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FINAL FEASIBILITY STUDY

CITY DISPOSAL CORPORATION LANDFILL

(DUNN LANDFILL)

VOLUME II OF II-APPENDICES

Prepared for

Waste Management of Wisconsin, Inc. -
Midwest Region
Two Westbrook Corporate Center, Suite 1000
Westchester, IL 60154

By

P.E. LaMoreaux & Associates, Inc.
Consulting Hydrologists, Geologists
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March 24, 1992

PELA REFERENCE NO. 495212

APPENDICES

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APPENDIX A

Correspondence

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Letter	April 4, 1991	Chuck Wilk, RPM	Michael R. Schmoller	5
Letter	June 20, 1991	Mr. Charles Wilk, 5HS-11 and Mr. Mike Schmoller	Daniel S. Green and Lois D. George	1
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Letter/Response To Comments	January 29, 1992	Mr. Charles Wilk (HSRW6J)/ Draft Feasibility Report	Jack E. Dowden and James B. Hutchison	8

A7

Waste Management of North America, Inc.
Wisconsin/Minnesota District
W124 N8925 Boundary Road · Menomonee Falls, Wisconsin 5305[illegible]
414/251-4000

RECEIVED ON 9/8/88
BY RGY
MASTER FILE [illegible]
cc File (s)

MONIT FILE
cc/route: KO RD DC HK RJ GM DH RP MI WY JH ME
see cc list

August 1, 1988

Mr. Paul Didier
Director of Bureau of Hazardous Waste
State of Wisconsin
Department of Natural Resources
101 S. Webster Street
GEF 2, Box 7921
Madison, WI 53707-7921

RE: Conformance with NR 506.08 Hazardous Air Contaminant Control Requirements at Waste Management of Wisconsin, Inc. Facilities

Dear Paul:

As we discussed in our meeting of June 9, 1988, Waste Management of Wisconsin, Inc. proposes to install landfill gas control and combustion (GCC) systems in conformance with the above regulation in a phased sequence at our existing landfills which are not currently equipped with these systems. We believe that this approach will optimize staff resources of both the DNR and Waste Management.

To this end we prepared the proposed implementation time table, shown on Attachment A, for those Waste Management sites which exceed the 500,000 cubic yard design capacity criteria. Please note that this table does not include the Omega Hills (License #1678), Metro (License #1099) or Brookfield (License #0001) Sanitary Landfills which are equipped with DNR approved gas control and combustion systems. The closed portion of the Green Lake Landfill (License #1890) is not included in this time table since it's design capacity is under 500,000 cu. yds. However, in accordance with the proposed Consent Decree a gas control and combustion system is being installed at Green Lake as part of the site closure.

The basic premise of this time table is that all WMWI sites with a moderate to high potential for landfill gas at the property line will receive priority attention in 1988. All other WMWI sites will be addressed in 1989. The major exception is for those sites undergoing remedial investigations and feasibility studies pursuant to consent orders with U.S. EPA and DNR. Upgraded systems for these sites will be incorporated in the final site remedy. Specifically this would include the inactive fill areas at the Muskego Landfill (License #'s 0141 and 0936) and the City Disposal Corporation Landfill (License #0037) in Stoughton. In anticipation of DNR's impending response on the proposed investigation at the Lauer I Landfill (License #0011) we would also request deferral of this facility until resolution of the outstanding remedial issues.

The proposed gas control and combustion system plans will be submitted, for DNR review and approval, in the context of proposed modifications to the existing closure plans. In addition to conforming to the general submittal requirements of NR 500.05 the proposed plans will provide the following specific information:

- o General plans and engineering details;
- o Supporting rationale for the selected design elements, including calculations used, assumptions made, and references provided for any empirical data utilized in the design;
- o Pipe sizing, pipe profiles, connection details and blower characteristics;
- o Estimates of maximum allowable vacuum pressures, radii of influence and vacuum pressure variations at various points in the system;
- o A construction documentation program which will cover installation of the extraction wells, piping, blower and flare(s);
- o A monitoring program to determine system performance and radii of influence for each extraction point;
- o Estimate of condensate production rates and a condensate management program; and
- o Information demonstrating conformance with NR 445 requirements for flare design and performance.

Please provide written acknowledgement of receipt of this letter and approval of the proposed implementation schedule.

Should you or your staff have any questions regarding this matter, or wish to arrange a meeting to discuss this further, please contact me at 414/251-4000.

Sincerely,

Ronald F. DeBattista, P.E.
Regional Engineering Manager
Waste Management of Wisconsin, Inc.

RD/JD/del

cc: Kevin O'Toole
Jay Rooney

Proposed Time Table for Compliance
with NR 506.08(6) Requirements at
WMWI Facilities

	Site Name and License Number	Date of Plan Modification Submittal	Anticipated Date of Revised Plan Modification Approval[1]	Anticipated Date of Initiation of Construction
1988	Pheasant Run (#1739)	May, 1988	July, 1988	August, 1988
1988	Green Lake (#3066)	Sept., 1988	Nov., 1988	At closure of Phase 1
1988	Reclamation (#1356)	Sept., 1988	April, 1989	May, 1989
1988	Eaton (#0003)	Nov., 1988	June, 1989	July, 1989
1989	Greidanus (#0140)	Jan., 1989	August, 1989	Sept., 1989
1989	Ridgeview HEP & EIP (#'s 2575 & 3041)	Feb., 1989	Sept., 1989	Oct., 1989
1989	Muskego Phase 1 (#2895)	March, 1989	October, 1989	Nov., 1989
1989	Parkview (#3108)	April, 1989	Nov., 1989	At closure of Phase 1
1989	Pheasant Run North 80 (#3062)	May, 1989	Dec., 1989	At closure of Phase 1
DEFERRED	Muskego Old Fill and Southeast Fill (#'s 0141 & 0936)	Gas Control and Combustion Systems will be incorporated in RI/FS's and installed as part of Remedial Action.		
DEFERRED	City Disposal Corp. (#0037)			
DEFERRED	Lauer I (#0011			

1 Anticipated plan approval dates assume submittal of a revised plan modification to DNR and two 90 day (65 working day) DNR review periods. If the DNR review is shorter, the schedule will be adjusted accordingly.

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES
Carroll D. Besadny, Secretary

Southern District Headquarters
3911 Fish Hatchery Road
Fitchburg, WI 53711
TELEFAX NO. 608-275-3338

RECEIVED
DEC 17 1990
REMEDIAL & ENFORCEMENT RESPONSE BRANCH

December 12, 1990

File Ref: 4400

United States Environmental Protection Agency
Mr. Charles Wilk, RPM
5HS-11
230 South Dearborn Street
Chicago, IL 60604

Subject: Review of City Disposal Superfund Alternatives Array Document - Source Control Operable Unit

Dear Mr. Wilk:

The Wisconsin Department of Natural Resources has reviewed Technical Memo 6A, Alternatives Array Document for the Source Control Operable Unit at the City Disposal Landfill. The Department has a number of concerns regarding the remedial alternatives retained and the rationale for eliminating certain remedial options which appear to have applicability to the site. These concerns are laid out point by point below. In addition, the Department is providing an ARAR list, attached to this letter, in response to the request for state requirements associated with this site. At this time, the Department is still investigating whether hazardous waste was sent to this site. The results of this investigation may alter the ARAR's in the future.

The Department very much wishes to further discuss the PRP decisions made in this tech memo. The Department needs further clarification why certain processes were either eliminated or retained. To that end the Department believes a meeting is necessary to resolve these differences as quickly as possible.

Specific Department Concerns

p7 - It is not clear how the 10 percent figure was derived. The Department would like a more detailed discussion of how this figure was calculated. Also, the Department would like a more detailed discussion of the ground penetrating radar results overall.

p9 - The term regulatory limits is used frequently throughout the memo. A definition for regulatory limits is needed. The Department standards for groundwater quality are preventative action limits established in NR 140, Wis. Adm. Code. Regulatory limits should be defined consistent with the preventative action limits.

P10 - The September, 1990 groundwater results should be shown in comparison to state standards. This would clarify which of the five tested piezometers showed elevated levels for which parameters.

p11 - Reference is made to VOC occurrences in surface soils down slope from cells 6 and 12. If these concentrations exceed background conditions, an analysis needs to be completed on the risks, both environmental and human health, posed by these concentrations. If warranted, remedial action to address these surface soils will be required. The source control alternatives discussed later in this tech memo must include surface soil remedial measures if the contamination levels warrant it.

p12 - The Department has a concern that the air migration pathway has not been properly addressed to date. State administrative codes require all landfills with waste capacity of greater than 500,000 cubic yards to install active gas control systems and specific flaring technologies to control hazardous air emissions. The City Disposal Landfill, because of its size, comes under these regulations. A specific site can be exempted from these regulations if sufficient monitoring is completed to verify that the site it not adversely impacting air quality.

These control and testing requirements are specified in NR 506 and 445, Wis. Adm. Codes. To date the testing necessary to attempt to exempt the City Disposal site has not begun. Consequently, the site is required to fully comply with the requirements in NR 506 and 445, Wis. Adm. Codes. Compliance with these requirements must be included in the various remedial alternatives developed at the end of this tech memo.

p12-13 - Until acceptable air monitoring is completed the Department believes that air migration may be a significant pathway of concern. Unless shown otherwise the Department believes an active gas control system with air emission controls is required for this site.

p13 - The elevated metal readings for iron, manganese, and arsenic need to be viewed as primary impacts of the site. The elevated concentrations of these substances may influence the remedial measures selected under the groundwater operable unit.

p13 - While there may not be an immediate danger to nearby water supplies, inconsistency between groundwater flow data and the apparent directions of groundwater contaminant migration, make any long term conclusions about the threat to water supplies tenuous. The potential threat to nearby water supplies is still an unresolved issue in the Department's opinion.

p14 - The interpretations provided on this page are, in general, correct. However, the Department has a concern that the contaminants found in groundwater at elevated concentrations, and for which no standard exists, are not forgotten in evaluating remedial measures.

When designing remedial actions, particularly for the groundwater operable unit, consideration must be given to reducing the concentrations of all contaminants to acceptable levels.

p14 - The data assessment on this page should include a clear definition of the principal environmental and human health threats from the site.

p14 - The Department has a concern, at this time, that the groundwater migration pathway is not yet fully understood. A pathway to explain the contaminant readings at locations P-8A, B-6RR, PZ-14, and well nest 2,A,B,C has not yet been developed. In addition, it is not clear that the vertical distribution of contaminants seen in well nest 11 is completely understood. These questions may well be answered during a detailed interpretation of the 1990 field work. However, at this time, the Department sees these issues as unanswered migration pathway concerns. Consequently, the conclusions regarding private well impacts should be qualified to say that to date no impacts have been seen.

p14 - The Department has a serious concern that the lack of source characterization data will hinder future decision making on the best source control measures needed for this site. At this time, the Department does not believe adequate waste characterization field work has been done to properly select source control measures. It is not clear how the various remedial options were developed at the end of this tech memo. The Department will need better documentation of the selection process used, before it can agree that some remedial measures are not applicable to this site.

p16 - There are some errors and uncertainties in Table 1. These are:

1. Landfill capping does not directly address gas generation.

2. Gas collection techniques may help deal with groundwater contamination particularly when dealing with volatile organic parameters. In fact, gas collection and treatment technologies can be used as partial groundwater remedies to control future releases to groundwater as required in Chapter 160, Stats.

3. Not all the methods shown under Waste/Soil Treatment deal with gas generation or air contamination.

4. In situ neutralization/detoxification needs to be defined. Also, it does not show up later in the report. The rationale for its elimination needs to be defined.

p17-18 - The discussion of institutional controls and site access restrictions as compliments to active remedial measures is a good description of the role these measures should play.

p18 - The state requirements for landfill capping are not guidance they are legal requirements contained in Administrative Code.

p18 - State regulations require landfill caps to have a saturated hydraulic conductivity of 1 X 10^{-7} centimeters/second (cm/s) or less. This requirement is in NR 504.07 and NR 181.44(13), Wis. Adm. Code. The statement concluding caps must have a permeability less than or equal to surrounding subsoils is not entirely accurate.

p19 - It is uncertain if the Department would approve a cap design relying solely on an impermeable membrane (Cover A). It is most likely that the Department would require some thickness of compacted low permeability clay similar to that requirement of an NR 504.07 cap to act as a backup measure to ensure reduced infiltration. The specific design and requirements would be developed if Cover A was chosen as the remedial action. Also, the reference to the underlying clay needs to be clarified. Is that the compacted native soil layer?

p19 - It needs to be clarified that the state RCRA requirements in NR 500 and NR 181 Wis. Adm. Code differ from (are more stringent) than the federal RCRA requirements. Consequently, the clay cap requirements in NR 504 and NR 181, Wis. Adm. Code are not the same as the federal criteria.

p24 - As discussed previously, the City Disposal site is required to meet the gas collection and hazardous air emission criteria in NR 506 and 445, Wis. Adm. Code, unless otherwise exempted based on extensive monitoring results. These requirements must be reflected in the gas control discussions in this tech memo.

p27 - It is understood by the Department that the contaminants to be treated under source control listed in section 5.2.8 is only a partial list representative of the types of contaminants to be addressed. Source control measures will be designed to address all the contaminants of concern at the site including heavy metals.

p27 - In situ vitrification is not proposed as a possible remedial technology. The Department would like to see this method considered as a possible alternative for this site particularly as it relates to possible "hot spot" control.

p28 - Waste stabilization has limited long term operation and maintenance costs however, there are some short term costs.

p29 - The use of excavation at this site will be controlled in part by the Department's decision on whether hazardous wastes were sent to this site.

p27-31 - Sections 5.2.8 and 5.2.9 provide a good brief narrative on the various waste and soil treatment technologies and disposal options considered for this site.

p31 - The state capacity assurance plan for hazardous wastes requires that off site disposal out of state be used only as a last resort measure.

p32 - The Department agrees with the decision not to pursue sheet piles, injected screens or asphalt curtains as remedial possibilities for this site.

p33 - The treatment measures discussed under 5.2.11 must include a discussion of best available technology for the control of inorganic parameter discharges also.

p33-34 - The air treatment discussion should be expanded to include the state regulations, referenced previously concerning air emissions from landfills. Also, air emission controls shall deal with all contaminants associated with the site, not just VOC's alone. The discussion on page 34 gives the impression only VOC's are an air concern, the Department believes all contaminants at the site are potential air concerns.

p35-36 - Under section 6.1.3 the narrative discusses six general steps for the development and screening of alternatives. However, there are seven individual points shown on pages 35-36.

p37 - ARAR's are not defined as frequently used standards but are legal requirements associated with the activities or problems at the site. Also, final acceptable exposure levels may be defined by ARAR's if they are more stringent than calculated acceptable exposure levels.

P35-40 - The FS process overview on these pages accurately reflects the FS process contained in the USEPA, 1988 guidance document.

p41 - It would be useful if at the beginning of this section the specific remedial objectives for each media were listed. This would help tie the objectives to the technologies discussed. Also, source control technologies will not preclude future releases from the site, but rather will control and limit future releases.

p41 - The rationale for elimination of several process options shown on Plate 1 is not clear. To make clear the Department's position, the decisions to delete the various process options are reviewed individually below.

1. Sedimentation Basin - The Department agrees that, at this time, contaminated surface water runoff from the site is not a concern consequently a basin is not necessary. However, if future site investigations or remedial actions expose waste to runoff waters such a control basin may be necessary. Also, a basin for sediment control from on site erosion during site activities may be necessary.

2. Excavation - The Department does not agree with the complete elimination of excavation as a remedial alternative. Clearly, complete excavation of the site is not feasible. However, excavation of smaller areas such as "hot spots" in cells 12 and/or 6 should be retained as possible actions. To date there has been very little source characterization of the waste

material on site. This is particularly true for cells 6 and 12 which appear to be the most significant source areas on site. Only a ground penetrating radar survey which shows that cell 12 produces a different signature than the rest of the site has been conducted as a source characterization study. Until a far better understanding of the physical and chemical nature of the waste in cells 6, 12, and other possible unknown "hot spots" is known, the Department will not agree to the elimination of various process options. There is no data to support the conclusions that certain process options can be eliminated in favor of others. Consequently, the Department believes excavation must stay as a possible action until other options are proven, based on site data, to be effective solutions.

3. Stabilization/Solidification - As stated above not enough site specific data has been produced to entirely eliminate this option. These processes may be applicable to "hot spot" control. The radar results show a low metal content in cell 12. It seems possible then, that this technology may be an applicable control measure for the wastes in cell 12 or elsewhere.

4. Vacuum Heap Extraction - The Department agrees that vacuum heap extraction does not appear to be a likely alternative at this time. It seems possible that the same results can be achieved by using in place injection and extraction methods.

5. Waste/Soil Washing - It is not clear why this option was eliminated at this stage. For possible use in "hot spot" control there appears to be some applicability for this measure. The Department would like to further discuss this measure before it is eliminated entirely.

6. In Situ Water/Soil Flushing - If the technology is selected, state concerns on groundwater injection systems will have to be satisfied.

7. On and Off Site Incineration - As with waste/soil washing the Department would like better documentation why these options were eliminated before it agrees on elimination.

8. On and Off Site Landfilling - the Department agrees that off site transport of waste for landfilling is not desirable. However, with some on-site treatment options (i.e., solidification/stabilization) landfilling of the treated waste may be required. Retaining this option is dependent on the final evaluation of several of the treatment alternatives previously discussed. Consequently, dependent on other option evaluations on site disposal may need to be retained.

9. Gas Extraction/Flaring/Cycling - As stated several times, the Department does not agree with the proposed gas control options developed for this site. The Department does not believe adequate testing has been conducted to determine the appropriate air emission control system. The requirements in NR 506 and 445, Wis. Adm. Code must be met for this site. Consequently, extraction wells and flaring options must be retained for further analysis.

p41 - As shown on Plate 1 the groundwater remedial action objectives should be compliance with groundwater preventative action limits not enforcement standards. This is required by state law. Also, the air treatment emissions section has applicability to many of the source controls measures under consideration. Air emissions control must be included in source control discussions.

p42 - As with Plate 1, the decisions to eliminate the two alternatives on Plate 2 needs to be further discussed. At this time, the Department is unwilling to accept the complete elimination of these process options. Both options appear to have possible applicability to "hot spot" control. Once a better description on the nature and extent of the "hot spots" on site are available, more decisions can be made regarding remedial alternative selections. Also, the remediation goals referenced on this page need to be more specifically defined to better evaluate the retained technologies.

p44-48 - The descriptions of the retained process options are accurate. However, as noted the Department does not agree necessarily that these are the only options to be further developed. The Department very much wants to further discuss the decision making process used to arrive at the conclusions presented.

p44 - The specific remedial action objectives for source control should be repeated here to be sure the alternatives developed meet the specific identified objectives.

p48 - The Department has the following comments on the eight specific remedial alternatives proposed for the site.

1. As with all eight alternatives the Department believes an active gas control and air emission control system is required for the site. Also, this alternative lacks additional control measures for "hot spot" remediation which likely appears necessary for some areas of the site. Also, as stated previously, it is not likely that the Department would accept Cover A as an acceptable cover technology for the site.

2. Same comments as with Alternative 1. The inclusion of Covers B and C likely more accurately reflects the cover options that will be used at the site.

3. The alternative approaches what may be an acceptable option for the site. However, the use of Cover A is likely not acceptable, no gas control and air emissions measure is included and other options may be more appropriate for control at cells 6 and 12 than gas injection/extraction or extraction.

4. The alternative is an increment improvement over Alternative 3. However it still maintains the same fatal flaws as described for the preceding alternatives.

5. This alternative may be acceptable if specific "hot spot" control measures are not necessary, Cover B was selected for use and on site monitoring can exempt the site from NR 506 and 445, Wis. Adm. Code air control measures.

6. This alternative is the same as 5 except the possible use of Cover C. This is viewed as a better alternative because the use of Cover C may be necessary for all or parts of the site.

7. This option may be acceptable, given the reservations already stated, if Cover B were selected.

8. This is the most acceptable option of the eight presented. However, depending on additional site investigation it is likely not an entirely acceptable alternative.

p51 - Under action specific ARAR's, NR 105 and 106 Wis. Adm. Codes should be included as surface water discharge regulations.

As can be seen from the brief review of each alternative, the Department does not believe any of the eight possibilities are acceptable. The most serious drawbacks are the lack of an active gas control and air emissions system, the limited alternatives kept available for "hot spot" control and the possible use of Cover A at the site.

In conclusion, the Department has reviewed this document and has identified several key areas in need of further discussion. The Department is confident that these differences can be resolved through further communications. It is the Departments desire that a meeting be set as soon as possible to resolve the concerns about this report and continue towards remediating this site.

Sincerely,

Mike Schmoller

Mike Schmoller
Solid Waste Specialist

MS:ps
Enc.
d:\swm\citydsps.mrs

cc: Sue Bangert - SW/3
Pat McCutcheon - SD

ARAR Determinations

Below are listed the ARAR's as determined by the Department based on the various remedial options presented. The Department may amend the list based on changes or additions to the list of possible remedial actions for the site.

