88	1	TOLUENE	92
1751		BB	06/07/88	1	XYLENES (TOTAL)	27
1768	104	MW-4	07/06/87	1	1,1-DICHLOROETHANE	2.5
1768	103	MW-3	09/14/87	1	1,1-DICHLOROETHANE	42.0
1768	103	MW-3	07/06/87	2	1,1-DICHLOROETHANE	42.0
1768	103	MW-3	07/06/87	1	1,1-DICHLOROETHANE	44.0
1768	103	MW-3	07/06/87	2	1,1,1-TRICHLOROETHANE	4.3
1768	103	MW-3	07/06/87	1	1,1,1-TRICHLOROETHANE	4.9
1768	103	MW-3	09/14/87	1	1,1,1-TRICHLOROETHANE	6.2
1768	103	MW-3	09/14/87	1	VINYL CHLORIDE	73.0
1768	104	MW-4	07/06/87	1	1,2-DICHLOROETHYLENE	8.1
1768	103	MW-3	09/14/87	1	1,2-DICHLOROETHYLENE	31.0
1768	103	MW-3	07/06/87	1	1,2-DICHLOROETHYLENE	97.0
1768	103	MW-3	07/06/87	2	1,2-DICHLOROETHYLENE	110.0
1768	103	MW-3	09/14/87	1	TRICHLOROETHYLENE	2.1
1768	103	MW-3	07/06/87	1	TRICHLOROETHYLENE	2.6
1768	103	MW-3	07/06/87	2	TRICHLOROETHYLENE	2.8
1768	103	MW-3	09/14/87	1	TETRACHLOROETHYLENE	2.4
1768	103	MW-3	07/06/87	1	BENZENE	20.0
1768	103	MW-3	07/06/87	2	BENZENE	31.0
1768	103	MW-3	09/14/87	1	BENZENE	32.0
1768	103	MW-3	09/14/87	1	CHLOROBENZENE	5.0
1768	103	MW-3	07/06/87	1	CHLOROBENZENE	12.0
1768	103	MW-3	07/06/87	2	CHLOROBENZENE	16.0
1768	103	MW-3	07/06/87	1	ETHYL BENZENE	13.0
1768	103	MW-3	07/06/87	2	ETHYL BENZENE	23.0

APPENDIX D. GROUNDWATER MONITORING DATA SORTED BY LANDFILL AND PARAMETER (CONTINUED).