Alternative	A or RA[1]	Code[2]	Preliminary Identification of Standards/Requirements
1) Institutional controls, access controls, monitoring cover A or B	RA	181.49	Groundwater monitoring to identify degree and extent of contamination, hazardous waste groundwater monitoring requirements
	A	181	Any waste generated during the remedial investigation must be handled consistent with hazardous waste requirements, general hazardous waste management requirements
	A	140	Groundwater standards and response requirements
	A	149	Laboratory certification for environmental testing
	A	504,506,445	Landfill gas collection, treatment and hazardous air emission controls
	A	508	Landfill monitoring requirements
	A	504,506,514,516	Landfill capping, closure and documentation requirements
2) Institutional controls, access controls, monitoring cover A or B/C	same requirements as alternative 1 above		
	RA	181.44(11)-(14)	Landfill capping, closure, monitoring and long term care requirements
3) Institutional controls, access controls, monitoring extraction, cover A or B	same requirements as alternative 1 above		
	A	181	Management requirements for hazardous wastes removed during construction of gas extraction systems
4) Institutional controls, access controls, monitoring, gas extraction, cover A or B/C	same as alternative 2		
	A	181	Management of hazardous wastes removed during construction of gas extraction systems
5) Institutional controls, access controls, monitoring trench/vent system, cover A or B	same as alternative 1		
6) Institutional controls, access controls, monitoring trench/vent system, cover A or B/C	same as alternative 2		

Alternative	A or RA[1]	Code[2]	Preliminary Identification of Standards/Requirements
7) Institutional controls, access restrictions, monitoring, gas extraction, trench/vent system, cover A or B	same as alternative 3		
8) Institutional controls, access restrictions, monitoring gas extraction, trench/vent system, cover A or B/C	same as alternative 4		

[1] A or RA = Applicable (A) or potentially Relevant and Appropriate (RA)
[2] Code = Wisconsin Administrative Code, Chapter NR series

Metcalf & Eddy

December 14, 1990

Mr. Charles Wilk
U.S. EPA
CERCLA Enforcement
230 S. Dearborn
Chicago, IL 60604

Re: TES X Work Assignment No. C05012
City Disposal Corporation Landfill (CDCL)

Subject: Review of Technical Memorandum No. 6a
Alternatives Array Document (SCOU)

Dear Mr. Wilk:

Metcalf & Eddy, Inc. (M&E) has conducted a review of Technical Memorandum No. 6a, Alternatives Array Document, (SCOU), prepared by P.E. LaMoreaux & Associates (PELA). As you requested, the review was conducted to determine the appropriateness of the proposed remedial technologies.

General Comments:

The Technologies and Process Options presented for the Source Control Operable Unit (SCOU) are appropriate for CDCL.

Vitrification should be added to the Stabilization/Solidification options.

The reasons for eliminating Process Options during screening are not presented in most instances and, where presented, are vague. Reasons for the elimination of each Process Option should be included.

Specific Comments:

Page	Section	Paragraph	Comment
18 22 29 31	5.2.4 5.2.5 5.2.8.7 5.2.9.1		Relative costs were identified for these Technologies/Process Options only. Relative costs for all Technologies/Process Options should be identified for consistency.

85 W Algonquin Road, Suite 500, Arlington Heights, Illinois 60005-4422
Tel 708 228-0900 FAX 708 228-5013

Page	Section	Paragraph	Comment
22	5.2.5	2	A detailed description for the use of sedimentation basins should be provided.
27	5.2.8	2	The waste has been characterized principally by the analyses of ground-water samples collected from beyond the fill area. Therefore, the waste may contain semi-volatile organics and inorganics not identified in ground-water samples. These additional parameters can have an adverse effect on the efficiency of certain process options. The potential problems associated with these parameters should be considered when evaluating process options.
32	5.2.10.1	1	In addition to installing physical barriers downgradient of the source area, physical barriers can be installed around the other sides of the fill area to reduce ground water flow through the waste area. However, it should be noted that the hydraulic conductivity will be decreased within the barrier area when any type of physical barrier is used.
		2	Health & Safety costs have been included in the Relative costs for physical barriers. This consideration should be included for most of the process options presented.

Page	Section	Paragraph	Comment
33	5.2.10.2	2	See previous comment.
33	5.1.11	1	See comment for section 5.2.8.
34	5.2.12	2	As with other air treatment options, the efficiency of the vapor condensation process should be included. Disadvantages are presented for only one air treatment option; activated carbon. Advantages and disadvantages should be presented for all options.
41	7.0	1	Options involving leachate control should not be screened out because leachate has not been observed during the RI. Leachate seeps have been observed in the past. Furthermore, the RI has been conducted over a period during which there has been below normal precipitation. The possibility of future leachate generation should be considered.
42	8.0	2	The evaluation process is illustrated in Plate 1 not Plate 2.
43	8.0	2	The text states that three process options were screened out. These options and the reasons for their elimination should be identified.
44	9.1	1	The "No Action" alternative should not be eliminated at this stage.

Page	Section	Paragraph	Comment
47	9.2.1.1.6	2	The text states that in situ bioremediation has been screened out. This is inconsistent with Plate 1. The reasons for eliminating technologies/process options should be expanded and should include all technologies/options.

Should you have any questions regarding the comments on Technical Memorandum No. 6a, please do not hesitate to contact me.

Very truly yours,

METCALF & EDDY, INC.

Robert A. Schoepke
Contractor Project Manager

cc: Lorraine Kosik, U.S. EPA
Thomas Lentzen, M&E
File

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES
Carroll D. Besadny, Secretary

Southern District Headquarters
3911 Fish Hatchery Road
Fitchburg, WI 53711
TELEFAX NO. 608-275-3338

December 26, 1990

File Ref: 4400

Mr. Chuck Wilk, RPM
United States Environmental Protection Agency
230 South Dearborn Street
5HS-11
Chicago, IL 60604

Dear Mr. Wilk:

This is a follow-up letter regarding our comments on Technical Memo 6A, Alternatives Array Document for the Source Control Operable Unit at the City Disposal Landfill. Based on the results of our December 19, 1990, meeting it is our understanding that Waste Management has committed to closing the City Disposal landfill in compliance with NR 500 and 445, Wis. Adm. Code requirements. These closure requirements will be met in addition to whatever closure measures are required by the CERCLA process. This commitment by Waste MAnagement addresses many of the concerns our Department has about Tech Memo 6A.

It is our hope that this commitment, together with the additional information to be supplied by Waste Management on why it retained the remedial technologies shown in Tech Memo 6A, will enable us to decide on the source control measures to be used at the site.

Sincerely,

Mike Schmoller

Mike Schmoller
Solid Waste Specialist

MS:ps
9101\swldspsl.mrs

cc: Sue Bangert - SW/3
Pat McCutcheon - SOD

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES
Carroll D. Besadny, Secretary

Southern District Headquarters
3911 Fish Hatchery Road
Fitchburg, WI 53711
TELEFAX NO. 608-275-3338

January 16, 1991

File Ref: 4400

Mr. Chuck Wilk, RPM
U.S. Environmental Protection Agency
5HS-11
230 South Dearborn Street
Chicago, IL 60604

Subject: City Disposal Landfill; Dane County; Town of Dunn, Wisconsin; ARAR Aplicability

Dear Mr. Wilk:

This letter is to document the applicability of state hazardous waste rules to the waste and possible remedial actions at the City Disposal landfill.

First of all, based on available information, it cannot be determined that listed hazardous wastes were disposed of at the site. Consequently, the wastes are not considered to be listed hazardous wastes. Also, at this time, the waste mass has not been tested to determine if it or any portions of it exhibit any hazardous characteristic. Consequently, the waste mass at the site is not considered to be characteristic hazardous wastes at this time. Lastly, waste disposal operations ceased in 1977 prior to the effective dates of RCRA and state hazardous waste rules. Therefore, state hazardous waste rules are not considered applicable to the waste mass. However, available information suggests that the wastes disposed on site are sufficiently similar in nature to hazardous waste and the Department considers state hazardous waste rules to be relevant and possibly appropriate to the waste mass while the wastes remain in place.

If during the course of remedial action, waste materials are removed from the site (i.e., excavated), then the waste material will be tested to determine if it exhibits a hazardous characteristic and, if applicable, state hazardous waste rules will be applied. This will include application of the land ban requirements.

In terms of the groundwater, based on the contaminant concentrations present, the groundwater exhibits a characteristic of hazardous waste. Consequently, the groundwater and any media contaminated by the groundwater that also exhibits the hazardous characteristics must be managed as hazardous wastes. The groundwater and contaminated material will continue to be a subject to hazardous waste regulations until the characteristic is no longer present. Consequently, state hazardous waste laws are applicable to any groundwater treatment technologies and to any residual material that is characteristically hazardous.

If there are questions on these determinations, please contact me at your convenience.

Sincerely,

Mike Schmoller

Mike Schmoller
Solid Waste Specialist
TELEPHONE: (608) 275-3303

MS:kas
9102\SW1CITY1.MRS

cc: Pat McCutcheon - SD
Ed Lynch - SW/3
Sue Bangert - SW/3

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
230 SOUTH DEARBORN ST.
CHICAGO, ILLINOIS 60604

JAN 16 1991

REPLY TO ATTENTION OF: 5HS-11

Ms. Dee Brncich
Waste Management of North America, Incorporated
Midwest Region
Two Westbrook Corporate Center, Suite 1000
Westchester, Illinois 60154

Re: City Disposal Corporation Landfill
SCOU Alternatives Array Review and Potential ARARs

Dear Ms. Brncich:

The United States Environmental Protection Agency (U.S. EPA) and the Wisconsin Department of Natural Resources (WDNR) have reviewed Technical Memorandum No. 6a Alternatives Array Document (SCOU) For Remedial Investigation/Feasibility Study City Disposal Corporation Landfill. Enclosed are (a) a table of potential Applicable or Relevant and Appropriate Requirements (ARARs) arranged according to each of the eight (8) Source Control Operable Unit (SCOU) remedial alternatives described in the Technical Memorandum No. 6a, and (b) U.S. EPA and WDNR comments on Technical Memorandum No. 6a.

Most ARARs pertaining to this operable unit are State requirements. Be advised that the State of Wisconsin hazardous waste management regulations, formally Wisconsin Administrative Code NR. 181, have been extensively revised and are now codified in Wisconsin Administrative Code NR. 600. These State regulations become effective February 1991.

U.S. EPA and WDNR comments must be addressed in the revision to Technical Memorandum 6a, due 30 calendar days after your receipt of this letter.

If you have any questions concerning this letter, please telephone me at (312) 353-1331.

Sincerely,

Charles Wilk

Charles Wilk
Remedial Project Manager

Enclosures

cc: Mike Schmoller, WDNR
Doug Ballotti, RERB
Eileen Fury, ORC

DATE RECEIVED/SENT 1/21/91
BY: DEE BRNCICH
SITE City Disposal
CC/ROUTE:
PK, DP, WS, HK, JD, GM, DO, AK, RO, AS
FILE SYSTEM: PROJECT/SITE
FILE CODE: 6-8.5 W/ATTACH
21 23.3 W/O ATTACH

City Disposal Corporation Landfill
Potential Applicable or Relevant and Appropriate Requirements
Source Control Operable Unit

All Alternatives. Each of the eight alternatives includes access restrictions, institutional controls, landfill cap and ground water monitoring.

ARARs: Wis. Adm. Code NR. 600 series (formally NR. 181), including requirements for ground water monitoring, management of hazardous waste resulting from remedial activities, landfill capping, closure, monitoring, post closure maintenance and use, and documentation;

Wis. Adm. Code NR. 500 series, including 504, 506, 508, 514 and 516. These solid waste regulations include requirements for landfill gas collection and treatment, landfill capping, landfill closure, monitoring, post closure maintenance and use and documentation;

Wis. Adm. Code NR 445, hazardous air emissions control;

Wis. Adm. Code NR. 140, ground water quality standards and response requirements;

Wis. Adm. Code NR. 149, laboratory certification for environmental testing; AND

Resource Conservation and Recovery Act (RCRA) Subtitles C and D.

To Be Considered:

Technical Guidance Document Final Covers on Hazardous Waste Landfills and Surface Impoundments
EPA/530/SW-89/047

Alternatives 3, 4, 5, 6, 7, and 8. These alternatives all include vacuum extraction, gas injection/extraction systems, and/or landfill gas trench/vent system.

ARARs: Wis. Adm. Code NR 445, hazardous air emissions control;

Title 40 of the Federal Code of Regulations (40 CFR) Part 50, National Ambient Air Quality Standards (NAAQS);

40 CFR Part 61, National Emission Standards for Hazardous Air Pollutants (NESHAP); AND

40 CFR Part 60, National New Source Performance Standards (NSPS).

To Be Considered:

OSWER Directive 9355.0-28, U.S. EPA policy guidance entitled Control of Air Emissions from Superfund Air Strippers at Superfund Ground Water Sites.

U.S. EPA Comments
Technical Memorandum 6a

Page 13. Data available at the time of writing the Technical Memorandum was insufficient to support the statement "The drinking water supply for the wells in closest proximity to the site have not been impacted by the site". Data available indicated that no contamination attributable to the site was found in wells tested down to the detection limits of the analysis. The method detection limits for some of the hazardous constituents analyzed for were above the MCLs for those constituents.

U.S. EPA is currently awaiting results from a resampling and analysis of private wells using lower detection limits. Future sampling and analysis of drinking water wells at the site will be required to use lower method detection limits that are below the MCL for all constituents analyzed for.

Page 14. The interpretation that data is sufficient to determine that the private wells in proximity to the site have not been impacted by the landfill may be misleading. The data is sufficient to determine that private wells have not been affected down to the method detection limits of the analysis. U.S. EPA and WDNR, at this time, do not believe that the wells have been affected by this site considering current information on ground water flow direction, and that contamination by the site would likely manifest itself as levels of contamination that would exceed the method detection limits used for analysis. However, in order to be more conservative, the U.S. EPA and the WDNR are currently resampling and analyzing the private wells in the area using lower detection limits at or below the MCLs established.

Page 34. Use of media like activated carbon to sorb hazardous constituents is not considered fulfillment of the 40 CFR 300.430 (a)(1)(iii) expectations (preferences) for use of treatment technologies to address principal threats posed by a site, unless the hazardous constituents sorbed are ultimately destroyed, as through incineration (regeneration of the activated carbon). Disposal of the contaminated carbon in a landfill without treatment of the sorbed constituents would not satisfy the expectations.

This preference for actual treatment of the hazardous constituent holds true for all treatment technologies proposed including air stripping, chemical filtration, physical filtration, etc.

Page 49. The Technical Memorandum proposes that the eight assembled alternatives be carried through to the detailed analysis. This is acceptable however, note that Alternatives 1, 2, 3 and 4 apparently will not fulfill the State requirement for installation of landfill gas control systems under Wis. Adm. Codes NR. 500 and NR. 600.

Page 50. ARARs for ground water remediation are not presented in this review. These ARARs will be provided upon review of the Alternatives Array document for the Ground Water Control Operable Unit (GCOU).

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES
Carroll D. Besadny, Secretary

Southern District Headquarters
3911 Fish Hatchery Road
Fitchburg, WI 53711
TELEFAX NO. 608-275-3338

January 25, 1991

File Ref: 4400

Mr. Chuck Wilk, RPM
U.S. Environmental Protection Agency
5HS-11
230 South Dearborn Street
Chicago, IL 60604

Subject: Review of Technical Memo 6B - Alternatives Array Document for the Groundwater Control Operable Unit

Dear Mr. Wilk:

The Department has completed its review of Technical Memo 6B, Alternative Array Document for the groundwater control operable unit at the City Disposal Landfill Superfund site. The Department has a number of page-by-page comments which are shown below. In addition, the Department has the following two major comments which it wishes to clearly state. Also, the Department has attached its ARAR determinations based on the proposed remedial alternatives.

1) Any groundwater remedial action taken at the site must be able to comply with the preventive action limits set in ch. NR 140, Wis. Adm. Code. The compliance point for this site is the waste boundary. If compliance with preventive action limits is proven not to be technically and economically feasible, as specified in s. NR 140.24, Wis. Adm. Code, the lowest technically and environmentally feasible groundwater concentration shall be achieved. In no case can the target cleanup level exceed state enforcement standards.

   For parameters for which no ch. NR 140, Wis. Adm. Code, standard exists, the cleanup standard shall be background concentrations. If achievement of background concentrations is proven not to be technically and economically feasible, the lowest technically and economically feasible concentrations shall be achieved as the cleanup standards.

2) It must be understood that all air emissions from both source control and groundwater control remedial measures must comply with the toxic air emissions criteria in ch. NR 445, Wis. Adm. Code. The technologies retained for air emission control must meet the mandated performance levels.

   The Department's concurrence with any remedial action to be taken at the site will be based on compliance with ARARs. The performance criteria in ch. NR 140 and ch NR 445, Wis. Adm. Code, are critical criteria to be used in evaluating the adequacy of any remedial measures.

PAGE-BY-PAGE COMMENTS:

P.11	On this page and in several other locations in the technical memo, the term "regulatory limits" is used. This term needs to be specifically defined. For groundwater quality, the regulatory limits are the preventive action limits contained in ch. NR 140, Wis. Adm. Code.
P.11	The regulatory concentrations that should be used to evaluate the significance of groundwater concentrations are preventive action limits—not enforcement standards. State groundwater law sets preventive action limits as the triggering levels for initiating response activities.
P.12	The Department does not have a record of a methylene chloride soil detect of 8.5 ug/kg downslope from cell 6. Please provide the sample location and date for this result.
P.19	The conclusion that there is no landfill gas production and low gas pressures needs to be verified with field data. There have been past complaints from nearby residences about "smells" around Grass Lake. It seems possible these odors are landfill gas migrating towards the topographic low of Grass Lake.
P.20	In a practical sense, source control measures will likely reduce contaminant migration from the landfill—not completely preclude any transport.
P.21	This page provides a good summary of the status of the groundwater studies and the conclusions that can be reached to date. The Department would like to see a proposed timeline for completing the additional studies proposed at the bottom of the page.
P.24	The section on environmental monitoring correctly states that monitoring surface water and groundwater quality are used to assess the performance of the remedial action. The concept of monitoring needs to be expanded for both operable units to include monitoring the performance of active source control alternatives and the active gas collection system. If a technology is chosen to actively remediate cells 6 and 12, such as vapor extraction, a monitoring program to assess the effectiveness of the remediation will be required. Monitoring source contaminant concentrations in the waste before, during, and after the remediation will be essential to evaluating system performance.
P. 25-34	Section 5.4 provides a good general discussion of the various groundwater control, treatment and discharge options.
P. 34-41	Section 6.0 provides a good general overview of the feasibility process for Superfund sites.
P.38	As stated in comments on the SCOU, ARARs are not frequently used standards, but rather are legally mandated requirements that must be met in designing and implementing remedial actions.
P.41-45	The Department agrees with the evaluation process discussed on these pages and summarized on Plate 1. The retained technologies are likely the most promising alternatives. However, it must be clear that the retained air emissions treatment technologies must be capable of meeting state air quality rules. ARARs for this process option, discussed in detail later, include air toxic substance emission controls. These requirements must be complied with.

P.45-49 The Department also agrees with the elimination process discussed on these pages and summarized on Plate 2. The remaining process options are believed to be the universe of practical alternatives available.

The following table summarizes the Department's ARAR determination for the remedial measures proposed in this tech memo.

TABLE 1
ARAR DETERMINATION

Below are listed the ARARs as determined by the Department based on the various remedial options presented. The Department may amend this list based on changes or additions to the list of remedial actions for this site.

Alternative	A or RA[1]	Code/Statute[2]	Preliminary Identification Standards/Requirements
1)	A	NR 140, s. 160	Groundwater standards and response requirements.
	A	NR 141	Monitoring well requirements.
	A	NR 149	Laboratory certification for environmental testing.
	A	NR 181	If the extracted groundwater exhibits a characteristic hazardous waste, the water and discharges are hazardous until the characteristic is no longer exhibited.
	A	NR 105, 106	Toxic substance effluent surface water standards.
	A	NR 112	Water well construction and reporting requirements.
	A	s. 144.04	Wastewater plan review requirements.
	A	NR 445	Toxic air emissions control requirements.
2)	Same requirements as Alternative 1.		
	A	NR 181	Spent carbon residues shall be treated as hazardous waste if the exhibit hazardous characteristics, unless regenerated.
3)	Same requirements as Alternative 2.		
4)	Same requirements as Alternative 2.		
5)	Same requirements as Alternative 2.		
	A	NR 211	State wastewater pretreatment requirement for discharge to POTWs.
6)	Same requirements as Alternative 1.		
	A	NR 112	Injection of material to the subsurface is regulated under water supply codes.
7)	Same requirements as Alternative 2.		
8)	Same requirements as Alternative 2.		
9)	Same requirements as Alternative 1.		

Sincerely,

Michael Schmoller

Mike Schmoller, Hydrogeologist
Environmental Response Program

MRS:kas (D\SWM\CITY6B.RVW)
cc: Darsi Foss - SW/3
Ed Lynch - SW/3
Pat McCutcheon - SD

[1] A or RA = Applicable (A) or potentially relevant and appropriate (RA).