LICENSE #	WELL #	WELL NAME	DATE	DUPLICATE #	VOC PARAMETER	[UG/L]
1768	103	MW-3	09/14/87	1	ETHYL BENZENE	25.0
1768	103	MW-3	09/14/87	1	1,2-DICHLOROBENZENE	2.4
1768	103	MW-3	07/06/87	1	1,2-DICHLOROBENZENE	5.7
1768	103	MW-3	07/06/87	2	1,2-DICHLOROBENZENE	7.4
1768	103	MW-3	07/06/87	1	1,4-DICHLOROBENZENE	2.2
1768	103	MW-3	07/06/87	2	1,4-DICHLOROBENZENE	3.0
1768	103	MW-3	09/14/87	1	TOLUENE	170.0
1768	103	MW-3	07/06/87	1	TOLUENE	180.0
1768	103	MW-3	07/06/87	2	TOLUENE	270.0
1768	103	MW-3	07/06/87	1	XYLENE (TOTAL)	45.0
1768	103	MW-3	09/14/87	1	XYLENE (TOTAL)	73.0
1768	103	MW-3	07/06/87	2	XYLENE (TOTAL)	75.0
1779	002	MW-2	09/28/87	2	VINYL CHLORIDE	1.3
1779	002	MW-2	09/28/87	1	VINYL CHLORIDE	2.7
1779	002	MW-2	09/28/87	2	1,2-DICHLOROETHYLENE	58.0
1779	002	MW-2	09/28/87	1	1,2-DICHLOROETHYLENE	59.0
1779	002	MW-2	09/28/87	2	BENZENE	3.1
1779	002	MW-2	09/28/87	1	BENZENE	5.3
1779	002	MW-2	09/28/87	2	ETHYL BENZENE	1.1
1779	002	MW-2	09/28/87	1	ETHYL BENZENE	2.3
1779	002	MW-2	09/28/87	1	TOLUENE	1.5
1779	002	MW-2	09/28/87	2	TOLUENE	4.4
1779	002	MW-2	09/28/87	2	XYLENE (TOTAL)	3.1
1779	002	MW-2	09/28/87	1	XYLENE (TOTAL)	6.3
1918	108	MW-3	09/29/87	1	1,2-DICHLOROPROPANE	1.1
1918	108	MW-3	09/29/87	1	1,1-DICHLOROETHANE	11.0
1918	108	MW-3	09/29/87	1	1,2-DICHLOROETHYLENE	10.0
1918	108	MW-3	09/29/87	1	TRICHLOROETHYLENE	4.6
1918	108	MW-3	09/29/87	1	TETRACHLOROETHYLENE	1.9
1918	108	MW-3	09/29/87	1	1,4-DICHLOROBENZENE	2.7
2054	805	MW-5	09/23/85	1	1,1-DICHLOROETHANE	3.4
2054	805	MW-5	09/23/85	1	1,1,1-TRICHLOROETHANE	1.3
2054	803	MW-3	12/10/85	1	1,1,1-TRICHLOROETHANE	1.8
2054	803	MW-3	09/23/85	1	1,1,1-TRICHLOROETHANE	1.8
2054	804	MW-4	12/10/85	1	1,1,1-TRICHLOROETHANE	23.0
2054	804	MW-4	12/10/85	2	1,1,1-TRICHLOROETHANE	34.0
2054	804	MW-4	09/23/85	1	1,1,1-TRICHLOROETHANE	51.0
2054	805	MW-5	09/23/85	1	TRICHLOROETHYLENE	1.2
2054	803	MW-3	09/23/85	1	TETRACHLOROETHYLENE	1.7
2054	803	MW-3	12/10/85	1	TETRACHLOROETHYLENE	2.5
2054	805	MW-5	09/23/85	1	TRICHLOROFLUOROMETHANE	9.4
2054	803	MW-3	09/23/85	1	TRICHLOROFLUOROMETHANE	15.0
2054	803	MW-3	12/10/85	1	TRICHLOROFLUOROMETHANE	24.0
2054	804	MW-4	12/10/85	1	TRICHLOROFLUOROMETHANE	36.0
2054	804	MW-4	12/10/85	2	TRICHLOROFLUOROMETHANE	55.0

APPENDIX D. GROUNDWATER MONITORING DATA SORTED BY LANDFILL AND PARAMETER (CONTINUED).

LICENSE #	WELL #	WELL NAME	DATE	DUPLICATE #	VOC PARAMETER	[UG/L]
2054	804	MW-4	09/23/85	1	TRICHLOROFLUOROMETHANE	66.0
2613	079	MW-21	10/26/87	1	TETRAHYDROFURAN	380.0

APPENDIX E. VOC MONITORING SURVEY LETTER

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Carroll D. Besadny
Secretary

BOX 7921
MADISON, WISCONSIN 53707

June 16, 1988 IN REPLY REFER TO: 4400

Mr. Charles Linn
Bureau of Waste Management
Department of Health and Environment
Forbes Field
Topeka, KS 66620

Dear Mr. Linn:

I contacted you or someone on your staff recently to let you know that this letter and survey would be coming.

The Wisconsin Department of Natural Resources is researching the extent of volatile organic compound (VOC) contamination of groundwater near municipal and industrial landfills in our state. We plan to use the results to help formulate regulations concerning groundwater monitoring for VOCs.