[2] Code = Wisconsin Administrative Code, Chapter NR series;
Statute = Wisconsin State Statutes.

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES
Carroll D. Besadny, Secretary
Southern District Headquarters
3911 Fish Hatchery Road
Fitchburg, WI 53711
TELEFAX NO. 608-275-3338

RECEIVED
JAN 31 1991
REMEDIAL & ENFORCEMENT
RESPONSE BRANCH

January 25, 1991

File Ref: 4400

Mr. Chuck Wilk, RPM
U.S. Environmental Protection Agency
5HS-11
230 South Dearborn Street
Chicago, IL 60604

Dear Mr. Wilk:

The Department has received the gas probe proposal contained in the January 18, 1991, letter from P. E. LaMoreaux and Associates. The Department approves of the proposal with the following conditions:

1. The monitoring of the probes must be done in compliance with NR 508, Wis. Adm. Code.

2. The installation and construction of the probes must be done in compliance with NR 504 and 508, Wis. Adm. Code.

3. An additional probe location shall be included along the north side of the facility somewhere north of LW-2.

Lastly, the Department would like to explore the idea of using the proposed gas probes as volatile organic chemical (VOC) sampling points. At this time some questions still remain about the migration pathway from the landfill to the contaminated monitoring wells west, southwest and southeast of the site. A proposed pathway was vapor migration from the waste mass to the wells. If this is occurring, sampling the probes for VOC's may give indication that the pathway exists.

If you have further questions on these comments please give me a call.

Sincerely,

Mike Schmoller

Mike Schmoller
Hydrogeologist
Environmental Response Program

MS:ps
d:\swm\gasprb.mrs

cc: Darsi Foss - SW/3
Pat McCutcheon - SD

Response to Comments on Technical Memorandum No. 6A
Alternatives Array Document (SCOU)
City Disposal Corporation (Dunn) Landfill
Dated January 28, 1991

PELA 495209 February 18, 1991

United States Environmental Protection Agency
Region V, Office of Superfund
Charles Wilk, Remedial Project Manager

Technical Memorandum 6A

 # 1. Page 13 Data available at the time of writing the Technical Memorandum was insufficient to support the statement *"The drinking water supply for the wells in closest proximity to the site have not been impacted by the site"*. Data available indicated that no contamination attributable to the site was found in wells tested down to the detection limits of the analysis. The method detection limits for some of the hazardous constituents analyzed for were above the MCLs for those constituents.

RESPONSE:

Samples were collected and analyzed in accordance with the approved *Sampling and Analysis Plan* (SAP) and *Quality Assurance Program Plan* (QAPP). During preparation of the SAP and QAPP, the draft documents were reviewed by the agencies on numerous occasions. The detection limits, as specified in the QAPP, are included in the SOPs for the routine analysis required under the Contract Laboratory Program.

U.S. EPA is currently awaiting results from a resampling and analysis of private wells using lower detection limits. Future sampling and analysis of drinking water wells at the site will be required to use lower method detection limits that are below the MCL for all constituents analyzed for.

RESPONSE:

Future sampling and analysis of drinking water wells using criteria for lower method detection limits can certainly be accomplished; however, will require a modification to the Work Plan (QAPP). The recommended approach to such modification is by letter to the agencies with reference to SOPs for special analytical services.

 # 2. Page 14 The interpretation that data is sufficient to determine that the private wells in proximity to the site have not been impacted by the landfill may be misleading. The data is sufficient to determine that private wells have not been affected down to the method detection limits of the analysis. U.S. EPA and WDNR, at this time, do not believe that the wells have been affected by this site considering current information on ground water flow direction, and that contamination by the site would likely manifest itself as levels of contamination that would exceed the method detection limits used for analysis. However, in order to be more conservative, the U.S. EPA and the WDNR are currently resampling and analyzing the private wells in the area using lower detection limits at or below the MCLs established.

RESPONSE:

Comment noted. There was no intent to misrepresent the data.

 # 3. Page 34 Use of media like activated carbon to sorb hazardous constituents is not considered fulfillment of the 40 CFR 300.430 (a) (1) (iii) expectations (preferences) for use of treatment technologies to address principal threats posed by a site, unless the hazardous constituents sorbed are ultimately destroyed, as through incineration (regeneration of the activated carbon). Disposal of the contaminated carbon in a landfill without treatment of the sorbed constituents would not satisfy the expectations.

This preference for actual treatment of the hazardous constituent holds true for all treatment technologies proposed including air stripping, chemical filtration, physical filtration, etc.

RESPONSE:

Comment noted. Based on our understanding of the impacts of TCLP, contaminated carbon would be a RCRA characteristic waste. Therefore, the use of carbon in the remedial strategy without treatment of carbon would not satisfy the statutory mandate of minimizing hazardous waste generation.

4. Page 49 The Technical Memorandum proposes that the eight assembled alternatives be carried through to the detailed analysis. This is acceptable however, note that Alternatives 1, 2, 3 and 4 apparently will not fulfill the State requirement for installation of landfill gas control systems under Wis. Adm. Codes NR. 500 and NR. 600.

RESPONSE:

In a letter written in August 1988 from Ron DeBattista to Lakshrimi Sridhara, WMWI committed to comply with the NR 506.08 requirements within the context of the remedial action. The failure to reference this commitment in Technical Memorandum 6A was an unintentional oversight.

5. Page 50 ARARs for ground water remediation are not presented in this review. These ARARs will be provided upon review of the Alternatives Array document for the Ground Water Control Operable Unit (GCOU).

RESPONSE:

Comment noted and concur.

Potential Applicable or Relevant and Appropriate Requirements, Source Control Operable Unit

1. All Alternatives Each of the eight alternatives includes access restrictions, institutional controls, landfill cap and ground water monitoring.

ARARs: Wis. Adm. Code NR. 600 series (formally NR. 181), including requirements for ground water monitoring, management of hazardous waste resulting from remedial activities, landfill capping, closure, monitoring, post closure maintenance and use, and documentation;

Wis. Adm. Code NR. 500 series, including 504, 506, 508, 514 and 516. These solid waste regulations include requirements for landfill gas collection and treatment, landfill capping, landfill closure, monitoring, post closure maintenance and use and documentation;

Wis. Adm. Code NR. 445, hazardous air emissions control;

Wis. Adm. Code NR. 140, ground water quality standards and response requirements;

Wis. Adm. Code NR. 149, laboratory certification for environmental testing; AND

Resource Conservation and Recovery Act (RCRA) Subtitles C and D.

To Be Considered:

Technical Guidance Document Final Covers on Hazardous Waste Landfills and Surface Impoundments EPA/530/SW-89-047

RESPONSE:

Comments noted. Please refer to WMWI's responses to the ARAR determinations provided by the Department (p. 27 of this document).

2. Alternatives 3, 4, 5, 6, 7, and 8 — *These alternatives all include vacuum extraction, gas injection/extraction systems, and/or landfill gas trench/vent system.*

ARARs: Wis. Adm. Code NR. 445, hazardous air emissions control;

Title 40 of the Federal Code of Regulations (40 CFR) Part 50, National Ambient Air Quality Standards (NAAQS);

40 CFR Part 61, National Emission Standards for Hazardous Air Pollutants (NESHAP); AND

40 CFR Part 60, National New Source Performance Standards (NSPS).

To Be Considered:

OSWER Directive 9355.0-28, U.S. EPA policy guidance entitled Control of Air Emissions from Superfund Air Strippers at Superfund Ground Water Sites.

RESPONSE:

Comment noted. Please refer to WMWI's responses to the ARAR determinations provided by the Department (p. 27 of this document).

State of Wisconsin, Department of Natural Resources
Southern District Headquarters
Mike Schmoller, Solid Waste Specialist

1. Page 7 — It is not clear how the 10 percent figure was derived. The Department would like a more detailed discussion of how this figure was calculated. Also, the Department would like a more detailed discussion of the ground penetrating radar results overall.

RESPONSE:

The 10 percent (10%) figure regarding the constituents of the waste at Cell 12 was based on recollection of operations at the facility. With the completion of the interpretation of GPR indicating the absence of concentrations of metals and/or drums, the qualitative assessment is no longer applicable.

Approximately 25,000 linear feet of ground penetrating radar survey was completed. In summary, results allow for interpretation to varying degrees of waste composition, horizontal and vertical limits of waste, and presence or absence of fluids. Interpretation of radar lines indicates and confirms the absence of accumulation of leachate. Radar signals at Cell 12 are significantly different in character than signals for the remainder of the landfill such that the area of Cell 12 can be identified. Where the base grade is visible, the occurrence of a relatively thin waste mass is confirmed. Metals and objects that may be identified as drums are sparse, including the area of Cell 12. No concentration of drums has been detected within the limits of the landfill.

Radar lines were run at approximately 100-foot spacings along the full length of the landfill (lines 100N, 200N, 300N, and 400N). Radar was set with 168 nanosecond two-way, travel-time, which corresponds to an approximate depth of penetration of 24 feet. In the northwestern portion of the landfill, north/south radar lines were run at approximately 25-foot spacings. In the southeast portion of the landfill, the approximate location of Cell 12, radar lines were spaced at 10-foot intervals and run east and west between lines 1700E and 2100E. Approximately 3,600 feet of radar lines were run outside the landfill area with predominant concentration in the area immediately north of the eastern half of the landfill. Off-site lines were concentrated in areas of accessibility.

Radar data were processed and enhanced to include digital processing, through computer stacking techniques, and analog processing, which consisted of enhanced range-gain of the tap recorded radar data. The processing was designed to enhance the ability to interpret the radar charts at depth. As a result of the process, near surface anomalies on the radar are not readily visible with the initial set of charts prepared. As a consequence, another set of charts was prepared, in which the upper portion of the charts was enhanced at the expense of the lower.

One of the obvious features on radar charts, in the landfill, is the existence of a dark image in the upper 7 to 11 feet in the landfill material. Correlation of the radar charts with data on the thickness of cover, along lines 100N and 200N indicates that such dark areas correspond with areas where the cover material is less than 1-1/2 feet thick. In areas where cover is greater than 1-1/2 feet thick, the radar image is much lighter in tone near the surface. The darker areas appear to be a result of increased infiltration through areas of the landfill that have a thinner cap. The infiltration of rain water has leached salt from the moist waste in the near surface. The decrease in salt content of the waste causes an increase in transparencies of the waste to transmission radar.

In general, the waste material exhibits a particularly light tone, indicating a low dielectric permittivity, which consumes radar energy and yields less reflected energy to the receiver. In appearance, the light tones are somewhat similar to an overexposed photograph. The waste in Cell 12 is distinct in that the waste is tonally lighter than the tone in the remainder of the landfill.

Lines 100N and 200N traverse the entire length of the landfill. The base of the landfill is indistinct, but discernable. On line 200N the thickness of the landfill varies somewhat, but between approximately 10 or less feet near the end of the landfill to 14 to 19 feet within the central portion of the landfill. On line 100N the base of the landfill exceeds 14 feet in depth between stations 400E and 1000E; and between stations 1900E and 2100E. In the intermediate zones, between stations 900E and 1800E, the landfill has an approximate average depth of 14 feet. The depth determined in this last interval is coincident with depths approximated from the contour map of the land surface, because line 100N runs along the edge of the landfill.

On line 100N, between stations 1850E and 2150E (within Cell 12), the bottom of the landfill is not visible on the radar charts. This particular section appears to have been entrenched more deeply than the adjacent portions of the landfill and may have been dug deeper than other portions of the landfill. The deeper portion extends northward for approximately 40 feet. It is visible on line 140N, but is not visible on the 150N line.

Metal objects are present, but randomly scattered throughout the landfill. Metal may consist of old refrigerators, stoves, drums, bathtubs, crushed metal or scrap metal. No concentrations of metal objects indicating disposal of stacked drums have been observed in Cell 6, Cell 12, nor along lines 100N through 400N.

Where the bottom of the landfill is discernable on the radar charts..it does not appear that the bottom serves as a boundary to constrain downward infiltration of moisture through the landfill system.

 # 2. Page 9 **The term regulatory limits is used frequently throughout the memo. A definition for regulatory limits is needed. The Department standards for groundwater quality are preventative action limits established in NR 140, Wis. Adm. Code. Regulatory limits should be defined consistent with the preventative action limits.**

RESPONSE:

Water Quality and Contaminants of Concern

No leachate is present in the landfill, therefore, no characterization of the constituents of the leachate has been completed. Analyses of water samples from monitoring wells indicate elevated concentrations for some parameters in ground water the immediate area of the landfill. Parameters detected in ground-water samples collected from September 25 to October 12, 1989, at levels above Enforcement Standards established in NR 140, Wisconsin Administrative Code include:

<u>Metals</u>	<u>Conventional Parameters</u>	<u>Miscellaneous Parameters</u>
Arsenic	Nitrate	Total dissolved solids
Iron		
Manganese		

<u>Volatile Organics</u>	
Benzene	Trichloroethylene
Methylene chloride	Vinyl Chloride
Tetrachloroethylene	Xylene
Tetrahydrofuran	1,2-dichloroethane
Toluene	1,2-trans-dichloroethylene

No pesticides, PCB compounds, or semi-volatiles, on the EPA Target Compound List, were detected. In September 1990 samples were collected from selected new piezometers southeast and east of the landfill. The samples were analyzed for volatile organics. Concentrations above Enforcement Standards were detected in five of the six piezometers tested.

Analyses of samples collected at CDCL indicate levels exceeding Wisconsin Enforcement Standards (NR 140, 1988) for volatile organic compounds in the following wells:

P-1B	P-5A	B-9AR	PZ-5
P-1C	P-8A	B-9RR	PZ-9
P-2C	P-10A	B-16RR	PZ-11S
P-4B	B-6RR	B-18RR	PZ-11I
P-4C	B-7RR	B-19RR	PZ-11D

Parameters detected in ground-water samples collected from September 25 to October 12, 1989, and September 1990, at levels above preventative action limits (PALs) established in NR 140, Wisconsin Administrative Code include:

<u>Metals</u>
Arsenic
Barium
Cadmium
Fluoride
Iron
Manganese
Selenium

<u>Conventional Parameters</u>
Nitrate

<u>Miscellaneous Parameters</u>
Total dissolved solids

<u>Volatile Organics</u>
Benzene
Ethylbenzene
Methylene chloride
Tetrachloroethylene
Tetrahydrofuran
Toluene
Trichloroethylene
Vinyl Chloride
Xylene
1,1-dichloroethane
1,1-dichloroethylene
1,2-dichloroethane
1,2-trans-dichloroethylene

Table 1 provides a listing of parameters, preventative action limits, and wells from which ground water analyzed exceeds the current PALs.

Analysis of samples collected at CDCL indicates levels exceeding Wisconsin PALs for volatile organic compounds in the wells listed above.

Well P-1A is the only bedrock well in which a parameter other than metals, total dissolved solids, or nitrate was detected at a level exceeding the PALs. The parameter is trichloroethylene (3.7 µg/ℓ). Limits for iron, manganese, and total dissolved solids were exceeded in wells P-3A and P-4A (bedrock wells). Total dissolved solids and selenium levels were exceeded in well P-4A, selenium at 1.4 µg/ℓ, 0.4 µg/ℓ above the PAL of 1.0 µg/ℓ.

On the basis of the one comprehensive round and one special round of sampling and analyses of ground-water samples, the highest concentrations of organic compounds (tetrahydrofuran, benzene, 1,2-trans-dichloroethylene, methyl ethyl ketone, vinyl chloride) occur near the area of documented industrial waste disposal at Cell 12 (wells 18RR, PZ-11S, PZ-11I, PZ-11D, P-4C). Tetrahydrofuran was not detected in the bedrock wells. Organic compounds (trichloroethylene, tetrachloroethylene, benzene, 1,2-trans-dichloroethylene) exceeding regulatory limits were also detected in wells near the western and northwestern perimeter of the landfilled area (Cell 6). Concentrations of methylene chloride, methyl ethyl ketone, methyl-iso butyl ketone, and acetone were detected at levels in excess of 1,000 µg/ℓ near the eastern, southeastern, and northwestern portions of the site, in wells in which other VOCs were detected.

TABLE 1. Summary of Water Quality Data Showing Parameters and Concentrations Relative to PALs.

Parameter	Well Number		PAL (µg/ℓ)	Concentration (µg/ℓ)
Arsenic			5	
	P-4	B		7.1
	P-4	C		18.0
	P-5	A		31.0
	P-9	A		30.0
	P-10	A		9.6
	B-9	AR		12.0
	B-9	AR		14.0
	B-9	RR		63.0
	B-17	RR		8.2
	B-18	RR		18.0
Barium			200	
	P-9	A		260
	P-10	A		380
	B-9	RR		670
Benzene			0.067	
	P-1	B		1.82
	P-1	C		1.61
	P-4	B		1.59
	P-4	C		3.15
	P-8	A		1.45
	P-10	A		2.43
	B-7	RR		5.24
	B-9	AR		2.75
	B-9	RR		2.77
	B-16	RR		1.63
	B-19	RR		7.47
	B-15			44.00
	B-18			470.00
Cadmium			1	
	P-1	B		3.2
	P-1	C		2.6
	P-2	C		2.0
	P-3	C		2.8
	P-4	A		1.1
	P-4	C		3.2
	P-5	A		4.2
	P-6	A		2.1
	P-7	A		1.6

	P-8	A		3.1
	P-9	A		2.1
	P-10	A		3.2
	B-6	RR		1.5
	B-18	RR		2.5
1,1-Dichloroethane			85	
	P-5	A		496
1,2-Dichloroethane			0.05	
	P-5	A		2,610
	B-15			29
1,1-Dichloroethylene			0.024	
	B-7	R		2.7
	B-9	A		31.0
	B-9	R		2.4
	B-14			1.6
	B-15			6,100.0
	B-17			1.6
	B-18			100,000.0
	B-19	R		3.7
1,2-Trans-dichloroethylene			20	
	P-4	B		779
	P-5	A		3,290
	P-8	A		22
	B-18	RR		145
	PZ-11	D		1,400
Ethylbenzene			272	
	B-18	RR		1,070
	B-15			720
	B-18			4,700
Fluoride			440	
	P-3	C		500
	B-17	RR		500
Iron			150	
	P-2	B		690
	P-3	A		1,000
	P-3	B		280
	P-4	B		1,800
	P-4	C		17,400
	P-5	A		32,300
	P-9	A		6,400
	P-10	A		8,800

	B-6	RR		160
	B-7	RR		790
	B-9	AR		1,600
	B-9	RR		23,000
	B-16	RR		2,700
	B-18	RR		37,600
	B-19	RR		1,800
Manganese			25	
	P-1	B		837
	P-1	C		270
	P-2	B		61
	P-2	C		240
	P-3	A		94
	P-3	B		250
	P-4	B		160
	P-4	C		636
	P-5	A		340
	P-7	A		76
	P-8	A		3,700
	P-9	A		1,090
	P-10	A		2,120
	B-7	RR		789
	B-9	AR		613
	B-9	RR		160
	B-12	RR		813
	B-14	RR		110
	B-16	RR		440
	B-17	RR		71
	B-18	RR		240
	B-19	RR		625
Methylene Chloride			15	
	P-5	A		1,130
	B-16	RR		516
	B-18	RR		63
Nitrate as N			2,000	
	P-3	C		6,900
	P-6	A		18,500
Selenium			1	
	P-4	A		1.4
	P-7	A		1.3
Tetrachloroethylene			0.1	
	P-1	B		47.10
	P-1	C		119.00

	P-8 A		116.00
	B-7 RR		6.91
	PZ-9		5.73
	B-12 R		1.90
Tetrahydrofuran		10	
	P-4 B		19,900
	P-4 C		16,700
	P-10 A		5,480
	B-7 RR		722
	B-9 AR		278
	B-9 RR		208
	B-16 RR		7,520
	B-18 RR		14,600
	B-19 RR		16
	PZ-11 I		160,000
	PZ-11 D		9,960
	B-6 R		1,800
	B-9 A		160
	B-14		360
	B-15		3,200
	B-16 R		1,200
	B-17		420
	B-18		60,000
Toluene		68.6	
	P-4 B		341
	P-4 C		385
	B-16 RR		164
	B-18 RR		5,190
	PZ-11 S		2,260
	PZ-11 I		18,500
	PZ-11 D		566
	B-15		4,800
	B-18		110,000
Total Dissolved Solids		250,000	
	P-1 B		1,000,000
	P-1 C		868,000
	P-2 A		411,000
	P-2 B		404,000
	P-2 C		521,000
	P-3 A		323,000
	P-3 B		324,000
	P-3 C		455,000
	P-4 A		308,000
	P-4 B		316,000
	P-4 C		692,000

	P-5 A		1,030,000
	P-6 A		433,000
	P-7 A		500,000
	P-8 A		621,000
	P-9 A		538,000
	P-10 A		841,000
	B-6 RR		527,000
	B-7 RR		424,000
	B-9 AR		927,000
	B-9 RR		945,000
	B-12 RR		527,000
	B-14 RR		663,000
	B-16 RR		572,000
	B-17 RR		462,000
	B-18 RR		631,000
	B-19 RR		397,000
Trichloroethylene		0.18	
	P-1 A		3.67
	P-1 B		84.90
	P-1 C		14.70
	P-2 C		87.30
	P-4 B		6.22
	P-8 A		20.70
	B-6 RR		16.30
	B-7 RR		23.40
	PZ-5		55.60
	PZ-9		367.00
	B-6 R		20.00
	B-7 R		40.00
	B-9 A		2.80
	B-9 R		1.40
	B-12 R		1.10
	B-19 R		3.00
Vinyl Chloride		0.0015	
	P-4 B		286
	PZ-11 I		3,260
	PZ-11 D		327
m-Xylene		124 [1]	
	B-18 RR		1,790
	PZ-11 I		1,680
o+p-Xylenes		124 [1]	
	B-18 RR		1,880
	PZ-11 I		1,610

[1] - total xylenes

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No parameters were detected above PALs in the samples collected from the private water wells, with the exception of limited inorganic constituents (i.e. manganese, iron, lead, arsenic, barium, nitrate, and total dissolved solids) in the wells, which cannot be directly attributed to the landfill site. Table 2 provides a summary of concentrations determined in excess of PALs in the private wells.