Toward the same end, we are soliciting information on other states' regulations and/or monitoring efforts regarding VOC contamination of groundwater near solid waste landfills. Attached please find a short questionnaire for this purpose. We would appreciate receiving the completed form as soon as possible. If you have any questions please call me at (608) 267-3533. Thank you for your help.

Sincerely,

Janet R. Battista
Solid and Hazardous Waste Management Section
Bureau of Solid and Hazardous Waste

JB:lm/4610E/5328E

APPENDIX E. VOC MONITORING SURVEY QUESTIONNAIRE

Contact Person: ______________________________ **Title:** ____________________

Address: ______________________________________ **Phone:** ____________________

____

____

Please mail to: Janet R. Battista
Bureau of Solid and Hazardous Waste
Wisconsin Department of Natural Resources
P.O. Box 7921
Madison, WI 53707

VOLATILE ORGANIC COMPOUNDS (VOCs) AT SOLID WASTE LANDFILLS

I. Monitoring Regulations:

A. Does your state require routine groundwater sampling and analysis for VOCs at or near municipal solid waste landfills?

YES NO

1. If yes:
   a. how often is this monitoring done? ____________________

   b. approximately what proportion of your state's municipal solid waste landfills are monitored routinely for VOCs? ____________________

2. If no,
   approximately what proportion of your state's municipal solid waste landfills are monitored for VOCs on a case by case basis?

   ____

B. Does your state require routine groundwater sampling and analysis for VOCs at or near industrial solid waste landfills?

YES NO

1. If yes:
   a. how often is this monitoring done? ____________________

   b. approximately what proportion of your state's industrial solid waste landfills are monitored routinely for VOCs?

   ____

2. If no,
   approximately what proportion of your state's industrial solid waste landfills are monitored for VOCs on a case by case basis?

   ____

3. For sites monitored on a case by case basis, what conditions prompt you to sample for VOCs (for example, elevated inorganic parameters, landfill design, landfill size, history of VOC dumping, urban or rural location, landfill site geology, other)?

   (Please list conditions and elaborate as necessary)

C. If your state does not sample for VOCs, please list specific reasons (for example: expense too great, no VOC problem in the state, inorganic parameters are sufficient, other):

   (please elaborate as necessary)

I. Extent of VOC Contamination:

A. Has your state conducted a statewide or regional evaluation of VOC contamination of groundwater at or near solid waste landfill sites?

YES NO

1. If yes, has a report been published? YES NO

Please indicate how we might obtain this report:

2. If yes, but a report has not been published please summarize significant results (or send abstracts or copies of available data):

B. Have you conducted any studies on the influence of landfill location, landfill design, site geology or waste type on the presence of VOCs in groundwater at or near solid waste landfills?

YES NO

1. If yes, please indicate how we might obtain any published reports:

2. If yes, but no reports were published please summarize any significant results (or send abstracts or copies of available data):

III. Should we be aware of any other information regarding VOC monitoring regulations or groundwater contamination in your state?

(please explain)

APPENDIX F. OFFICIALS CONTACTED DURING THE SURVEY

Mr. Walter Nichols — phone contact only
Solid Waste Section
Alabama Department of Environmental Management
1751 Federal Drive
Montgomery, Alabama 36130 — (205) 271-7761

Mr. Henry Friedman — phone contact only
Suite 1350
3601 C Street
Ankorage, Alaska 99503 — (907) 563-6529

Mr. Mark Witherspoon — phone contact only
Arkansas Department of Pollution Control and Ecology
P.O. Box 9583
Little Rock, Arkansas 72219 — (501) 562-7444

Mr. Ty Canez — no response
Department of Solid and Hazardous Waste
Arizona Department of Environmental Quality
2005 North Central
Phoeniz, Arizona 85004 — (602) 257-6829

Mr. James Parsons — phone contact only
California State Water Resources Control Board
P.O.Box 100
Sacramento, California 95826 — (916) 322-0205