Elevated concentrations of iron, manganese, and total dissolved solids are not uncommon in Dane County.

3. Page 10 — The September, 1990 groundwater results should be shown in comparison to state standards. This would clarify which of the five tested piezometers showed elevated levels for which parameters.

RESPONSE:

In September 1990, samples were collected from six new piezometers installed southeast and east of the landfill. The piezometers include PZ-5, PZ-9, PZ-10, PZ-11S, PZ-11I, and PZ-11D. Volatiles were detected at levels in excess of the PALs in each piezometer with the exception of PZ-10. Data are provided in the response to the previous comment of WDNR.

4. Page 11 — Reference is made to VOC occurrences in surface soils down slope from cells 6 and 12. If these concentrations exceed background conditions, an analysis needs to be completed on the risks, both environmental and human health, posed by these concentrations. If warranted, remedial action to address these surface soils will be required. The source control alternatives discussed later in this tech memo must include surface soil remedial measures if the contamination levels warrant it.

RESPONSE:

Surficial soil samples collected and analyzed as a part of Subtask 3.1, Soil Sampling, indicate the occurrence of volatile organics at downslope locations from waste disposal. The organics include methylene chloride and acetone directly downslope from Cells 6 and 12, respectively. Table 3 provides a summary of the organic constituents detected in the samples collected and analyzed. The risks will be evaluated and provided in the qualitative risk assessment for the SCOU. With regard to measures for remediation of surface soils: (1) The highest concentration detected is 20,250 µg/kg acetone at SD-5. Elevated concentrations of VOCs, mainly acetone, in the topographic low are limited and isolated as the sample collected at X2230, Y640 (approximately 530 feet from SD-5) was reported at <13 µg/kg. (2) The concentration of 9,540 µg/ℓ determined in the sample collected from X1920, Y200 is from surficial material on Cell 12.

5. Page 12 — The Department has a concern that the air migration pathway has not been properly addressed to date. State administrative codes require all landfills with waste capacity of greater than 500,000 cubic yards to install active gas control systems and specific flaring technologies to control hazardous air emissions. The City Disposal Landfill, because of its size, comes under these regulations. A specific site can be exempted from these regulations if sufficient monitoring is completed to verify that the site is not adversely impacting air quality.

These control and testing requirements are specified in NR 506 and 445, Wis. Adm. Codes. To date the testing necessary to attempt to exempt the City Disposal site has not begun. Consequently, the site is required to fully comply with the requirements in NR 506 and 445, Wis. Adm. Codes. Compliance with these requirements must be included in the various remedial alternatives developed at the end of this tech memo.

TABLE 2. Summary of Water Quality Data, Private Wells, Showing Parameters and Concentrations Relative to PALs

Parameter	PAL (µg/ℓ)	Well ID	Concentration (µg/ℓ)	Sample Date
Arsenic	5	[redacted]	7.2 (BMDL) [1]	1989
Barium	200	[redacted]	230	1989
			210	1990
Iron	150	[redacted]	3,500	1989
			1,200	1989
			3,600	1990
Lead	5	[redacted]	18	1989
			12	1989
			12	1989
			17	1990
			1,920	1990
Total Dissolved Solids	250 mg/ℓ	[redacted]	467 mg/ℓ	1989
			384 mg/ℓ	1989
			377 mg/ℓ	1989
			487 mg/ℓ	1990
			670 mg/ℓ	1990
			594 mg/ℓ	1990
Nitrate	2 mg/ℓ	[redacted]	12.7 mg/ℓ	1989
			10.7 mg/ℓ	1990
			8.65 mg/ℓ	1990
Manganese	25	[redacted]	90	1989
			300	1989
			320	1990
Cadmium	1	[redacted]	2.5	1989
Selenium	1	[redacted]	1.5 (BMDL)	1989
			1.4 (BMDL)	1989
			0.99 (Duplicate)	

[1] BMDL: below method detection limits.

TABLE 3. Results of Analyses, Soil Samples

Sample Designation			Acetone Acetone (µg/kg) [1]	bis (z-ethylhexyl) phthalate (µg/kg)	Di-n-octyl phthalate (µg/kg)	Methylene Chloride (µg/kg)
	X120	Y600	<11	NA [2]	NA	<5.7
	X1520	Y300	11.5	NA	NA	15.4
	X1920	Y200	9,540	NA	NA	<6.4
	X220	Y300	<11	NA	NA	<5.7
	X220	Y700	<12	NA	NA	<6.0
	X2230	Y640	<13	NA	NA	<6.5
(SD-1)	XE1500	YN1250	ND [3]	ND	ND	18.3
(SD-2)	XE2000	YN00	6.94 (BMDL) [4]	ND	ND	10.6
(SD-3)	XE2275	YN15	9.59 (BMDL)	ND	149 (BMDL)	18.7
(SD-4)	XE1650	YN00	63.6.	ND	ND	19.5
(SD-5)	XE2175	YN575	20,250	ND	ND	0
(SD-6)	XE1440	YN635	ND	54 (BMDL)	ND	11
(SD-7)	XE400	YN800	ND	ND	ND	81.5

[1] µg/kg - micrograms/kilogram
[2] NA - not analyzed
[3] ND - not detected
[4] BMDL - below method detection limits

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RESPONSE:

See response to comment # 4 from Charles Wilk (p. 2).

6. Pages 12 - 13 Until acceptable air monitoring is completed the Department believes that air migration may be a significant pathway of concern. Unless shown otherwise the Department believes an active gas control system with air emission controls is required for this site.

RESPONSE:

See response to comment # 4 from Charles Wilk (p. 2).

7. Page 13 The elevated metal readings for iron, manganese, and arsenic need to be viewed as primary impacts of the site. The elevated concentrations of these substances may influence the remedial measures selected under the groundwater operable unit.

RESPONSE:

Comment noted and as appropriate will be addressed in the detailed evaluation of alternatives. WMWI will complete a comparison of results of analyses from 1989 and 1990 samplings to background conditions after completion and receipt of the results of analyses.

8. Page 13 While there may not be an immediate danger to nearby water supplies, inconsistency between groundwater flow data and the apparent directions of groundwater contaminant migration, make any long term conclusions about the threat to water supplies tenuous. The potential threat to nearby water supplies is still an unresolved issue in the Department's opinion.

RESPONSE:

Information obtained and interpreted regarding direction of ground-water movement indicates two dominant directions of movement: (1) northeast under the eastern portio of the landfill, and (2) predominantly north under the western portion of the landfill. WMWI would like to point out that there are no inconsistencies in data, the setting is complex. The gradient expressed by the various water levels is gentle. Based on the data collected to date, PELA's opinion is that the TCE and other volatiles of low molecular weight that occur in wells in locations directly upgradient, however slight, represent dispersion.

9. Page 14 The interpretations provided on this page are, in general, correct. However, the Department has a concern that the contaminants found in groundwater at elevated concentrations, and for which no standard exists, are not forgotten in evaluating remedial measures.

RESPONSE:

Comment noted and concur. As applicable, these other parameters will be addressed in the GCOU - Detailed Analysis of Alternatives.

When designing remedial actions, particularly for the groundwater operable unit, consideration must be given to reducing the concentrations of all contaminants to acceptable levels.

Table 1. Summary of Cost Effectiveness of the Capping Alternatives

Cover	Infiltration (cubic feet per year)	Percent Reduction	Total Present Worth ($)[1/]
Existing	460,000 (average)	--	N/A
A	1,000	99.8	2,918,000.00
B	91,000	80.2	3,269,000.00
C	30	99.99	4,060,000.00
B/C	74,000	83.9	3,465,000.00

Assumptions: <u>Water Balance</u>

Maximum/Minimum Slopes of 5%/3% were used.

<u>Cost Analysis</u>

Landfill total acreage assumed to be 24.2 acres with Cells 6 and 12 containing 4.4 acres.

Also, an interest rate of 7.6% was used for the present worth analysis.

1/ Source control cost only. Does not include GCOU costs.

Page 29 Paragraph 2, Section 5.1.5.2, Amount of Hazardous Materials Destroyed or Treated. The operational life of the active landfill gas extraction and combustion system should be indicated.

RESPONSE: The prediction of long-term landfill gas generation is an extremely inexact science which is highly dependent on site specific factors. Some of these factors, such as the depth and age of the waste and absence of leachate are well enough defined at the CDCL to allow us to state with a fair degree of confidence that mitigation of gas will be a relatively short term issue. The placement of a synthetic cover system will have the affect of reducing the moisture content of the waste, and will in turn, further shorten the time required to mitigate gas generation in the landfill. However, at this time there does not exist either: 1) a rationale method or model, or 2) sufficient site specific information to accurately predict future landfill gas generation rates. This is a dilemma posed by all solid waste landfill and one which the WDNR has implicitly acknowledged in its proposed method for determining hazardous air contaminant levels in landfills. Consistent with this methodology, WMWI is proposing that the gas extraction and combustion system be installed and operated for a two-year demonstration period. At the end of the two-year demonstration period there should be sufficient site specific data to establish future operating standards and accurately predict the time required to achieve remediation. The draft FS report will be modified to reflect this approach.

Page 37 Paragraph 4, Section 5.2.6.1, Risks to Community During Remedial Action.
Further explanation/details regarding air contaminant monitoring at the site boundary should be included. The duration/intervals of monitoring should be stated.

RESPONSE: Text will be added to the draft FS regarding site boundary air monitoring. (see Section 7.2.6.1)

Page 40 Section 5.3, Alternative III.
Alternative III is incorrectly labeled as Alternative II. This should be corrected.

RESPONSE: Comment acknowledged.

Page 49 Paragraph 1, Section 5.4.8.1, Capital Costs.
The installation costs for Cover B are presented in the capital cost estimate for Alternative IV. This alternative actually stipulates use of the combination Cover B/C. This typographical error should be corrected.

RESPONSE: Comment acknowledged.

State of Wisconsin
Department of Natural Resources
Michael R. Schmoller, Hydrogeologist
Environmental Response Program
April 4, 1991

Review of Technical Memorandum 9A

The Department has completed its review of Technical Memo 9A. The Department believes the memo does a very good job in presenting and evaluating the possible remedial options for the site. In particular, the report does a very good job applying the specific review criteria to each alternative. Based on its review, the Department has concluded that Alternative V is potentially an acceptable remedial option for the site. As discussed later, there are concerns about the long term reliability of an artificial membrane without a backup infiltration barrier. In addition, the Department has concluded that Alternative VI, as proposed, is an acceptable measure. While not providing the same level of infiltration control as other options, this alternative does include the range of source control actions necessary to adequately address site concerns. The Department believes both Alternatives V and VI can be retained for future review and discussion. The remaining four options are not recommended by the Department to be carried forward for further review for the various reasons stated below.

In addition to these introductory remarks, the Department has the following general and specific comments on the memo.

General Comments

1. In reviewing the first 18 pages of the report, a number of specific design details were noted. Specifics such as trench spacing, depth of cutoff wall, trench depth, number of extraction wells per cell, blower sizing, number of vent pipes, etc. are given. The Department interprets all of these to be estimates only and that the exact design details will be developed during the remedial design phase. The Department wants to be clear that it is not agreeing to the specific design details discussed in this tech memo. Rather, we are agreeing to remedial approaches to be used.

RESPONSE: Comment acknowledged.

2. The Department appreciates the complete evaluations done on each of the proposed alternatives. The explanation and application of the review criteria is consistent with what is expected in the CERCLA process. The presentation of the evaluations made the Departments review of the remedial options very easy.

RESPONSE: Comment acknowledged.

Specific Comments

Page 8 Before the Department can make a final decision on the acceptability of Cover A, more information on the proposed compacted soil layer is needed. Technical Memos 1, 2, and 3 present a large volume of physical data describing the existing cover material (i.e. soil depth, grain size curves, moisture density curves, etc.). The Department would like an interpretation of this data to describe what the characteristics of this compacted native soil layer would be. Issues such as degree of compaction, resulting permeability, soil layer thickness, etc. need to be addressed. The extent to which this soil layer will provide a "backup" infiltration barrier is a key criteria in Department decision making. Also, more detailed information on the synthetic material proposed for use is needed.

RESPONSE: An interpretation of the data obtained regarding the existing cover materials will be presented in the draft FS along with more detailed information on the synthetic material proposed for use. (see Section 5.2.1.2, paragraphs 2, 3 and 4)

Table 1 The performance level of Cover A, as shown in Table 1, makes it an attractive alternative. However, concerns on long term effectiveness and the possible need for a secondary barrier need to be resolved. (Please see Attachments A and B for further discussion of the proposed use of Cover A.)

RESPONSE: It is believed that tight QA/QC control during membrane installation is a more effective and less expensive form of secondary containment than either placing more clay or placement of clay in thin lifts. The responses to attachments A and B are attached.

Page 11 During the remedial design phase, specific supporting information will be needed to document the proposed trench spacing and construction. There is a concern that the 2-foot proposed trench depth may not adequately address gas concentrations deep in the fill. There may be a need to use extraction wells in areas outside of cells 6 and 12. Also, there is a concern that the proposed 300-foot spacing may be too wide to adequately control gas conditions. Lastly, the detailed design will need to discuss handling condensate produced during system operation.

RESPONSE: Comment acknowledged. These details will be addressed in the remedial phase upon determination of the appropriate remedial action.

Page 19-26 These pages provide a good discussion of the review criteria and their proper use in evaluating remedial alternatives.

RESPONSE: Comment acknowledged.

Page 26 Alternative I does not reduce infiltration through the site and does not adequately address the remediation needs for cells 6 and 12. Consequently, this alternative is not acceptable to the Department. The evaluation on pages 26-32 does a very good job of highlighting strengths and weaknesses of this proposal. Based on this review, the Department believes this alternative does not satisfactorily remediate known site conditions and recommends that it not be further reviewed during the Feasibility Study.

RESPONSE: Comment acknowledged.

Page 32-39 Alternative II is an incremental improvement over Alternative I because it includes Cover A. The Department has already expressed its concerns about the use of Cover A. This proposal also does not provide specific remedial measures to deal with cells 6 and 12. The Department believes additional source control measures beyond capping and the trench gas extraction system are needed to remediate the contamination sources in cells 6 and 12. Based on the RI data available, cells 6 and 12 are acting as major ground-water contamination source areas. Since Alternative II does not contain specific actions to remediate these cells, the Department does not believe this option is acceptable and should not be carried forward to the Feasibility Study stage.

RESPONSE: Comment acknowledged.

Page 36 If the extraction system is operated at higher vacuum pressure, it increases the importance of having a continuous low permeability layer below the membrane cover. This continuous layer will help protect the membrane from increased stresses because of the higher operating vacuums.

RESPONSE: It is not envisioned that high vacuums will be applied at or near the geomembrane. Scarifying the top 6 inches of cohesive material beneath the geomembrane should be adequate to insulate the geomembrane from vacuum induced stresses.

Page 38 There needs to be some supporting information given for the estimated 2-year compliance period for NR 445 Wis. Adm. Code.

RESPONSE: Comment acknowledged. Further supporting information will be provided in the draft FS regarding an active venting demonstration period (see Section 7.2.6.4).

Page 40 There is a typographic error. This section should be titled Alternative III.

RESPONSE: Comment acknowledged.

Page 40 The drainage layer design will need to incorporate measures to prevent sloughing of saturated sideslopes.

RESPONSE: Comment acknowledged. Design items will be addressed upon determination of the appropriate remedial action.

Page 40-44 Based on the HELP model evaluation of the various caps, Cover B does not perform as well as Cover A or Cover B/C. Consequently, alternatives that use Cover B alone are not as effective and therefore less acceptable. In addition, Alternative III does not address the remediation needs of cells 6 and 12.

RESPONSE: Comment acknowledged.

Alternative III is not an acceptable measure to the Department because of the shortcomings in infiltration reduction in comparison to the other possibilities and in the lack of specific remedial options for cells 6 and 12.

RESPONSE: Comment acknowledged.

As with the narrative describing Alternatives I and II, the discussion of Alternative III and the use of the evaluation criteria was well done.

RESPONSE: Comment acknowledged.

Page 45 Alternative IV, while again an incremental improvement over the preceding three options, is not an acceptable measure because of the lack of attention given to cells 6 and 12. The use of cover B/C does provide for a further reduction of water through cells 6 and 12. Therefore its proposed use is an acceptable infiltration control option. However, when used alone, it does not adequately address migration from cells 6 and 12. Consequently, use of cover B/C will need to be done in conjunction with other remedial measures as proposed in Alternative VI. The Department recommends this alternative not receive further review.

RESPONSE: Comment acknowledged.

Page 49 As stated, Alternative V is an improvement of Alternative II with the inclusion of extraction wells for cells 6 and 12 and the membrane cutoff wall. The Department believes this is possibly an acceptable alternative. Questions on the use of cover A need to be resolved. Once the capping issues are addressed, a final decision on this option will be made.

RESPONSE: Comment acknowledged. See comments concerning Cover A.

Page 50 It should be stated that the installation of active gas extraction wells will remove more contaminants from the depths of waste. This in turn provides more migration control and is consequently somewhat more protective than Alternative II.

RESPONSE: Comment acknowledged.

Page 55 As proposed, Alternative VI is an acceptable remedial measure. This option addresses all the source control issues of concern. While not providing the same level of infiltration control as Alternative V, there is improved long term reliability of the proposed cover. This alternative provides for more contaminant removal from the waste mass, therefore is more protective than some of the previous options.

RESPONSE: Comment acknowledged.

As stated earlier, the Department believes either Alternatives V or VI are potentially acceptable. This position is reaffirmed by comparative analysis conducted on pages 60-64. Alternatives V and VI include the range of source control measure needed to address releases from the site. Each of the rejected options, while having individual strong points, do not completely address the source control problem. Consequently, the Department believes Alternative V and VI can be retained for consideration and additional evaluation.

RESPONSE: Comment acknowledged.

The Department has no specific comments on Appendices A, B, C, or D.

RESPONSE: Comment acknowledged.

Attachment A

On March 19, 1991, WDNR staff visited the landfill to preliminarily evaluate the feasibility of a synthetic membrane cap at the site. Based on initial observations, site slopes appear compatible with the use of a synthetic cap. Also, during the site discussions, it was concluded that installation of the gas collection and vapor extraction trenching and piping would need to be done before the cap was placed. It is believed this would help address the concern of fitting the pipes through the cover and preventing any possible leakage around the pipes. Also, it was noted that the level of gas production would have to be reviewed to insure that excessive methane production would not cause long term problems with the cap. Further more, it was discussed that since the fill was fairly shallow (approximately 15-22 feet thick) and relatively old (last waste filled in 1977) that differential settling is not expected to be a major problem. Lastly, the issue was raised of the need for reference information on the use of synthetic materials as caps at other solid and hazardous waste disposal facilities.

RESPONSE: There is general agreement to many of the statements in Attachment A, namely that existing sideslopes at the site appear compatible with the use of a synthetic cap, differential settlement is not expected to be a major problem due to the relative shallowness (15-22 ft.) and age of the landfill (last filled in 1977), and that gas collection and vapor extraction piping should be installed prior to the final cover to minimize leakage around pipes.

The level of excess methane production is expected to be relatively low due to the fact that the landfill is relatively shallow (15-22 ft.) and the refuse consists of a mixture of both organic putrescent waste and inorganic refuse.

References for use of geosynthetics as barriers to hazardous waste include, "Background Document on Button Liner Performance in Double-Lined Landfills and Surface Impoundments" (NTIS #PB87-182291, EPA/530-SW-87-013), and the following attached list from a paper by John Boschuk, Jr., "Landfill Covers - An Engineering Perspective."

Attachment A - References

1. USEPA "Technical Guidance Document: Final Covers on Hazardous Waste Landfills and Surface Impoundments," EPA-530/SW-89-047, US EPA, Cincinnati, OH, 1989.

2. Pennsylvania Environmental Quality Board, Municipal Waste Management Regulations, Chapter 273, "Municipal Waste Landfills."

3. Zienkiewicz, O.C., 1977, The Finite Element Method for Engineers, Prentice-Hall, Inc., Englewood Cliffs, NJ.

4. Huebner, K. H., The Finite Element Method for Engineers, John Wiley and Sons.

5. Segerlind, S. J., Applied Finite Element Analysis, John Wiley and Sons.

6. Gallagher, R. H., Finite Element Analysis Fundamentals, Prentice-Hall, Inc., Englewood Cliffs, NJ.

7. Fenves, S. J., Computer Methods in Civil Engineering, Prentice-Hall, Inc., Englewood Cliffs, NJ.

8. Wong, P. C. W., Kulhawy, F. H. and Ingraffea, A. R., 1989, "Numerical Modeling of Interface Behavior for Drilled Shaft Foundations Under Generalized Loading," ASCE Foundation Engineering, p. 565-579.

9. Herrmann, L. R., (1978), "Finite Element Analysis of Contact Problems," J. Eng. Mech. (ASCE), 104(5), p. 1043-1059.

10. Whitman, J. R., ed. The Mathematics of Finite Elements and Applications II, Academic Press, NY.

11. Desai, C. S., Zaman, Lightner and Siriwardane, 1984, "Thin-Layer Element for Interfaces and Joints," Int. J. Num. & Anal. Meth. Geomech., vol. 8, p. 19-43.

12. Ghaboussi, J., Wilson, E. L., and Isenberg, J., 1973, "Element for Rock Joints and Interfaces," J. Soil Mech. Fndns. Div. (ASCE), vol. 10, p. 833-848.

13. Taylor, R. L., Beresford, P. J., and Wilson, E. L., 1976, "A Non-conforming Element for Stress Analysis," Int. Journal of Numerical Methods in Engr., vol. 10, p. 1211-1219.

14. Wilson, El L., Taylor, R. L., Doherty, W. P. and Ghaboussi, J., 1973, "Incompatible Displacement Models," Numerical and Computer Methods in Structural Mechanics, p. 43-57, edited by Fenves, S. J., et. al., Academic Press Inc., NY.

15. Beer, G., 1988, Isoparametric Joint/Interface Element for Finite Element Analysis, Int. J. Num. Meth. in Eng., vol. 21, p. 585-600.

16. Pande, G. N. and Sharma, K. G., 1979, "On Joint/Interface Elements and Associated Problems of Numerical Ill-Conditioning," Int. J. Num. & Anal. Meth. Geomech., vol. 3, p. 293-300.

Attachment B

The following narrative was provided by WDNR Central Office staff concerning the proposed cover types. It provides a good discussion of Department concerns specific to the proposed use of Cover A.

Different cover options are provided: cover A, cover B, cover B/C, and cover C. The upper components of these caps are the same; the caps differ in the low permeability barriers provided. Cover A provides a geomembrane over the existing cover as the low permeability barrier (with estimated saturated hydraulic conductivity of 3.2×10^{-4}) and uses the HELP model to estimate infiltration through this cap. It is not clear how these values were derived, or how the interaction between the membrane and the lower soil layer was modeled. Flow through holes in geomembranes is dependent upon characteristics of the underlying materials. A major assumption of the HELP model is that flow occurs only through soil pores. With the existing cap, significant fractures and macro-structure are likely to be present. Flow through this macro-structure may not behave as porous media flow and it may not be appropriate to model this flow using porous media assumptions. It is unlikely that the existing cap presents a continuous permeability of 3.2×10^{-6} cm/sec. I understand that the existing cover may meet the NR 500 material specifications, but does not meet placement specifications. The clay layer must meet both the soil specifications and placement specifications. I do not believe that compaction of the existing cap could effectively eliminate the macro-structure such that a consistent 1×10^{-7} hydraulic conductivity would be present across the entire cap. Without the re-working of the existing cover such that the macro-structure is removed, this cap would not be as effective as is presented in the discussion of this alternative. I believe it is necessary to strip the existing cover, test the material, and replace acceptable clay soils in thin lifts such that the completed clay layer meets placement specifications throughout the 2-foot depth, prior to placement of a membrane. Also, it is unknown how much additional settlement will follow capping of this landfill. A low-permeability soil layer is necessary below the membrane to not only limit infiltration through membrane holes, but to provide redundancy should settlement strain exceed the membrane capacity.

RESPONSE: Attachment B refers to the analysis of Cover A with the HELP model and comments on the importance of having a low permeability soil beneath the membrane to limit infiltration and to provide redundancy should settlement strain exceed the membrane capacity.

In order to clear up any misunderstanding, a brief description of the HELP model input for Cover A follows:

> It was assumed one foot of beneath the synthetic liner had a permeability rate of 3.2 x 10^{-6} cm/s (not 3.2 x 10^{-4} cm/s). A leakage ratio of 0.00025 was assigned to the membrane which corresponds to a 1 cm diameter hole spaced 200 ft. on centers within the membrane (ref. NTIS Background Document PB87-182291). Considering the fact that re-compacted (to 100% field density) permeability tests of existing cover soils had permeability rates of 1.2 x 10^{-8} cm/s to 1.0 x 10^{-9} cm/s, using 3.2 x 10^{-6} cm/s may be conservative.
>
> Also, because the clayey soils which comprise the existing cover have relatively low to medium plasticity, it may be reasonably assumed that scarifying the top six inches of cover, moistening and re-compacting may provide a cover similar to that produced by total removal and replacement of the cover in place.

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January 29, 1992

Mr. Charles Wilk
Remedial Project Manager
United States Environmental Protection Agency
Region 5
Mail Code HSRW 6J
77 West Jackson Boulevard
Chicago, IL 60604-3590

Dear Mr. Wilk:

RE: City Disposal Corporation Landfill - Response to EPA Draft Feasibility Report Comments (HSRW 6J)

Per your letter of December 19, 1991, this brief narrative is being submitted with the amended Draft Feasibility Report for the City Disposal Corporation Landfill. The narrative presents the reviewer comments and corresponding response by Waste Management of Wisconsin.

In addition to the changes which were made in direct response to your comments, numerous other changes were made in an attempt to provide a more balanced presentation of the cover alternatives. These changes are too numerous to list individually, but are generally located in Sections 5, 7, and 8.

Comment A: Final Site Remedy

> "The RI/FS for this site is no longer being conducted in Operable Units. U.S. EPA plans to issue one Record of Decision on this site that encompasses remedial action for the landfill (source control) and the contaminated groundwater (groundwater control). The term Operable Unit has a distinct definition in the National Contingency Plan. The use of the terms: Source Control Operable Unit and Groundwater Control Operable Unit are no longer appropriate for this site. The authors may wish to use the terms Source Control and Groundwater Control to denote the separate activities necessary at the site."

Revision: The early chapters of the draft FS (Chapters 1 through 4) refer to previous reports and therefore usage of the terms "SCOU" and "GCOU" are used appropriately. The later chapters of the draft FS were edited to remove the operable unit terminology. Sections 5 through 14 were generally affected by this revision.

Comment B: NR 500 CAP Requirement

"As stated on page 84, Section 5.3.2.3, Cover A does not comply with Wisconsin's NR 504.07. Cover A consists of a geomembrane underlain by one foot of compacted native soil. NR 504.07 requires a cover consisting of a minimum of two feet of clay compacted in six-inch lifts.

The Draft Feasibility Report discusses Cover A as a cap which exceeds the performance of an NR 504.07 cap. It is important to note that the NR 504.07 cap is a minimum cover technical specification, and is not a performance standard for infiltration.

The revised Report shall include another alternative that includes an NR 504.07 cover, in addition to Alternative VI, with an active landfill gas extraction system. The extraction system should use wells with additional wells in Cells 6 and 12. The description of such an alternative must include a discussion of methods to minimize air intrusion into Cells 6 and 12 during vacuum extraction."

Revisions: Alternative VII was added to the Draft FS. Alternative VII uses an NR 504.07 cover (Cover B) and a deep well extraction system for the entire landfill. Section 7.4 was added between Sections 7.3 and 8.0 to address Alternative VII.

Comment No. 1 - Page 76, Section 5.2.1.6, Summary of Capping Technologies

"The U.S. EPA does not agree with third paragraph of this section. The U.S. EPA believes that a clay liner a minimum of 2 feet thick (thicker than the layer proposed in Cover A) is necessary to ensure the cap's integrity during and after construction. As important, WDNR's regulation NR 500 requires a minimum thickness for a clay cap. The Section shall be revised to include a discussion of this requirement"

Revisions: Section 5.2.1.6 has been expanded to address the concerns associated with Cover A. In addition, a discussion of Cover A's non-compliance with NR 504.07 is presented in Section 7.2.3.3. Finally, the WDNR's preliminary response to the proposed Cover A design is presented in Section 7.2.9.1.

Comment No. 2 - Page 92, 7.0, Detailed Analysis of Alternatives-SCOU

"The first sentence reads: A detailed analysis of Alternatives I through VI is performed in this section. The section includes a discussion of Alternatives I, V, and VI. The first sentence in the section should be revised to indicate only the alternatives discussed in the section."

Revision: The first sentence of Section 7.0 was revised to read that a detailed analysis of I, V, VI, and VII is performed in this section.

Comment No. 3 - Page 100, 7.2, Alternative V

"Alternative V includes the Cover A capping component. Some of the text discussing Alternative V is referenced in the discussion of Alternative VI. The referenced text should be incorporated into the discussion on Alternative VI."

Revision: Referenced text in section was incorporated into the discussion in Alternative VI.

Comment No. 4 - Page 100, 7.2.1.1, Active Extraction Through Wells

The second sentence in the section references Section 5.2.4.2 as a description of vent wells. Section 5.2.4.2 does not appear to describe the active extraction wells.

Revision: The reference to Section 5.2.4.2 was unintentional. Section "5.2.4.2" was changed in the text to Section "5.2.3.2".

Comment No. 5 - Page 105, 7.2.6.1, Risks to Community During Remedial Action

"This discussion includes a statement that air monitoring will be conducted twice annually. This statement shall be changed to be a suggestion of twice annual monitoring.

This discussion appears more detailed than the similar discussion found at page 112, Section 7.3.6.1. The Section 7.3.6.1 discussion shall be as detailed."

Revision: The statement of air monitoring frequency was changed to the suggested wording. The discussion in Section 7.3.6.1 was changed to be as detailed as Section 7.2.6.1.

Comment No. 6 - Page 112, Section 7.3.6.1, Risks to Community During Remedial Action

"This section includes a discussion about potential for vehicular traffic. The appendix to the report shall include a calculated estimate of the amount of vehicular traffic for each alternative. This estimate should be expressed in cubic yards of material that will be transported, the capacity of a truck and number of truck trips necessary to transport the estimated volume."

Revision: Gross estimates of vehicular traffic required for material transport for each alternative are included in the appendix. The results are briefly mentioned in Sections 7.1.6.1, 7.2.6.1, 7.3.6.1, and new Section (Alternative VII) 7.4.6.1. In addition, a table summarizing the haul trips required for each option was included in Section 5.2.1.6.

Comment No. 7 - Page 116, 8.2, Compliance With ARARs

"This section and Table 5 discusses the performance of the proposed covers and compares them to the cost of each cover. The discussions are misleading since they hint that the selection of a cover type for the landfill should be based on the aspect of landfill cover performance (infiltration rate) compared to cost of installation alone. As stated an earlier comment, NR 504.07 is a technical specification for a landfill cover not a performance standard. The U.S. EPA and the WDNR must consider a number of factors when deciding on a cover type. Among other factors to consider is the ability to install a synthetic membrane cover without damage and long-term reliability.

The U.S. EPA and WDNR have serious reservations on the ability of Cover A to perform in the long-term. Cover A relies on a synthetic membrane to achieve impermeability performance. The agencies are concerned that the synthetic membrane has the potential to become damaged during installation or during the long-term closure period of the landfill. The clay layer beneath the synthetic membrane of Cover A does not meet NR 504.07 and therefore may not provide sufficient backup should the synthetic membrane be damaged."

Revisions: See Comment No. 1. The issues of concern raised in Comment No. 7 were discussed in a meeting with the U.S. EPA, WMWI and WDNR held on January 8, 1992. Subsequent to that meeting, the U.S. EPA determined that it was appropriate to carry Alternative V through the detailed analysis in the FS, on the condition that a balanced, unbiased discussion of the cover options was presented.

To comply with this condition, numerous changes have been made throughout the report. In general, most of these changes are simply expanded discussions of issues and concerns that were perhaps too brief in the prior submittal. Chapters 5, 7, and 8 were generally affected in an attempt to provide a balanced discussion of Alternatives I, V, VI, and VII.

Comment No. 8 - Page 119, Section 8.8, State Acceptance

"This section shall be revised to be consistent with page 91, Section 6.3.1 which states that this criterion will not be addressed in this report, but will be addressed in the ROD after WDNR review of the proposed plan."

Revision: To present a balanced discussion of the various source control alternatives, we found it necessary to identify and discuss WDNR's preliminary indications of acceptance. We have, however, indicated in all of these sections that this input is preliminary and that final acceptance will be addressed in the ROD after WDNR review of the proposed plan. Sections 7.1.9.1, 7.2.9.1, 7.3.9.1, 7.4.9.1, and 8.9 have been revised to address this comment.

Comment No. 9 - Page 127, Section 9.4.6, Alternatives 7 and 8

"Alternative 7 was dropped from further consideration in the Draft Feasibility Study Report based on the belief that the high moisture content on the air-stripper emissions would prevent the catalytic oxidation system from functioning properly. Reduction of the moisture content would result in higher operating costs and generation of a side stream.

It is U.S. EPA's understanding that a high-moisture content would not significantly affect operation of the catalytic oxidation system. Consequently, there would be no additional cost or side stream. Alternative 7 should not be eliminated."

Revision: The limitations of air stripping as a core technology were not addressed adequately in the feasibility study. Air stripping cannot remove significant levels of acetone, methyl ethyl ketone and tetrahydrofuran which constitute a high percentage of the projected total organic load at this site, owing to their unfavorable air/water partition coefficients, i.e., Henry's Law constants $<10^{-2}$ atm-m^3/mole for all three components. Section 9.4.6 will be revised to clearly present the limitations of the air stripping technology for this application. Nevertheless, Alternative 7, Air Stripping - Catalytic Oxidation has been included. The evaluation has been provided as Section 12.5 to avoid revising numerous section references and maintain the clarity and continuity of the report. Section 13 has also been revised to include Alternative 7. In addition to the new Section 12.5 and revised Section 13, references to Alternative 7 or to its evaluation have been modified.

In conclusion, it must be noted that due to the nature of the primary organic contaminants at this site, air stripping as a core technology is believed to be fundamentally flawed. Nevertheless, an evaluation of

Alternative 7 has been provided. Numerous revisions were made in Sections 9, 12, and 13 and on Table 8 in response to this comment.

Comment No. 10 - Page 129, Section 9.4.9, Final Summary of Alternatives

"Alternative 10 presented in the report consists of UV oxidation as the primary technology. Elsewhere in the report, and also in the WMI memo discussing the treatability study conducted at Hagen Farm, only chemical oxidation is discussed. If the chemical oxidation technology evaluated in the Hagen Farm treatability study and discussed in the Feasibility Study Report is UV oxidation specifically, then it should be referred to as UV oxidation in all documents. If the technology evaluated was non-specific chemical oxidation, then all references to UV oxidation should be eliminated."

Revision: The reference to UV oxidation throughout Sections 9 and 12 has been changed to chemical oxidation. All other references have also been to chemical oxidation.

Comment No. 11 - Page 141, 12.1.3.2, Compliance with Location-Specific ARARs

"This section includes a discussion on point of compliance. The U.S. EPA has determined that the point of compliance for this site is the waste boundary. This determination is made in accordance with 40 CFR 300.430(f)(5)(iii)(A).

The waste-boundary point of compliance shall be used for alternatives development and analysis."

Revision: Section 12.1.3.2 and the corresponding sections in 12.2 through 12.5 have been revised to properly note this ARAR. The revisions in Sections 12.2 through 12.5 do, however, note the potential technical infeasibility of achieving this requirement. In addition to the limitations of hydraulic extraction of groundwater noted in the revision, it is important to note that the site was initially designed, permitted, and operated as a natural attenuation landfill. An implicit assumption in the concept of natural attenuation was that a portion of the area immediately around and beneath the landfill would act as a filter for the exfiltrating leachate and would become part and parcel of the waste management unit. While this concept is no longer considered state-of-the-art engineering, it must also be recognized that no technologies currently exist to totally reverse it's consequences. As such, it may be appropriate and more accurate to cite this location-specific ARAR as a goal rather than a requirement.

Numerous other changes have been made to address internal inconsistencies, misrepresentations of code requirements or to minimize the potential for future confusion. The most notable of these changes are:

- The drainage layer in Cover B has been removed so as to assure that the cover conforms exactly to the technical specification requirements of NR 504.07. The cost and predicted infiltration performance of Cover B have been similarly modified to reflect this change.

- Plate 2, which depicts plan view schematics of the various source control alternatives which have been carried through detailed analysis, has been deleted. The rationale for removing this plate is that the final design may not exactly conform to the layout presented as a conceptual design. It has been Waste Management's experience that the general public may not understand the difference between conceptual design and final design drawings and are unduly alarmed when the final design does not conform exactly to the conceptual design. Plate 2 has served a valid purpose in communicating the proposed source control concepts to the U.S. EPA and WDNR but may only serve to cause unwarranted future confusion if presented in the final FS and deposited in the public repository.

- The maximum slope value used in the HELP model infiltration predictions has been changed from five percent to nine percent to more accurately represent the anticipated sideslope grades. While this change does effect the value of the predicted infiltration, it does not change the relative effectiveness of the various cover alternatives since it was applied to each cover design.

- The basis for the present net worth cost estimates has been changed from a 7.6 percent discount rate to a nine percent discount rate and a five percent inflation rate. This change has been made to more accurately present the expected actual costs. Again, this change has resulted in an increase in the estimated values but has not resulted in any significant relative cost changes between alternatives since this basis was applied equally to all the alternatives.

- The terminology of "enhanced oxidation" used in Section 4.3.3.2.2.3 has been changed to "chemical oxidation" to resolve internal inconsistencies. A generic definition or description of the basic theory of chemical oxidation was also included in this section for further clarification.

Mr. Charles Wilk
United States Environmental Protection Agency
January 29, 1992
Page 8

As stated previously, every effort has been made to present the key issues and selection criteria in a factual and unbiased manner. Should you have any questions or comments regarding these revisions, please contact Mr. March Smith of Waste Management of North America at (708) 409-0700.

Sincerely,

Jack E. Dowden
Director
Foth & Van Dyke

James B. Hutchison, P.E.
Project Engineer
Foth & Van Dyke

JBH1/lb

cc: March Smith
Don Otter
Dee Brncich

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RESPONSE:

With regard to the GCOU, it is assumed that ARARs will be provided. ARARs generally are specific to regulations, standards, and limits set by State or Federal code, etc. All contaminants are not addressed.

10. Page 14 — The data assessment on this page should include a clear definition of the principal environmental and human health threats from the site.

RESPONSE:

Comment noted. Environmental and human health threats and endangerment will be addressed in detail in the Risk Assessment.

11. Page 14 — The Department has a concern, at this time, that the groundwater migration pathway is not yet fully understood. A pathway to explain the contaminant readings at locations P-8A, B-6RR, PZ-14, and well nest 2,A,B,C has not yet been developed. In addition, it is not clear that the vertical distribution of contaminants seen in well nest 11 is completely understood. These questions may well be answered during a detailed interpretation of the 1990 field work. However, at this time, the Department sees these issues as unanswered migration pathway concerns. Consequently, the conclusions regarding private well impacts should be qualified to say that to date no impacts have been seen.

RESPONSE:

See response to comment # 8.

12. Page 14 — The Department has a serious concern that the lack of source characterization data will hinder future decision making on the best source control measures needed for this site. At this time, the Department does not believe adequate waste characterization field work has been done to properly select source control measures. It is not clear how the various remedial options were developed at the end of this tech memo. The Department will need better documentation of the selection process used, before it can agree that some remedial measures are not applicable to this site.

RESPONSE:

Comment noted. Refer to responses to comment # 33 and reference to the EPA fact sheet.

13. Page 16 — There are some errors and uncertainties in Table 1. These are:

1. Landfill capping does not directly address gas generation.

RESPONSE:

Capping does have a direct effect on the moisture content of the waste which in turn has a direct effect on gas generation. See response to comment # 4.

2. Gas collection techniques may help deal with groundwater contamination particularly when dealing with volatile organic parameters. In fact, gas collection and treatment technologies can be used as partial groundwater remedies to control future releases to groundwater as required in Chapter 160, Stats.

RESPONSE:

Comment noted.

3. Not all the methods shown under Waste/Soil Treatment deal with gas generation or air contamination.

RESPONSE:

It is agreed that treatment and excavation does not deal with gas generation on hazardous air emissions per se; Table 1 will be revised accordingly.

4. In situ neutralization/detoxification needs to be defined. Also, it does not show up later in the report. The rationale for its elimination needs to be defined.