Ms. Pam Harley
4210 East 11th Avenue
Denver, Colorado 80220 — (303) 331-4830

Mr. James Dziuba
122 Washington Street
Hartford, Connecticut 06226 — (203) 566-5847

Mr. Wayne Thomas
Solid Waste Management Branch
DNREC
Post Office Box 1401
Dover, Delaware 19903 — (302) 736-3824

Mr. Chongman Lee
Department of Environmental Regulation
Solid Waste Section
2600 Blairstone Road
Tallahassee, Florida 32301 — (904) 488-0300

Mr. James W. Dunbar, Program Manager
Solid Waste Management Program
Georgia Environmental Protection Division
3420 Norman Berry Drive, 7th Floor
Hapeville, Georgia 30354 — (404) 656-2836

Mr. Albert Dung — phone contact only
Environmental Permit Branch
Department of Health
P.O. Box 3378
Honolulu, Hawaii 96813 — (808) 548-6410

Mr. Jerome Jankowski
Idaho State Hazardous Materials Bureau
State House
Boise, Idaho 83720 — (208) 334-5879

Ms. Angela Aye Tin
Illinois EPA
2200 Churchill
Springfield, Illinois 62706 — (217) 782-2829

Ms. Karyl Schmidt
Department of Environmental Management
P.O. Box 6015
105 South Meridian Street
Indianapolis, Indiana 46206-6015 — (317) 232-8713

Mr. Morris Preston
Iowa Department of Natural Resources
Wallace State Office Building
DeMoines, Iowa 50319 — (515) 281-4698

Mr. Joseph Cronin
Kansas Division of Environment
Forbes Field
Topeka, Kansas 66620 — (913) 296-1595

Ms. Beverly Oliver
Division of Waste Management
18 Reilly Road
Frankfort, Kentucky 40324 — (502) 564-6716

Mr. Narendra Dave
Groundwater Protection Division
Department of Environmental Quality
P.O. Box 44274
Baton Rouge, Louisiana 70804-4274 — (504) 342-8950

APPENDIX F. OFFICIALS CONTACTED (CONTINUED)

Ms. Florence G. Hoar
Maine Department of Environmental Protection
Land Quality Control
Station #17, State House
Augusta, Maine 04333 (207) 289-2111

Mr. James M. Trouba
Department of the Environment
Hazardous and Solid Waste Management Administration
201 West Preston Street
Baltimore, Maryland 21201 (301) 225-5730

Mr. Luke A. Fabbri
Division of Solid Waste
1 Winter Street, 4th Floor
Boston, Massachusetts 02108 (617) 556-1061

Ms. Becky Kocsis
7150 Harris Drive
G.O.B., 3rd Floor
Dimondale, Michigan 48821 (517) 322-1300

Mr. Donald L. Jakes
Solid and Hazardous Waste Division
Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, Minnesota 55155 (612) 296-7736

Mr. Mark Williams phone contact only
Bureau of Pollution Control
P.O.Box 10385
Jackson, Mississippi 39209 (601) 961-5171

Ms. Jan Neher
Missouri Department of Natural Resources
Division of Environmental Quality
Waste Management Program
P.O. Box 176
Jefferson City, Missouri 65102 (314) 751-0944

Mr. James Leiter
Solid and Hazardous Waste Bureau
Cogswell Building
Helena, Montana 59620 (406) 444-2821

Mr. Bruce Baugh
Nebraska Department of Environmental Control
State Office Building
P.O. Box 98922
Lincoln, Nebraska 68509-8922 (402) 471-4210

Mr. Allan Biaggi
Nevada Division of Environmental Protection
201 South Fall Street
Carson City, Nevada 89710 (702) 885-5872

Mr. Thomas L. Sweeney, Administrator
Solid Waste Bureau
Health and Human Services
Hazen Drive
Concord, New Hampshire 03301 (603) 271-2925

Ms. Maryann Kukerk
Bureau of Groundwater Discharge Control — phone contact only
Department of Water Resources
CN 029
Trenton, New Jersey 08625 (609) 292-0424