RESPONSE:

In site neutralization/detoxification pertains to pH adjustment and/or other means to chemically treat a waste mass to reduce toxicity. The technology is typically used to treat contaminated soils and sludges through the injection of chemical solutions. It is not generally applicable to sanitary landfills. Because of the ground-water flow regime, injection of any fluids into the subsurface at the CDCL site is not recommended and probably would not be accepted by the State.

14. Pages 17 - 18 The discussion of institutional controls and site access restrictions as compliments to active remedial measures is a good description of the role these measures should play.

RESPONSE:

Comment noted.

15. Page 18 The state requirements for landfill capping are not guidance they are legal requirements contained in Administrative Code.

RESPONSE:

Comment noted.

16. Page 18 State regulations require landfill caps to have a saturated hydraulic conductivity of 1 X 10^{-7} centimeters/second (cm/s) or less. This requirements is in NR 504.07 and NR 181.44(13), Wis. Adm. Code. The statement concluding caps must have a permeability less than or equal to surrounding subsoils is not entirely accurate.

RESPONSE:

Comment noted.

17. Page 19 It is uncertain if the Department would approve a cap design relying solely on an impermeable membrane (Cover A). It is most likely that the Department would require some thickness of compacted low permeability clay similar to that requirement of an NR 504.07 cap to act as a backup measure to ensure reduced infiltration. The specific design and requirements would be developed if Cover A was chosen as the remedial action. Also, the reference to the underlying clay needs to be clarified. Is that the compacted native soil layer?

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RESPONSE:

To clarify the intent of Cover A, the existing site cover would be regraded and supplemented to provide a minimum of 1 foot thick clay, after the existing topsoil is stripped. The synthetic would be placed directly over this clay layer. The advantage of this system is that re-exposure of the waste will be minimized during cover construction.

18. Page 19 It needs to be clarified that the state RCRA requirements in NR 500 and NR 181 Wis. Adm. Code differ from (are more stringent) than the federal RCRA requirements. Consequently, the clay cap requirements in NR 504 and NR 181, Wis. Adm. Code are not the same as the federal criteria.

RESPONSE:

Comment noted. This point will be emphasized in the draft feasibility study report.

19. Page 24 As discussed previously, the City Disposal site is required to meet the gas collection and hazardous air emission criteria in NR 506 and 443, Wis. Adm. Code, unless otherwise exempted based on extensive monitoring results. These requirements must be reflected in the gas control discussion in this tech memo.

RESPONSE:

See response to comment # 4 from Charles Wilk.

20. Page 27 It is understood by the Department that the contaminants to be treated under source control listed in section 5.2.8 is only a partial list representative of the types of contaminants to be addressed. Source control measures will be designed to address all the contaminants of concern at the site including heavy metals.

RESPONSE:

WMWI disagrees with the DNR's assertion that elevated metal readings for iron, manganese, and arsenic are primary impacts of the site. (See response to comment # 2.) With respect to the SCOU, minimization of exfiltration from the landfill through enhancement of the cover will effectively contain the heavy metals and other relatively immobile constituents which may be in the waste mass. WMWI will complete a comparison of results of analysis from 1989 and 1990 samplings to background conditions after completion and receipt of the results of analyses.

21. Page 27 In situ vitrification is not proposed as a possible remedial technology. The Department would like to see this method considered as a possible alternative for this site particularly as it relates to possible "hot spot" control.

RESPONSE:

Vitrification is inapplicable to hot spot control because you must be able to stop the secondary combustion process. Vitrification is applicable to materials with high silica content (i.e. soil). Waste properties, particularly carbon content as a result of total combustion of large quantities of paper wastes which generally comprise sanitary landfills, do not lend themselves to vitrification.

22. Page 28 Waste stabilization has limited long term operation and maintenance costs however, there are some short term costs.

RESPONSE:

Comment noted.

23. Page 29 The use of excavation at this site will be controlled in part by the Department's decision on whether hazardous wastes were sent to this site.

RESPONSE:

In light of Department's January 16, 1991, letter to Chuck Wilk, all waste material excavated will be tested to determine if it exhibits a hazardous characteristic. Therefore, the use of any technologies involving excavation may result in the generation of hazardous wastes.

24. Pages 27 - 31 Sections 5.2.8 and 5.2.9 provide a good brief narrative on the various waste and soil treatment technologies and disposal options considered for this site.

RESPONSE:

Comment noted.

25. Page 31 The state capacity assurance plan for hazardous wastes requires that off site disposal out of state be used only as a last resort measure.

RESPONSE:

It is not clear if by this comment the State is defining the in-state preference as a *To Be Considered* criteria. Please clarify.

26. Page 32 The Department agrees with the decision not to pursue sheet piles, injected screens or asphalt curtains as remedial possibilities for this site.

RESPONSE:

Comment noted.

27. Page 33 The treatment measures discussed under 5.2.11 must include a discussion of best available technology for the control of inorganic parameter discharges also.

RESPONSE:

Please be specific as to which Wis. Adm. Code requires consideration of BAT and the circumstances of its applicability or relevance and appropriateness.

28. Pages 33 - 34 The air treatment discussion should be expanded to include the state regulations, referenced previously concerning air emissions from landfills. Also, air emission controls shall deal with all contaminants associated with the site, not just VOC's alone. The discussion on page 34 gives the impression only VOC's are an air concern, the Department believes all contaminants at the site are potential air concerns.

RESPONSE:

See response to comment # 4 of Charles Wilk. Please clarify or be specific as to what other contaminants are of concern to the Department.

29. Pages 35 - 36 Under section 6.1.3 the narrative discusses six general steps for the development and screening of alternatives. However, there are seven individual points shown on pages 35-36.

RESPONSE:

Points 4 and 5 on page 36 were inadvertently split into two paragraphs during final preparation of the document.

30. Page 37 ARAR's are not defined as frequently used standards but are legal requirements associated with the activities or problems at the site. Also, final acceptable exposure levels may be defined by ARAR's if they are more stringent than calculated acceptable exposure levels.

RESPONSE:

This definition was taken verbatim from the 1988 U.S. EPA RI/FS Guidance Document.

31. Pages 35 - 40 The FS process overview on these pages accurately reflects the FS process contained in the USEPA, 1988 guidance document.

RESPONSE:

Comment noted.

32. Page 41 It would be useful if at the beginning of this section the specific remedial objectives for each media were listed. This would help tie the objectives to the technologies discussed. Also, source control technologies will not preclude future releases from the site, but rather will control and limit future releases.

RESPONSE:

Comment noted. Supplementary text (see comment # 33) has been prepared to address the Department's comment. This supplement will simply reiterate, in text form, the objectives defined on Plate 1.

33. Page 41 The rationale for elimination of several process options shown on Plate 1 is not clear. To make clear the Department's position, the decisions to delete the various process options are reviewed individually below.

1. Sedimentation Basin - The Department agrees that, at this time, contaminated surface water runoff from the site is not a concern consequently a basin is not necessary. However, if future site investigations or remedial actions expose waste to runoff waters such a control basin may be necessary. Also, a basin for sediment control from on site erosion during site activities may be necessary.

RESPONSE:

Comment is noted. This issue will be addressed as part of the remedial design considerations.

2. Excavation - The Department does not agree with the complete elimination of excavation as a remedial alternative. Clearly, complete excavation of the site is not feasible. However, excavation of smaller areas such as "hot spots" in cells 12 and/or 6 should be retained as possible actions. To date there has been very little source characterization of the waste material on site. This is particularly true for cells 6 and 12 which appear to be the most significant source areas on site. Only a ground penetrating radar survey which shows that cell 12 produces a different signature than the rest of the site has been conducted as a source characterization study. Until a far better understanding of the physical and chemical nature of the waste in cells 6, 12, and other possible unknown "hot spots" is known, the Department will not agree to the elimination of various process options. There is no data to support the conclusions that certain process options can be eliminated in favor of others. Consequently, the Department believes excavation must stay as a possible action until other options are proven, based on site data, to be effective solutions.

RESPONSE:

As indicated in the meeting on December 19, 1990, the ground penetrating radar did not reveal any metallic anomalies which could be associated with drummed wastes. Therefore, delineation of "hot spots" within Cells 6 and 12 will not be possible without extensive intrusive activities. Therefore, Waste Management believes that the idea of isolating and remediating specific "hot spots" should be abandoned in favor of dealing with Cells 6 and 12 as generally anomalogous areas. Given the size of these areas, excavation is impractical. Reference is made to the EPA "Quick Reference Fact Sheet" dated September 1990 and the article titled "Landfill Contents/Hot Spots." The article states that *"Characterization of a municipal landfill's contents generally is not necessary because containment, which is often the most practical technology, does not require such information."* The article also states that hot spots are characterized where the waste is in *"discrete locations"* and must be *"small enough that it is reasonable to consider removal . . . ."* In addition, given the potential exposure to construction workers and the local public during excavation, WMWI does not believe that options involving excavation activities are protective of human health.

3. Stabilization/Solidification - As stated above not enough site specific data has been produced to entirely eliminate this option. These processes may be applicable to "hot spot" control. The radar results show a low metal content in cell 12. It seems possible then, that this technology may be an applicable control measure for the wastes in cell 12 or elsewhere.

RESPONSE:

In addition to the above stated concerns regarding excavation, there is no demonstrated technology to chemically or physically fix VOCs or to solidify municipal waste. The mixing processes required for stabilization would release a large percentage of the VOCs to the atmosphere.

4. Vacuum Heap Extraction - The Department agrees that vacuum heap extraction does not appear to be a likely alternative at this time. It seems possible that the same results can be achieved by using in place injection and extraction methods.

RESPONSE:

Comment noted.

5. Waste/Soil Washing - It is not clear why this option was eliminated at this stage. For possible use in "hot spot" control there appears to be some applicability for this measure. The Department would like to further discuss this measure before it is eliminated entirely.

RESPONSE:

Again the concerns regarding excavation apply to this option as well as the concerns for releasing VOCs to the atmosphere during the handling and washing process.

6. In Situ Water/Soil Flushing - If the technology is selected, state concerns on groundwater injection systems will have to be satisfied.

RESPONSE:

WMWI shares the DNR's concerns that the ground-water flow regime may not be conducive to the degree necessary to allow fluid injection at this site.

7. On and Off Site Incineration - As with waste/soil washing the Department would like better documentation why these options were eliminated before it agrees on elimination.

8. On and Off Site Landfilling - the Department agrees that off site transport of waste for landfilling is not desirable. However, with some on-site treatment options (i.e., solidification/stabilization) landfilling of the treated waste may be required. Retaining this option is dependent on the final evaluation of several of the treatment alternatives previously discussed. Consequently, dependent on other option evaluations on site disposal may need to be retained.

RESPONSE:

These two comments appear to contradict DNR Comment # 25 that out of state disposal be used only as a last resort measure. Since the State has indicated that he waste must be handled as if it were hazardous waste, but there is no in-state hazardous waste landfill or incinerator it would seem that these would not be viable options. On-site landfilling and incineration would require excavation. WMWI's concerns about excavation processes are presented in the response to comment # 33 (3).

9. Gas Extraction/Flaring/Cycling - As stated several times, the Department does not agree with the proposed gas control options developed for this site. The Department does not believe adequate testing has been conducted to determine the appropriate air emission control system. The requirements in NR 506 and 445, Wis. Adm. Code must be met for this site. Consequently, extraction wells and flaring options must be retained for further analysis.

RESPONSE:

See response to comment # 4. In addition, enhanced in-situ vapor extraction, over and above that proposed to comply with NR 506.08 requirements, will be defined and carried forward into the detailed analysis.

INITIAL SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS - REVISED TEXT

The technology types and process options as related to *source control* that were identified in Technical Memorandum 5A and Section 5.0 were subjected to a screening process as described in Section 6.0. The purpose of the screening process was to reduce the array of potentially applicable technology types and process options for *source control* by evaluating the options with respect to technical implementability. This process is illustrated in Plate 1. The technology types and process options are described in Section 5.0 of the text. The plate includes the media of concern at the City Disposal Corporation Landfill site and the remedial action objectives associated with each environmental medium. The remedial action objectives for the CDCL site are summarized as follows:

- Solid Waste/Soils - prevent direct contact with waste/soils having 10^{-6} excess cancer risk. Prevent migration of contaminants that would result in ground-water contamination in excess of Wisconsin Enforcement Standards.
- Liquid Waste (Leachate) - prevent migration of contaminants that would result in ground-water contamination in excess of Wisconsin Enforcement Standards and/or 10^{-6} excess cancer risk.
- Air (Landfill Gas) - prevent inhalation of carcinogens in excess of 10^{-6} excess cancer risk.

Leachate does not occur; therefore, technology types and process actions associated with leachate are not addressed. General response actions were identified for each medium/remedial action objective. Technology types and the associated process options for *source control* were listed for each general response action. The ground-water medium and air treatment emissions will be addressed in the GCOU Alternatives Array Document (Technical Memorandum 6B) as *source control* will control and limit future releases.

Each process option identified in Plate 1 was described and then evaluated in terms of technical implementability, as described in Section 6.2.4. The evaluation of technical implementability was based on information from the RI site characterization regarding contaminant types and concentrations and other on-site characteristics (e.g., depth of ground water, depth to bedrock, ground-water flow regime, etc.). Those process options that were screened out (shaded boxes) for technical implementability reasons were not carried forward to the next phase, i.e., evaluation of process options (Section 8.0).

A total of 33 process options for 22 technology types were evaluated for the three media applicable to the SCOU. Twelve of the process options were screened out. A sedimentation basin was screened out because contaminated surface-water runoff from the site is currently not a concern. However, if future site investigations or remedial actions expose waste to runoff waters, such a control basin may be necessary. Also, a basin for sediment control from on-site erosion during site activities may be necessary.

Excavation was eliminated because complete excavation of the site is clearly not feasible, and because the ground penetrating radar survey of the landfill did not reveal any metallic anomalies which could be associated with drummed waste. Therefore, delineation of "hot spots" within Cells 6 and 12 would not be possible without intensive exploratory intrusive activities. Since this activity would be "hit or miss" at best and could result in adverse impacts to construction workers and to the local public, it would be abandoned in favor of dealing with Cells 6 and 12 as generally homogeneous areas. Given the size of these areas, excavation of Cells 6 and 12 would be impractical. An in-situ technology that treats these areas as a whole would be technically more practical and in the end more protective of human health and the environment than any technology that requires excavation of contaminated refuse.

Stabilization/solidification would require excavation and was eliminated for the above stated reasons. In addition, the effective physical/chemical fixation of volatile organic compounds in municipal waste through a solidification process has yet to be demonstrated. Also the mixing process required for stabilization would release large volumes of VOCs to the atmosphere.

Vacuum heap extraction was screened out because of required excavation, potential difficulties in handling the refuse, and because the same results could be achieved by using in-place extraction methods.

Waste/Soil washing was eliminated for the reasons stated above for screening out excavation, as well as the concerns regarding the release of VOCs to the atmosphere during the handling and washing process. In-situ waste/soil flushing was carried forward as it is technically feasible. However, the ground-water flow regime may not be conducive to the degree necessary to allow fluid injection at this site.

On-site incineration was eliminated for the reasons stated above regarding excavation. Off-site incineration was screened out because of required excavation and because there is currently no in-state incineration facility. The state capacity assurance plan for hazardous waste requires that out-of-state disposal be used only as a last resort measure.

On-site landfilling was eliminated because of required excavation. Off-site landfilling was screened out for the same reasons that off-site incineration was eliminated from further consideration.

Gas extraction and flaring were retained for further analysis and will be included in each recommended alternative because the requirements of NR 506 and 445, Wis. Adm. Code must be met for this site. In addition, in situ vapor extraction, over and above that required to comply with NR 506 requirements, will be carried forward into the detailed analysis.

34. Page 41 As shown on Plate 1 the groundwater remedial action objectives should be [in] compliance with groundwater preventative action limits not enforcement standards. This is required by state law. Also, the air treatment emissions section has applicability to many of the source controls measures under consideration. Air emissions control must be included in source control discussions.

RESPONSE:

A. As a point of clarification, the State law requires: (1) minimizing the concentration of the substance at the point of standards application where technically and economically feasible; (2) regain and maintain compliance with PALs to the extent it is economically and technically feasible; and (3) ensure that the enforcement standard is not attained or exceeded at the point of standards application.

B. WMWI is aware of the State's air emission standards. These standards will be addressed in the source control evaluations.

35. Page 42 As with Plate 1, the decisions to eliminate the two alternatives on Plate 2 needs to be further discussed. At this time, the Department is unwilling to accept the complete elimination of these process options. Both options appear to have possible applicability to "hot spot" control. Once a better description on the nature and extent of the "hot spots" on site are available, more decisions can be made regarding remedial alternative selections. Also, the remediation goals referenced on this page need to be more specifically defined to better evaluate the retained technologies.

RESPONSE:

As noted in the response to comment # 33 (2), WMWI does not believe that "hot spot" remediation is amenable to the situation at the CDCL.

36. Pages 44 - 48 The descriptions of the retained process options are accurate. However, as noted the Department does not agree necessarily that these are the only options to be further developed. The Department very much wants to further discuss the decision making process used to arrive at the conclusions presented.

RESPONSE:

See revised text prepared in response to comment # 33.

37. Page 44 The specific remedial action objectives for source control should be repeated here to be sure the alternatives developed meet the specific identified objectives.

RESPONSE:

Comment noted.

38. Page 48 The Department has the following comments on the eight specific remedial alternatives proposed for the site.

1. As with all eight alternatives the Department believes an active gas control and air emission control system is required for the site. Also, this alternative lacks additional control measures for "hot spot" remediation which likely appears necessary for some areas of the site. Also, as stated previously, it is not likely that the Department would accept Cover A as an acceptable cover technology for the site.

RESPONSE:

See response to comment # 4 of Charles Wilk.

2. Same comments as with Alternative 1. The inclusion of Covers B and C likely more accurately reflects the cover options that will be used at the site.

RESPONSE:

WMWI believes that Cover A may be equally protective as C and exceed the performance of B and therefore should not be disregarded at this stage.

3. The alternative approaches what may be an acceptable option for the site. However, the use of Cover A is likely not acceptable, no gas control and air emissions measure is included and other options may be more appropriate for control at cells 6 and 12 than gas injection/extraction or extraction.

RESPONSE:

See response to comment # 4 of Charles Wilk and comment # 38 (2) above.

4. The alternative is an increment improvement over Alternative 3. However it still maintains the same fatal flaws as described for the preceding althmatives.

RESPONSE:

See response to comment # 4 of Charles Wilk and comment # 38 (2) above.

5. This alternative may be acceptable if specific "hot spot" control measures are not necessary, Cover B was selected for use and on site monitoring can exempt the site from NR 506 and 445, Wis. Adm. Code air control measures.

RESPONSE:

With respect to "hot spot" control measures, see response to comment # 33 (2). With respect to gas control, see response to comment # 4 of Charles Wilk.

6. This alternative is the same as 3 except the possible use of Cover C. This is viewed as a better alternative because the use of Cover C may be necessary for all or parts of the site.

RESPONSE:

Comment noted.

7. This option may be acceptable, given the reservations already stated, if Cover B were selected.

RESPONSE:

Comment noted.

8. This is the most acceptable option of the eight presented. However, depending on additional site investigation it is likely not an entirely acceptable alternative.

RESPONSE:

Comment noted.

39. Page 51 Under action specific ARAR's, NR 105 and 106 Wis. Adm. Codes should be included as surface water discharge regulations.

RESPONSE:

Comment noted.

ARAR Determinations

Below are listed the ARAR's as determined by the Department based on the various remedial options presented. The Department may amend the list based on changes or additions to the list of possible remedial actions for the site.

Alternative	A or RA[1]	Code[2]	Preliminary Identification of Standards/Requirements
1) Institutional controls, access controls, monitoring cover A or B	RA	181.49	Groundwater monitoring to identify degree and extent of contamination, hazardous waste groundwater monitoring requirements

RESPONSE:

With the exception of NR 181.49 (5) paragraphs o, p, and q, NR 181.49 deals with detection monitoring. WMWI requests clarification from the DNR regarding expectations for remedial performance monitoring.

	A	181	Any waste generated during the remedial investigation must be handled consistent with hazardous waste requirements, general hazardous waste management requirements

RESPONSE:

Pursuant to the DNR's January 16, 1991, letter to Mr. Chuck Wilk, it is understood that this requirement pertains only to the extent that the waste demonstrated hazardous characteristics.

	A	140	Groundwater standards and response requirements

RESPONSE:

Requirement noted.

	A	149	Laboratory certification for environmental testing

RESPONSE:

Requirement noted.

	A	504, 506, 445	Landfill gas collection, treatment and hazardous air emission controls

RESPONSE:

Requirement noted.

	A	508	Landfill monitoring requirements

RESPONSE:

It is not clear how these requirements may conflict or overlap with the 181.49 requirements (or the NR 600 equivalents). It is also not clear if these requirements still pertain in light of the DNR letter dated January 16, 1991, to Mr. Chuck Wilk. Inasmuch as NR 508 deals primarily with detection and assessment monitoring, WMWI requests clarification from the DNR regarding expectations for remedial performance monitoring.