Mr. Phillip Weston
P.O. Box 968
Environmental Improvement Department
Solid Waste Section
Sante Fe, New Mexico 87504 (505) 827-2780

Division of Solid and Hazardous Waste
New York State Department of Environmental Conservation
50 Wolf Road
Albany, New York 12233-0001

Mr. Michael Babuin — phone contact only
Solid Waste Management Section
Department of Health
P.O. Box 2091
Raleigh, North Carolina 27602 (919) 733-2178

Mr. David Cameron — phone contact only
North Dakota Health Department
P.O. Box 5520
Bismark, North Dakota 58520-5520 (701) 224-2366

Mr. Tim Krichbaum
Ohio EPA, Division of Ground Water
1800 WaterMark Drive
Columbus, Ohio 43266-0149 (614) 644-2905

APPENDIX F. OFFICIALS CONTACTED (CONTINUED)

Mr. Chris Varga
Solid Waste Division
1000 NE 10th Street
Oklahoma City, Oklahoma (405) 271-7075

Mr. M. Goodwin
Ontario Ministry of the Environment
Waste Management Branch, 5th Floor
40 St. Clair Avenue, West
Toronto, Canada M4V 1P5 (416) 323-5217

Mr. Randy Albright
Department of Environmental Quality
811 SW 6th Avenue
Portland, Oregon 97204 (503) 229-5110

Mr. Jeffrey A. Hanssen
P.O.Box 2063
Harrisburg, Pennsylvania 17120 (717) 787-6239

Mr. Richard Martel
Quebec Ministry of the Environment
3900, rue Marly, 5^{e} etage
Sainte-Foy, Que. G1X 4E4 (418) 646-7688

Mr. James Ashton
Rhode Island Department of Environmental Management
Room 204 phone contact only
75 Davis Street
Providence, Rhode Island 02903 (401) 277-2808

Mr. Allan Raymond phone contact only
Bureau of Solid and Hazardous Waste Management
Department of Health and Environmental Control
2600 Bull Street
Columbia, South Carolina 29210 (803) 734-5200

Terry Jorgensen
Joe Foss Building
523 East Capitol
Pierre, South Dakota 57501 (605) 773-3153

Mr. Doye Rowland
Division of Solid Waste Management
701 Broadway, 4th Floor
Customs House
Nashville, Tennessee 37219-5403 (615) 714-3424

APPENDIX F. OFFICIALS CONTACTED (CONTINUED)

Mr. Chet Safe Texas Department of Health Division of Solid Waste Management 1100 West 49th Street Austin, Texas 78756-3199	(512) 458-7271
Ms. Mary P. Bock Bureau of Solid and Hazardous Waste 288 North 60 West P.O. Box 16700 Salt Lake City, Utah	(801) 538-6170
Ms. Julie Hackbarth Solid Waste Management Division Vermont Department of Environmental Conservation 103 S. Main Street Waterbury, Vermont 05676	(802) 244-8702
Mr. Terry Bonine 11th Floor, Monroe Building 101 North 14th Street Richmond, Virginia 23219	(804) 225-2525
Mr. Al Hansen Department of Ecology Mail Stop OV-11 Olympia, Washington 98504	phone contact only (206) 428-7266
Mr. George Chappell Division of Waste Management 1260 Greenbriar Street Charleston, West Virginia 25311	(304) 348-5993
Mr. Robert Groenwold Department of Environmental Quality Solid Waste Program 122 West 25th Street Cheyenne, Wyoming 82002	phone contact only (307) 777-7752

APPENDIX G. WISCONSIN STATE LABORATORY OF HYGIENE REPORTING FORM

Department of Natural Resources — VOCS Form 4800-5 Rev. 12-87

☐ if New Facility

Bill to: ☐ Solid Waste ☐ Hazardous Waste ☐ Wastewater ☐ Water Supply ☐ Spills ☐ Other ________