	A	504, 506, 514, 516	Landfill capping, closure and documentation requirements

RESPONSE:

In light of the January 16, 1991, letter to Mr. Chuck Wilk, it is not clear that these still are applicable or relevant and appropriate.

2) Institutional controls, access controls, monitoring cover A or B/C	same requirements as alternative 1 above		
	RA	181.44(11)-(14)	Landfill capping, closure, monitoring and long term care requirements

RESPONSE:

Requirements noted. In light of the DNR's January 16, 1991, letter to Mr. Chuck Wilk, WMWI requests clarification as whether the hazardous waste monitoring and long-term care requirements will continue to exist if, at some point in the future, the wastes and ground water no longer exhibit hazardous characteristics.

3) Institutional controls, access controls, monitoring cover A or B	same requirements as alternative 1 above		
	A	181	Management requirements for hazardous wastes removed during construction of gas extraction systems

RESPONSE:

It is understood that this pertains to the extent that the wastes exhibit hazardous characteristics.

4) Institutional controls, access controls, monitoring gas extraction, cover A or B/C	same as alternative 2		
	A	181	Management requirements for hazardous wastes removed during construction of gas extraction systems

RESPONSE:

See response to previous comment.

5) Institutional controls, access controls, monitoring trench/vent system, cover A or B	same as alternative 1
6) Institutional controls, access controls, monitoring trench/vent system, cover A or B/C	same as alternative 2
7) Institutional controls, access restrictions, monitoring, gas extraction, trench/vent system, cover A or B	same as alternative 3
8) Institutional controls, access restrictions, monitoring gas extraction, trench/vent system, cover A or B/C	same as alternative 4

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[1] A or RA = Applicable (A) or potentially Relevant and Appropriate (RA)

[2] Code = Wisconsin Administrative Code, Chapter NR series

Metcalf & Eddy, Inc.
Robert A. Schoepke, Contractor Project Manager

# 1.	Pg 18, § 5.2.4 Pg 22, § 5.2.5 Pg 29, § 5.2.8.7 Pg 31, § 5.2.9.1	Relative costs were identified for these Technologies/Process Options only. Relative costs for all Technologies/Process Options should be identified for consistency.

RESPONSE:

The relative costs for all options were identified on Plate 2 but were not repeated in the text.

# 2.	Pg 22, § 5.2.5, ¶ 2	A detailed description for the use of sedimentation basins should be provided.

RESPONSE:

WMWI agrees with DNR comment # 33 (1) regarding the need for sedimentation basin. As indicated in response to comment # 33 (1), WMWI will address the use of sedimentation basins in the remedial design.

# 3.	Pg 27, § 5.2.8, ¶ 2	The waste has been characterized principally by the analyses of ground-water samples collected from beyond the fill area. Therefore, the waste may contain semi-volatile organics and inorganics not identified in ground-water samples. These additional parameters can have an adverse effect on the efficiency of certain process options. The potential problems associated with these parameters should be considered when evaluating process options.

RESPONSE:

Currently there is no evidence that any semi-volatiles or inorganics with the exception of alkalinity will have any effect on the process options. However, the potential for such adverse effects will be considered in the detailed analysis.

# 4.	Pg 32,§ 5.2.10.1, ¶ 1	In addition to installing physical barriers downgradient of the source area, physical barriers can be installed around the other sides of the fill area to reduce ground water flow through the waste area. However, it should be noted that the hydraulic conductivity will be decreased within the barrier area when any type of physical barrier is used.

RESPONSE:

Please note that the waste is above the water table and consequently ground water is not flowing through the waste. The addition of ground-water flow barriers may only serve to complicate an already complex ground-water flow regime.

	¶ 2	Health & Safety costs have been included in the Relative costs for physical barriers. This consideration should be included for most of the process options presented.

RESPONSE:

Comment noted.

# 5.	Pg 33, § 5.2.10.2, ¶ 2	See previous comment.

RESPONSE:

Comment noted.

# 6.	Pg 33, § 5.1.11, ¶ 1	See comment for section 5.2.8.

RESPONSE:

Comment noted.

7. Pg 34, § 5.2.12, ¶ 2 As with other air treatment options, the efficiency of the vapor condensation process should be included.

RESPONSE:

The efficiency of this process is a function of the vapor moisture and therefore is site specific. The text will be revised to present the advantages and disadvantages of all options.

Activated carbon will adsorb both chlorinated and non-chlorinated hydrocarbons from a vapor stream. The process requires only a blower to move the vent gas stream and a vessel to hold the activated carbon. The primary disadvantage of this process is the high cost of replacing the activated carbon after it becomes saturated with hydrocarbons. Also, the spent carbon, if disposed, may be a hazardous waste.

In the vapor condensation process, a blower supplies VOC-laden vapor to a condenser. In the condenser, refrigerant (e.g., chloro-fluorocarbons or propane) extracts heat from the contaminated vapor stream. Organic compounds in the vapor condense as the temperature of the stream drops. The condensed organics may either be recycled or disposed.

The disadvantages of this process is that high moisture conditions in the vapor feed to the condenser (as would be the case with an air stripper) limit the efficiency of the process. This would require drying the vapor stream before it enters the condenser, significantly increasing the cost of the treatment.

A typical vent gas combustion system for VOC emissions consists of a blower, a supplemental air source, a combustion chamber, a natural gas burner, and a stack. The system includes a quench section to cool the exhaust gas from the combustion chamber and a caustic scrubber to control hydrogen-chloride emissions. The disadvantage of this system is that it requires a feed source and generates several undesirable by-products such as carbon monoxide, nitrogen oxides, hydrogen chloride, dioxins, and furans, dependent on the waste characteristics. These emissions may require additional treatment prior to drainage.

Thermal oxidation is similar to vent gas combustion except that oxidation occurs without an open flame. The contaminated vapor stream enters an insulated oxidation chamber containing a heated silica gravel bed. Electric heating elements are used for start-up and to maintain the temperature of the silica gravel bed. A thermal oxidation unit typically operates at about 1800°F. The disadvantage of this process is that it is not suitable for chlorinated hydrocarbons because these compounds may corrode the electric heating elements in the oxidation chamber.

8. Pg 41, § 7.0, ¶ 1 Options involving leachate control should not be screened out because leachate has not been observed during the RI. Leachate seeps have been observed in the past. Furthermore, the RI has been conducted over a period during which there has been below normal precipitation. The possibility of future leachate generation should be considered.

RESPONSE:

Given that the waste is currently dry and an enhanced cover system will only serve to further reduce the waste moisture, WMWI does not believe leachate control measures will be of any consequential benefit.

# 9.	Pg 42, § 8.0, ¶ 2	The evaluation process is illustrated in Plate 1 not Plate 2.

RESPONSE:

Comment noted.

# 10.	Pg 43, § 8.0, ¶ 2	The text states that three process options were screened out. These options and the reasons for their elimination should be identified.

RESPONSE:

Please see revised text prepared in response to DNR comment # 33.

# 11.	Pg 44, § 9.1, ¶ 1	The "No Action" alternative should not be eliminated at this stage.

RESPONSE:

No action will be retained at EPA's request.

# 12.	Pg 47, § 9.2.1.1.6, ¶ 2	The text states that in situ bioremediation has been screened out. This is inconsistent with Plate 1.

RESPONSE:

In-situ bioremediation was screened during the evaluation of process options (see Plate 2) and not in the Screening of Alternatives (Figure 8).

The reasons for eliminating technologies/process options should be expanded and should include all technologies/options.

RESPONSE:

See response to DNR comment # 33 and the associated revised text.

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES
Carroll D. Besadny, Secretary

Southern District Headquarters
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Fitchburg, WI 53711
TELEFAX NO. 608-275-3338

April 4, 1991

File Ref: 3303

Chuck Wilk, RPM
United States Environmental Protection Agency
Region V, 5HS-11, 230 Dearborn Street
Chicago, IL 60604

Subject: Review of Technical Memorandum 9A Analysis of Alternatives (SCOU) for the City Disposal Landfill

Dear Mr. Wilk:

The Department has completed its review of Technical Memo 9A. The Department believes the memo does a very good job in presenting and evaluating the possible remedial options for the site. In particular, the report does a very good job applying the specific review criteria to each alternative. Based on its review, the Department has concluded that Alternative V is potentially an acceptable remedial option for the site. As discussed later, there are concerns about the long term reliability of an artificial membrane without a backup infiltration barrier. In addition, the Department has concluded that Alternative VI, as proposed, is an acceptable measure. While not providing the same level of infiltration control as other options, this alternative does include the range of source control actions necessary to adequately address site concerns. The Department believes both Alternatives V and VI can be retained for future review and discussion. The remaining four options are not recommended by the Department to be carried forward for further review for the various reasons stated below.

In addition to these introductory remarks, the Department has the following general and specific comments on the memo.

General Comments

1) In reviewing the first 18 pages of the report, a number of specific design details were noted. Specifics such as trench spacing, depth of cutoff wall, trench depth, number of extraction wells per cell, blower sizing, number of vent pipes, etc. are given. The Department interprets all of these to be estimates only and that the exact design details will be developed during the remedial design phase. The Department wants to be clear that it is not agreeing to the specific design details discussed in this tech memo. Rather, we are agreeing to remedial approaches to be used.

7) The Department appreciates the complete evaluations done on each of the proposed alternatives. The explanation and application of the review criteria is consistent with what is expected in the CERCLA process. The presentation of the evaluations made the Departments review of the remedial options very easy.

Specific Comments

Page 8, before the Department can make a final decision on the acceptability of Cover A, more information on the proposed compacted soil layer is needed. Technical memos 1, 2 and 3 present a large volume of physical data describing the existing cover material (i.e. soil depth, grain size curves, moisture density curves, etc.). The Department would like an interpretation of this data to describe what the characteristics of this compacted native soil layer would be. Issues such as degree of compaction, resulting permeability, soil layer thickness, etc. need to be addressed. The extent to which this soil layer will provide a "backup" infiltration barrier is a key criteria in Department decision making. Also, more detailed information on the synthetic material proposed for use is needed.

The performance level of Cover A, as shown in Table 1, makes it an attractive alternative. However, concerns on long term effectiveness and the possible need for a secondary barrier need to be resolved. (Please see Attachments A and B for further discussion of the proposed use of Cover A).

Page 11, during the remedial design phase specific supporting information will be needed to document the proposed trench spacing and construction. There is a concern that the 2-foot proposed trench depth may not adequately address gas concentrations deep in the fill. There may be a need to use extraction wells in areas outside of cells 6 and 12. Also, there is a concern that the proposed 300-foot spacing may be too wide to adequately control gas conditions. Lastly, the detailed design will need to discuss handling condensate produced during system operation.

Page 19-26, these pages provide a good discussion of the review criteria and their proper use in evaluating remedial alternatives.

Page 26, Alternative I does not reduce infiltration through the site and does not adequately address the remediation needs for cells 6 and 12. Consequently, this alternative is not acceptable to the Department. The evaluation on pages 26-32 does a very good job of highlighting strengths and weaknesses of this proposal. Based on this review, the Department believes this alternative does not satisfactorily remediate known site conditions and recommends that it not be further reviewed during the Feasibility Study.

Page 32-39, Alternative II is an incremental improvement over Alternative I because it includes Cover A. The Department has already expressed its concerns about the use of Cover A. This proposal also does not provide specific remedial measures to deal with cells 6 and 12. The Department believes additional source control measures beyond capping and the trench gas extraction system are needed to remediate the contamination sources in cells 6 and 12. Based on the RI data available, cells 6 and 12 are acting as major groundwater contamination source areas. Since Alternative II does not contain specific actions to remediate these cells, the Department does not believe this option is acceptable and should not be carried forward to the Feasibility Study stage.

Page 36, if the extraction system is operated at higher vacuum pressure, it increases the importance of having a continuous low permeability layer below the membrane cover. This continuous layer will help protect the membrane from increased stresses because of the higher operating vacuums.

Page 38, there needs to be some supporting information given for the estimated 2-year compliance period for NR 445 Wis. Adm. Code.

Page 40, there is a typographic error. This section should be titled Alternative III.

Page 40, the drainage layer design will need to incorporate measures to prevent sloughing of saturated sideslopes.

Page 40-44, based on the HELP model evaluation of the various caps, Cover B does not perform as well as Cover A or Cover B/C. Consequently, alternatives that use Cover B alone are not as effective and therefore less acceptable. In addition, Alternative III does not address the remediation needs of cells 6 and 12.

Alternative III is not an acceptable measure to the Department because of the shortcomings in infiltration reduction in comparison to the other possibilities and in the lack of specific remedial options for cells 6 and 12.

As with the narrative describing Alternatives I and II, the discussion of Alternative III and the use of the evaluation criteria was well done.

Page 45, Alternative IV, while again an incremental improvement over the preceding three options is not an acceptable measure because of the lack of attention given to cells 6 and 12. The use of cover B/C does provide for a further reduction of water through cells 6 and 12. Therefore its proposed use is an acceptable infiltration control option. However, when used alone, it does not adequately address migration from cells 6 and 12. Consequently, use of cover B/C will need to be done in conjunction with other remedial measures as proposed in Alternative VI. The Department recommends this alternative not receive further review.

Page 49, as stated Alternative V is an improvement of Alternative II with the inclusion of extraction wells for cells 6 and 12 and the membrane cutoff wall. The Department believes this is possibly an acceptable alternative. Questions on the use of cover A need to resolved. Once the capping issues are addressed, a final decision on this option will be made.

Page 50, it should be stated that the installation of active gas extraction wells will remove more contaminants from the depths of waste. This in turn provides more migration control and is consequently somewhat more protective than Alternative II.

Page 55, as proposed Alternative VI is an acceptable remedial measure. This option addresses all the source control issues of concern. While not providing the same level of infiltration control as Alternative V, there is improved long term reliability of the proposed cover. This alternative provides for more contaminant removal from the waste mass, therefore is more protective than some of the previous options.

As stated earlier, the Department believes either Alternatives V or VI are potentially acceptable. This position is reaffirmed by comparative analysis conducted on pages 60-64. Alternatives V and VI include the range of source control measures needed to address releases from the site. Each of the rejected options, while having individual strong points, do not completely address the source control problem. Consequently, the Department believes Alternative V and VI can be retained for consideration and additional evaluation.

The Department has no specific comments on Appendices A, B, C or D.

This completes the Departments review of this memo. If you have questions or concerns, please contact me directly.

Sincerely,

Michael R. Schmoller

Michael R. Schmoller
Hydrogeologist
Environmental Response Program

MRS:cmt
SWM\TCH9A.MRS
cc: Pat McCutcheon - SD
Sue Bangert - SW/3

Attachment A

On March 19, 1991 WDNR staff visited the landfill to preliminarily evaluate the feasibility of a synthetic membrane cap at the site. Based on initial observations site slopes appear compatible with the use of a synthetic cap. Also, during on site discussions, it was concluded that installation of the gas collection and vapor extraction trenching and piping would need to be done before the cap was placed. It is believed this would help address the concern of fitting the pipes through the cover and preventing any possible leakage around the pipes. Also, it was noted that the level of gas production would have to be reviewed to insure that excessive methane production would not cause long term problems with the cap. Furthermore, it was discussed that since the fill was fairly shallow (approximately 15-22 feet thick) and relatively old (last waste filled in 1977) that differential settling is not expected to be a major problem. Lastly, the issue was raised of the need for reference information on the use of synthetic materials as caps at other solid and hazardous waste disposal facilities.

Attachment B

The following narrative was provided by WDNR Central Office staff concerning the proposed cover types. It provides a good discussion of Department concerns specific to the proposed use of Cover A.

Different cover options are provided; cover A, cover B, cover B/C, and cover C. The upper components of these caps are the same; the caps differ in the low permeability barriers provided. Cover A provides a geomembrane over the existing cover as the low permeability barrier (with estimated saturated hydraulic conductivity of 3.2×10^{-4}) and uses the HELP model to estimate infiltration through this cap. It is not clear how these values were derived, or how the interaction between the membrane and the lower soil layer was modeled. Flow through holes in geomembranes is dependent upon characteristics of the underlying materials. A major assumption of the HELP model is that flow occurs only through soil pores. With the existing cap, significant fractures and macro-structure are likely to present. Flow through this macro-structure may not behave as porous media flow and it may not be appropriate to model this flow using porous media assumptions. It is unlikely that the existing cap presents a continuous permeability of 3.2×10^{-4} cm/sec. I understand that the existing cover may meet the NR 500 material specifications, but does not meet placement specifications. The clay layer must meet both the soil specifications and placement specifications. I do not believe that compaction of the existing cap could effectively eliminate the macro-structure such that a consistent 1×10^{-7} hydraulic conductivity would be present across the entire cap. Without the re-working of the existing cover such that the macro-structure is removed, this cap would not be as effective as is presented in the discussion of this alternative. I believe it is necessary to strip the existing cover, test the material, and replace acceptable clay soils in thin lifts such that the completed clay layer meets placement specifications throughout the 2 foot depth, prior to placement of a membrane. Also, it is unknown how much additional settlement will follow capping of this landfill. A low-permeability soil layer is necessary below the membrane to not only limit infiltration through membrane holes, but to provide redundancy should settlement strain exceed the membrane capacity.

P.E. LaMoreaux & Associates, Inc.
Hydrologists Geologists Engineers & Environmental Scientists

Via Airborne

June 20, 1991

Mr. Charles Wilk, 5HS-11
Remedial Project Manager
City Disposal Corporation
Hazardous Waste Enforcement Branch
U.S. EPA, Region V
230 South Dearborn Street
Chicago, Illinois 60604

Mr. Mike Schmoller
Project Coordinator
City Disposal Corporation
State of Wisconsin
Department of Natural Resources
3911 Fish Hatchery Road
Fitchburg, Wisconsin 53711

RE: **CDCL - Technical Memorandum No. 6B**
PELA Reference Number 495209

Dear Sirs:

Transmitted on behalf of Waste Management of Wisconsin, Inc. is the document entitled, *"Response to Comments on Technical Memorandum No. 6B, Alternatives Array Document (GCOU) for Remedial Investigation/Feasibility Study, City Disposal Corporation Landfill."*

If you have any questions, please contact March Smith, Remedial Project Manager (708-409-0700).

Sincerely,

Daniel S. Green
Project Manager

Lois D. George
Vice President
Environment & Ecology

LDG\pmb 13-D:\495200\Wilk-Sch.L01

Enclosures: Wilk - 12 copies; Schmoller - 3 copies (2-Southern District/1-Central Office)

cc: March Smith
Dee Brncich
Jack Dowden
Oliver Janney
Nick Odom, Jr.

Home Office: P.O. Box 2310, Tuscaloosa, AL 35403 205/752-5543 FAX 205/752-4043
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P.O. Box 164, Macon, GA 31201 912/743-6485

PELA

Response to Comments on Technical Memorandum No. 6B
Alternatives Array Document (GCOU)
For Remedial Investigation Feasibility Study
City Disposal Corporation (DUNN) Landfill

PELA 495209 **June 20, 1991**

U.S. Environmental Projection Agency
Charles Wilk
Remediation Project Manager
May 20, 1991

U.S. EPA List

Nine alternatives have been proposed for potential application to the GCOU. Each alternative includes zoning/deed restrictions and ground-water monitoring. Alternatives 1-3, 5 and 7-9 include an extraction well system. Alternatives 1-2 and 7-8 include air stripping. Alternatives 1-3 and 7-9 include discharging treated ground water to a local stream. Alternative 5 proposes discharge of untreated or pre-treated ground water to a local publicly-owned treatment works ("POTW"). Alternatives 1 and 7 call for catalytic oxidation of treatment emissions. Alternatives 2 and 8 call for activated carbon absorption of treatment emissions. Centralized carbon absorption of contaminated ground water is proposed in Alternative 3: activated carbon absorption at individual wells is proposed in Alternative 4. (Activated carbon absorption of treated ground water is proposed as "effluent polishing" in Alternatives 7 and 8.) *In-situ* bio-remediation is proposed in Alternative 6. Above ground bio-treatment is proposed in Alternative 9.

A. Zoning, Fencing/Deed Restrictions

Each of the proposed GCOU alternatives includes proposals to restrict access to the site by means or zoning regulations, fencing requirements and deed restrictions. The ARARs pertinent to such proposals were listed in my memorandum on 12/26/90, but are restated here for convenience:

Section (40 CFR §)	A/RA/TBC	Standard/Requirement
264.177(c)	RA	post-closure use of property on or in which hazardous wastes remain
264.310(b)(5)	RA	protect and maintain surveyed benchmarks

RESPONSE: Waste Management of Wisconsin, Inc. would like to clarify if, by citing 40 CFR 264, the Environmental Protection Agency (EPA) is asserting that affirmative evidence exists that the materials in the landfill are Resource Conservation and Recovery Act (RCRA) hazardous. If so, Waste Management requests access to such evidence. Waste Management believes that, while an argument may be made that hazardous waste regulations may be relevant to this site, they are not appropriate given site specific conditions.