I.D. Number __________ Point/Well # ___ Field No. __ ______ County # __ Route Code ____

I.D. Name ________________ P.O. or City ________________

Collection Date MM/DD/YY Time: HH:MM Sample Location ________________

Description ________________

Send Report To: [ ]

Account Number ______

Collected By ________________

Phone (___) ___-____

Check any appropriate:

☐ S Split ☐ E Enforcement ☐ B Field Blank ☐ S Surface Source ☐ T Treated

_ Free Chlorine Residual (Field) _ . __ mg/L

_ Free Chlorine Residual (Lab) _ . __ mg/L

_ MW Monitoring Well _ EF Effluent _ OW Waste
_ LY Lysimeter _ IF Influent
_ LE Leachate _ SO Soil
_ SE Sediment _ OI Oil
_ SU Surface Water _ SL Sludge
_ PW Private Well _ OT Other

Analysis Type:
_ Q GC/MS Screen and Quantification
S GC/MS Screen
_ O Parameter Specific
(NOTE: if followup enter previous sample no.) ______

Water System Type (Water Supply Use ONLY)
_ M Community-Municipal
_ O Community-OTM
_ N Non-community
_ P Private
_ X Non-potable

Sample Type:
_ D (SDWA) Compliance Sample
_ C (SDWA) Check __/__/__ (Initial Sample Date)
_ W Raw Water _ ✓ if New Well
_ I Miscellaneous Distribution

Detection limits (ug/L) are indicated by [ ]	Detected	ug/L
_ Benzene [1.0]	_ 025	___ . _
_ Bromobenzene [4.0]	_ 046	___ . _
_ Bromodichloromethane [2.0]**	_ 051	___ . _
_ Bromoform [5.0]**	_ 053	___ . _
_ Bromomethane [1.0]	_ 055	___ . _
_ Carbon Disulfide [5.0]	_ 071	___ . _
_ Carbon Tetrachloride [2.0]	_ 073	___ . _
_ Chlorobenzene [2.0]	_ 083	___ . _
_ Chloroethane [2.0]	_ 087	___ . _
_ 2-Chloroethylvinyl ether [4.0]	_ 093	___ . _
_ Chloroform [1.0]**	_ 095	___ . _
_ 0-Chlorotoluene [1.0]	_ 108	___ . _
_ P-Chlorotoluene [1.0]	_ 110	___ . _
_ Dibromomethane [2.0]	_ 146	___ . _
_ Dibromochloromethane [2.0]**	_ 147	___ . _
_ 1,2-Dibromo-3-Chloropropane [7.0]	_ 148	___ . _
_ 1,2-Dichlorobenzene [2.0]	_ 153	___ . _
_ 1,3-Dichlorobenzene [2.0]	_ 155	___ . _
_ 1,4-Dichlorobenzene [2.0]	_ 157	___ . _
_ 1,1-Dichloroethane [1.0]	_ 165	___ . _
_ 1,2-Dichloroethane [1.0]	_ 167	___ . _
_ 1,2-Dichloroethylene, cis [1.0]	_ 168	___ . _
_ 1,1-Dichloroethylene [1.0]	_ 169	___ . _
_ 1,2-Dichloroethylene, trans [1.0]	_ 170	___ . _
_ 1,3-Dichloropropane [1.0]	_ 178	___ . _
_ 1,1-Dichloropropene [2.0]	_ 180	___ . _
_ 1,2-Dichloropropane [1.0]	_ 181	___ . _

	Detected	ug/L
_ 2,2-Dichloropropane [2.0]	_ 182	___ . _
_ 1,3-Dichloropropene, cis [2.5]	_ 183	___ . _
_ 1,3-Dichloropropene, trans [2.5]	_ 185	___ . _
_ Ethylbenzene [1.0]	_ 233	___ . _
_ Ethylene Dibromide [1.0]	_ 236	___ . _
_ Methylethylketone (MEK) [12]	_ 319	___ . _
_ Methylene Chloride [5.0]	_ 325	___ . _
_ Styrene [2.0]	_ 393	___ . _
_ 1,1,1,2-Tetrachloroethane [3.0]	_ 396	___ . _
_ 1,1,2,2-Tetrachloroethane [3.0]	_ 397	___ . _
_ Tetrachloroethylene [1.0]	_ 399	___ . _
_ Tetrahydrofuran (THF) [200]	_ 401	___ . _
_ Toluene [1.0]	_ 411	___ . _
_ 1,2,4-Trichlorobenzene [1.0]	_ 419	___ . _
_ 1,1,1-Trichloroethane [1.0]	_ 421	___ . _
_ 1,1,2-Trichloroethane [2.0]	_ 423	___ . _
_ Trichloroethylene [1.0]	_ 425	___ . _
_ Trichlorofluoromethane [1.0]	_ 427	___ . _
_ Trichlorotrifluoroethane [3.0]	_ 428	___ . _
_ 1,2,3-Trichloropropane [2.0]	_ 432	___ . _
_ Vinyl Chloride [1.0]	_ 434	___ . _
_ Xylenes [2.0]	_ 437	___ . _
** Total Trihalomethanes	_	___ . _

☐ NO Detects

Date Received And Sample No. ________________

Date Reported ________________

R.H. Laessig, PhD., Director
Wisconsin State Laboratory of Hygiene
Madison, Wisconsin 53706

APPENDIX H. WISCONSIN STATE LABORATORY OF HYGIENE VOC MEMORANDUM

STATE LABORATORY OF HYGIENE

University of Wisconsin Center for Health Sciences

AREA CODE 608
TEL. NO. 262-1293

WILLIAM D. STOVALL BUILDING
465 HENRY MALL
MADISON, WISCONSIN
53706

MEMORANDUM

DATE: July 27, 1987

TO: Jim Anklam

FROM: David Degenhardt DD

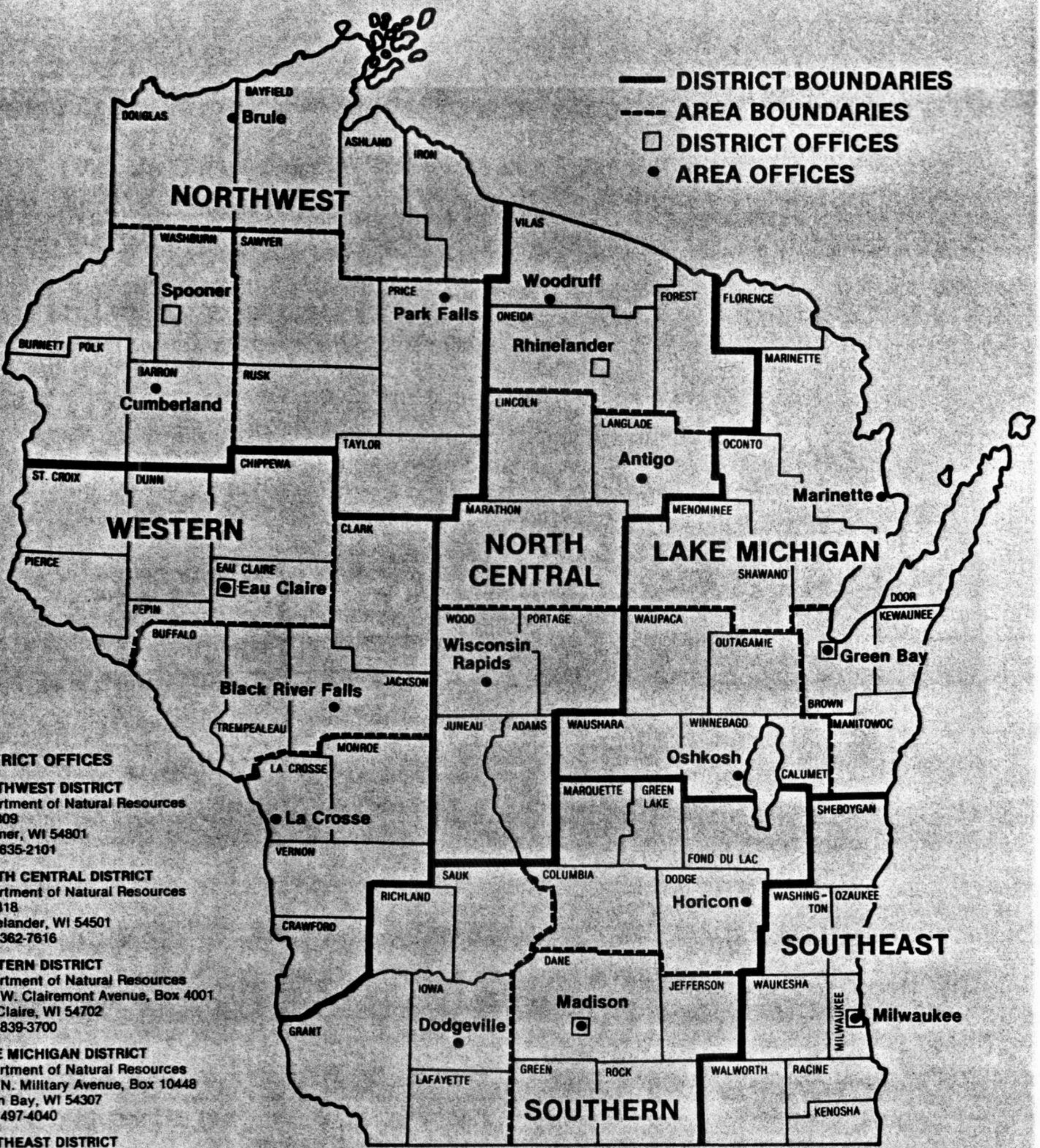
State Laboratory of Hygiene sample 48, field number 103 from the Osseo Area Sanitary Landfill, may contain the compound(s) listed below according to tentative computer identification from gas chromatography/mass spectroscopy analysis. The concentration of contaminant(s) could not be determined, nor has the presence of the compound(s) been confirmed by alternative analysis techniques.

dichlorofluoromethane
thiobismethane
naphthalene
hydrocarbons
alkylated benzene

If you have any questions, contact me at (608) 262-2797.

DD:hd

DNR FIELD DISTRICTS AND AREAS



DISTRICT OFFICES

NORTHWEST DISTRICT
Department of Natural Resources
Box 309
Spooner, WI 54801
(715) 635-2101

NORTH CENTRAL DISTRICT
Department of Natural Resources
Box 818
Rhinelander, WI 54501
(715) 362-7616

WESTERN DISTRICT
Department of Natural Resources
1300 W. Clairemont Avenue, Box 4001
Eau Claire, WI 54702
(715) 839-3700

LAKE MICHIGAN DISTRICT
Department of Natural Resources
1125 N. Military Avenue, Box 10448
Green Bay, WI 54307
(414) 497-4040

SOUTHEAST DISTRICT
Department of Natural Resources
2300 N. Dr. Martin Luther King, Jr. Drive
Box 12436
Milwaukee, WI 53212
(414) 562-9500

SOUTHERN DISTRICT
Department of Natural Resources
3911 Fish Hatchery Road
Fitchburg, WI 53711
(608) 275-3266

Rev. 5-88

Department of Natural Resources
Box 7921
Madison, WI 53707

OUR MISSION:

To protect and enhance our Natural Resources —
our air, land and water;
our wildlife, fish and forests.

To provide a clean environment
and a full range of outdoor opportunities.

To insure the right of all Wisconsin citizens
to use and enjoy these resources in
their work and leisure.

And in cooperation with all our citizens
to consider the future
and those who will follow us.

Wisconsin
Dept. of Natural Resources