B. Ground Water Extraction and Discharge

The following ARARs pertain to the GCOU's proposals regarding an extraction well system, discharge of untreated water to a POTW, and direct discharge of treated ground water to surface water:

Section (40 CFR §)	A/RA/TBC	Standard/Requirement
§ 123	A	NPDES requirements of CA
§ 403.5	TBC	POTW limitations

(Wis. Adm. Code) NR 102, 104, 200, 217 and 219	A	regulating discharge to surface water, effluent limits, discharge permit applications, sampling/testing procedures
NR 112	A (?)	regulates wells which singly or collectively with other wells on the property extract >70 gpm
WPDES permit requirements	A	
CA § 304	RA	water quality criteria for specific pollutants
CA Ambient Water Quality Criteria for Protection of Aquatic Life	RA	ambient water quality criteria
RCRA Part 264	RA	RCRA ground-water monitoring requirements

RESPONSE: No response to any ARAR cited with the exception of RCRA Part 264. With respect to the relevance of 40 CFR 264, see response to comment EPA-A.

C. Ground-Water Treatment

1. Activated carbon adsorption

Alternatives 3 and 4 propose activated carbon adsorption of contaminated ground water. Alternatives 7 and 8 propose activated carbon adsorption as "effluent polishing." The following ARAR may pertain to this alternative if the resulting spent carbon material is a TCLP hazardous waste or a characteristic waste:

Section (40 CFR §)	A/RA/TBC	Standard/Requirement
268	RA	RCRA land disposal restrictions

RESPONSE: Comment noted; no response.

2. Air stripping

Alternatives 1, 2, 7 and 8 include proposals for air stripping. Alternatives 1 and 7 propose catalytic oxidation of treatment emissions from the air stripper: alternatives 2 and 8 propose activated carbon adsorption of treatment emissions from the air stripper. The following ARARs would pertain to these proposed actions:

Section	A/RA/TBC	Standard/Requirement
(Wis. Adm. Code) NR 140	A	Wis. ground-water standards
NR 160	A	Wis. protective action limits
NR 400-499	A	regulates air emissions from air stripping
CAA Part 61	RA	NESHAPs for, inter alia, vinyl chloride, benzene, radon(?)

OSWER Directive 9355.0-28	RA	EPA policy guidance entitled Control of Air Emission from Superfund Air Strippers at Superfund Ground-Water Sites
(40CFR §) 141.11-141.16	RA/TBC	SDWA MCLs
141.50	RA/TBC	MCL Goals for, inter alia, vinyl chloride
264.94	RA	RCRA MCLs
264.97	RA	general ground-water monitoring requirements for any ground-water monitoring program developed to satisfy, inter alia, § 264.100

RESPONSE: Please clarify the intent of the reference to WAC NR 160. NR 160 pertains to Federal and State Construction Grant Projects and would not seem to be applicable to this situation.

No response to any other cited ARARs/To Be Considered (TBCs) criteria with the exception of 40 CFR 264. With respect to the relevance of 40 CFR 264, see response to comment EPA-A.

State of Wisconsin
Department of Natural Resources
Michael Schmoller, Hydrogeologist
Environmental Response Program
January 25, 1991

Technical Memorandum 6B

General Comment

#1 Any groundwater remedial action taken at the site must be able to comply with the preventive action limits set in ch. NR 140. Wis. Adm. Code. The compliance point for this site is the waste boundary. If compliance with preventive action limits is proven not to be technically and economically feasible as specified in s. NR 140.24, Wis. Adm. Code, the lowest technically and environmentally feasible ground-water concentration shall be achieved. In no case can the target cleanup level exceed state enforcement standards.

For parameters for which no ch. NR 140, Wis. Adm. Code standard exists, the cleanup standard shall be background concentrations. If achievement of background concentrations is proven not to be technically and economically feasible, the lowest technically and economically feasible concentrations shall be achieved as the cleanup standards.

RESPONSE: The assertion that the point of compliance is the waste boundary is contrary to the promulgated regulations of Wisconsin. Since there has been no assertion of affirmative evidence that the landfill contents are RCRA hazardous, a design management zone (DMZ) of 0 feet is inapplicable. Rather, a DMZ of 300 feet, or the limit of property ownership, in accordance with WAC NR 140.22 - point of standards application would seem to be applicable. If a non-promulgated Department of Natural Resources (DNR) policy or guideline requires compliance at the waste boundary, it should be cited as a TBC; ARARs are reserved for promulgated standards.

It should be noted for the administrative record that there exists no evidence that the Preventative Action Limits (PAL) standards or even all the Enforcement Standards (ES) are technically attainable. In fact, the presiding definitive work on ground-water remediation (Kerr Research Lab in Ada, Oklahoma) has indicated that such standards cannot be achieved within the limits of existing technology.

General Comment

#2 It must be understood that all air emissions from both source control and ground-water control remedial measures must comply with the toxic air emissions criteria in ch. NR 445. Wis. Adm. Code. The technologies retained for air emission control must meet the mandated performance levels.

The Department's concurrence with any remedial action to be taken at the site will be based on compliance with ARARs. The performance criteria in ch. NR 140 and ch. NR 445, Wis. Adm. Code, are critical criteria to be used in evaluating the adequacy of any remedial measures.

RESPONSE: Comment noted; no response.

Page 11 On this page and in several other locations in the technical memo, the term "regulatory limits" is used. This term need to be specifically defined. For ground-water quality the regulatory limits are the preventive action limits contained in ch. NR 140, Wis. Adm. Code.

RESPONSE: Comment noted; no response.

Page 11 The regulatory concentrations that should be used to evaluate the significance of ground-water concentrations are preventive action limits - not enforcement standards. State ground-water law nets preventive action limits as the triggering levels for initiating response activities.

RESPONSE: Comment noted; no response.

Page 12 The Department does not have a record of a methylene chloride soil detect of 8.5 ug/kg (81.5) downslope from cell 6. Please provide the sample location and date for this result.

RESPONSE: The concentration of methlylene chloride was determined at 81.5 ug/kg from a soil sample collected downslope from cell 6. The sample (SD-7) was collected at location E400, N800 (grid reference). The organic constituents determined in surficial soil samples are provided in a summary table on page 33 of Technical Memorandum No. 3A, April 12, 1991.

Page 19 The conclusion that there is no landfill gas production and low gas pressures needs to be verified with field data. There have been past complaints from nearby residences about "smells" around Grass Lake. It seems possible these odors are landfill gas migrating towards the topographic low of Grass Lake.

RESPONSE: Data collected and evaluated to date are presented in section 4.1.1 of Technical Memorandum No. 3A. April 12, 1991. The data indicate that the occurrence and venting of volatile gases is minimum. WMWI concurs that additional data will be collected.

Odors are likely attributable to Bad Fish Creek. The discharge of which is predominantly effluent from the Madison sewage treatment plant (24 to 52 million gallons per day). PELA personnel, while reading staff gages and stream gaging, have noted malodorous effluvium at Bad Fish Creek. In addition, Grass Lake comprises a water body and swamp where generation and migration of natural organic gases can occur.

Page 20 In a practical sense, source control measures will likely reduce contaminant migration from the landfill - not completely preclude any transport.

RESPONSE: Comment noted; no response.

Page 21 This page provides a good summary of the status of the ground-water studies and the conclusions that can be reached to date. The Department would like to see a proposed timeline for completing the additional studies proposed at the bottom of the page.

RESPONSE: WMWI is currently considering technologies researched at other sites and will address treatability in detail in Technical Memorandum No. 9B and the Draft FS (GCOU).

Testing to determine aquifer characteristics and the area of influence from ground water withdrawal will be addressed in the Remedial Design (RD) Phase.

Page 24 This section on environmental monitoring correctly states that monitoring surface water and groundwater quality are used to assess the performance of the remedial action. The concept of monitoring needs to be expanded for both operable units to include a monitoring the performance of active source control alternatives and the active gas collection system. If a technology is chosen to actively remediate cells 6 and 12, such as vapor extraction, a monitoring program to assess the effectiveness of the remediation will be required. Monitoring source contaminant concentrations in the waste before, during, and after the remediation will be essential to evaluating system performance.

RESPONSE: Waste Management of Wisconsin, Inc. agrees that the concept of separate monitoring systems and objectives needs to be expanded further in the Feasibility Study (FS) documents, but only to the extent that the monitoring goals and data quality objectives are defined. The actual details of the monitoring program should be addressed in the remedial design (RD) phase.

Page 25-34 Section 5.4 provides a good general discussion of the various ground-water control, treatment and discharge options.

RESPONSE: Comment noted; no response.

Page 34-41 Section 6.0 provides a good general overview of the feasibility process for Superfund sites.

RESPONSE: Comment noted; no response.

Page 38 As stated in comments on the SCOU, ARARs are not frequently used standards, but rather are legally mandated requirements that must be met in designing and implementing remedial actions.

RESPONSE: Comment noted; no response.

Page 41-45 The Department agrees with the evaluation process discussed on these pages and summarized on Plate 1. The retained technologies are likely the most promising alternatives. However, it must be clear that the retained air emissions treatment technologies must be capable of meeting state air quality rules. ARARs for this process option, discussed in detail later, include air toxic substance emission controls. These requirements must be complied with.

RESPONSE: See responses to EPA comments B and C (pages 2 and 3 of this document).

Page 45-49 The department also agrees with the elimination process discussed on these pages and summarized on Plate 2. The remaining process options are believed to be the universe of practical alternatives available.

RESPONSE: Comment noted; no response.

The following table summarizes the Departments ARAR determination for the remedial measures proposed in this tech memo.

Table 1. ARAR DETERMINATION

Below are listed the ARARs as determined by the Department based on the various remedial options presented. The department may amend this list based on changes or additions to the list of remedial actions for this site.

Alternative	A or RA[1]	Code/Statute[2]	Preliminary Identification Standards/Requirements
1.	A	NR 140 s. 160	Ground-water standards and response requirements
	A	NR 141	Monitoring well requirements
	A	NR 149	Laboratory certification for environmental testing
	A	NR 181	If the extracted ground water exhibits a characteristic hazardous waste, the water and discharges are hazardous until the characteristic is no longer exhibited
	A	NR 105, 106	Toxic substance effluent surface water standards.
	A	s. 144.04	Waste-water plan review requirements.
	A	NR 445	Toxic air emissions control requirements.
2.			Same requirements as Alternative 1.
	A	NR 181	Spent carbon residues shall be treated as hazardous waste if the exhibit hazardous characteristics, unless regenerated.
3.			Same requirements as Alternative 2.
4.			Same requirements as Alternative 2.
5.			Same requirements as Alternative 2.
	A	NR 211	State waste-water pretreatment requirement for discharge to POTWs.
6.			Same requirements as Alternative 1.
	A	NR 112	Injection of material to the subsurface is regulated under water supply codes
7.			Same requirements as Alternative 2.
8.			Same requirements as Alternative 2.
9.			Same requirements as Alternative 1.

1 A or RA = Applicable (A) or potentially relevant and appropriate (RA).

2 Code = Wisconsin Administrative Code, Chapter NR series;
Statute = Wisconsin State Statutes

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
230 SOUTH DEARBORN ST.
CHICAGO, ILLINOIS 60604

REC 7/1(

mailed 7/17

JUL 15 1991

REPLY TO ATTENTION OF:
5HS-11

Mr. March Smith
Remedial Projects Manager
Waste Management of North America, Inc.
Midwest Region
Two Corporate Center, Suite 1000
P.O. Box 7070
Westchester, Illinois 60154

Re: City Disposal Corp. Landfill Technical Memorandum 9a.

Dear Mr. Smith:

The United States Environmental Protection Agency (U.S. EPA) has completed its review of Technical Memorandum 9a of the Remedial Investigation/Feasibility Study (RI/FS) for the City Disposal Corporation Landfill "Superfund" site. Technical Memorandum 9a is an analysis of alternatives for the Scource Control Operable Unit (SCOU) of this site.

U.S. EPA and Wisconsin Department of Natural Resources (WDNR) comments are presented in the enclosures. U.S. EPA and WDNR comments should be addressed in the SCOU Draft Feasibility Study Report.

If you have any questions concerning this letter and comments please telephone me at (312) 353-1331.

Sincerely,

Charles Wilk

Charles Wilk
Remedial Project Manager

cc: Mike Schmoller, WDNR
Bob Schoepke, M&E

U.S. EPA Comments
Technical Memorandum 9a

General Comments:

1. The SCOU Draft Feasibility Study Report should carry Alternative 1 (No-Action), Alternative V and Alternative VI through evaluation against the nine evaluation criteria. These Alternatives were selected because; (a) Alternative 1 is a No-Action alternative and required to be carried through as a baseline, and (b) Alternatives V and VI include active remediation of landfilled waste in Cells 6 and 12.

2. Although costs presented are included for discussion purposes only, costs presented for each alternative in Appendix C should be identical to costs presented for the same alternative in the text. Several discrepancies exist and should be corrected.

Specific Comments:

1. page 8, paragraph 2, Section 3.2.1.2, Cover A - Synthetic Cover

   Alternative V includes the use of Cover A. Cover A does not meet the Wisconsin Administrative Codes [NR 504.07 or NR 181.44(13)]. Cover A consists of a 1 - foot thick compacted clay layer. The code requires a 2 - foot clay layer. Alternative V may continue to be considered if the performance of the 1 - foot thick compacted clay layer can be further verified.

2. page 10, Table 1, Summary of Cost Effectiveness of the Capping Alternatives

   The U.S. EPA Hydraulic Evaluation of Landfill Performance (HELP) model should be used to estimate the infiltration rate for the current landfill covers. The infiltration rate for the current conditions would serve as a comparison between proposed covers and existing conditions. If it were to be determined that a proposed cover provides no more protection than the current cover, then this would be a basis for eliminating the proposed cover.

3. page 13, paragraph 2, Section 3.2.5.1, Purpose

Further discussion detailing the landfill gas extraction system monitoring program should be included. For example, sampling intervals, duration of sampling, contaminants to be sampled and the permissible limits. The cost should be calculated and added to all alternatives using the monitoring program

4. page 26, paragraph 1, Section 5.1.1, Description

The text states that pulsed extraction of the landfill gas may be effective for approximately two years. Further explanation and/or calculations substantiating this estimate should be included within the document.

5. page 26, paragraph 2, Section 5.1.1, Description

The first sentences states that runoff from the landfill drains into nearby ponds or streams. This statements is partially incorrect. Runoff may drain into Badfish Creek but may not drain into nearby ponds. This statement should be corrected.

6. page 29, paragraph 2, Section 5.1.5.2, Amount of Hazardous Materials Destroyed or Treated

The operational life of the active landfill gas extraction and combustion system should be indicated.

7. page 37, paragraph 4, Section 5.2.6.1, Risks to community During Remedial Action

Further explanation/details regarding air contaminant monitoring at the site boundary should be included. The duration/intervals of monitoring should be stated.

8. page 40, Section 5.3, Alternative III

Alternative III is incorrectly labelled as Alternative II. This should be corrected.

9. page 49, paragraph 1, Section 5.4.8.1, Capital Costs

The installation costs for Cover B are presented in the capital cost estimate for Alternative IV. This alternative actually stipulates use of the combination Cover B/C. This typographical error should be corrected.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
230 SOUTH DEARBORN STREET
CHICAGO, IL 60604

DATE RECEIVED/SENT
BY: MARCH SMITH
SITE City Disposal
REPLY TO THE ATTENTION OF:
CC/ROUTE:
PK, DP, WS, HK, GH, GM, DO, DS-RO, AS
FILE SYSTEM: PROJECT/SITE
FILE CODE: 2.1.2.3.6.MS/MSW/ATTACH
W/O ATTACH

AUG 22 1991

Mr. March Smith
Remedial Projects Manager
Waste Management of North America, Inc.
Midwest Region
Two Corporate Center, Suite 1000
P.O. Box 7070
Westchester, Illinois 60154

Re: City Disposal Corp. Landfill Project Schedule

Dear Mr. Smith:

Based on our recent telephone discussions concerning the conduct and schedule of the Remedial Investigation (RI) and Feasibility Study (FS) for the City Disposal Corporation Landfill in Wisconsin the following agreements have been made. The operable unit approach for this project will be replaced with a final site remedy approach. Therefore, the RI Report and the FS Report shall investigate all releases at the site and evaluate remedial technologies to address the entire site.

The schedule for deliverables to the U.S. EPA is as follows:

Draft RI Report	September 12, 1991
Final RI Report	30 days after U.S. EPA comments on Draft RI Report
Draft FS Report	November 1, 1991
Final FS Report	30 days after U.S. EPA comments on Draft FS Report

If your understanding of the agreed schedule is different than the one above, please telephone me immediately at (312) 353-1331.

Sincerely,

Charles Wilk
Remedial Project Manager

cc: Mike Schmoller, WDNR
Bob Schoepke, M&E

PELA

Response to Comments on Technical Memorandum No. 9A Analysis of Alternatives (SCOU) for the City Disposal Corporation Landfill (DUNN) Landfill

PELA 495210 **October 31, 1991**

U.S. Environmental Projection Agency
Charles Wilk
Remedial Project Manager
July 15, 1991

U.S. EPA Comments

General Comments

1. The SCOU draft Feasibility Study Report should carry Alternative 1 (No-Action), Alternative V and Alternative VI through evaluation against the nine evaluation criteria. These Alternatives were selected because: (a) Alternative 1 is a No-Action alternative and required to be carried through as a baseline, and (b) Alternatives V and VI include active remediation of landfilled waste in Cells 6 and 12.

RESPONSE: Comment acknowledged.

2. Although costs presented are included for discussion purposes only, costs presented for each alternative in Appendix C should be identical to costs presented for the same alternative in the text. Several discrepancies exist and should be corrected.

RESPONSE: The costs and backup data (in the appendix) will be consistent in the Draft Feasibility Study (FS).

Specific Comments

Page 8 Paragraph 2, Section 3.2.1.1, Cover A - Synthetic Cover.
Alternative V includes the use of Cover A. Cover A does not meet the Wisconsin Administrative Codes [NR 504.07 or NR 181.44(13)]. Cover A consists of a 1-foot thick compacted clay layer. The code required a 2-foot clay layer. Alternative V may continue to be considered if the performance of the 1-foot thick compacted clay layer can be further verified.

RESPONSE: Although Cover A does not meet the minimum requirements of clay thickness for RCRA Subtitle D (NR 504.07) or RCRA Subtitle C, the cover may be as effective as the other covers options because of the efficiency of the synthetic cover. As shown in Table 1 (Tech Memo 9A), Cover A is very effective in reducing infiltration to about 1000 cubic feet per year and is virtually equivalent to Cover C in terms of infiltration reduction.

Page 10 Table 1, Summary of Cost Effectiveness of the Capping Alternatives.
The U.S. EPA Hydraulic Evaluation of Landfill Performance (HELP) model should be used to estimate the infiltration rate for the current landfill covers. The infiltration rate for the current conditions would serve as a comparison between proposed covers and existing conditions. If it were to be determined that a proposed cover provides no more protection than the current cover, then this would be a basis for eliminating the proposed cover.

RESPONSE: Due to the fact that the existing cover thickness and consistency varies across the site, it is difficult to determine a precise value of current infiltration through the cover. Using extreme cases, the infiltration may vary between 92,000 to 532,000 cubic feet per year. An average value may be 460,000 cubic feet per year (Table to follow).

Page 13 Paragraph 2, Section 3.2.5.1, Purpose.
Further discussion detailing the landfill gas extraction system monitoring program should be included. For example, sampling intervals, duration of sampling, contaminants to be sampled and the permissible limits. The cost should be calculated and added to all alternatives using the monitoring program.

RESPONSE: Additional details regarding landfill gas extraction system monitoring will be included in the draft FS. (see Section 5.2.5.1, 3rd paragraph)

Page 26 Paragraph 1, Section 5.1.1, Description.
The text states that pulsed extraction of the landfill gas may be effective for approximately two years. Further explanation and/or calculations substantiating this estimate should be included within the document.

RESPONSE: The two year estimate was used because it will take approximately two years for the combined effects of the cover system and extraction system to dry the waste enough to reduce or hinder methane generation. Further explanation of a two-year demonstration will be provided in the draft FS. (see Section 7.2.6.4)

Page 26 Paragraph 2, Section 5.1.1, Description.
The first sentence states that runoff from the landfill drains into nearby ponds or streams. This statement is partially incorrect. Runoff may drain into Badfish Creek but may not drain into nearby ponds. This statement should be corrected.

RESPONSE: The draft FS will not refer to ponds in Section 7.1.1.

PELA

APPENDIX B

Water Balance Calculations for Landfill Cover Alternatives
(61 Pages)

1. Effectiveness of Capping Alternatives

2. Dunn Landfill Final Cover Design, Revised Cover "A" 3% Slope
   - Poor Construction QA, 1/7/92
   - Average Construction QA, 1/24/92
   - Excellent Construction QA, 1/11/92

3. Dunn Landfill Final Cover Design, Revised Cover "A" 9% Slope
   - Poor Construction QA, 1/24/92
   - Average Construction QA, 1/24/92
   - Excellent Construction QA, 1/24/92

4. Dunn Landfill Final Cover Design, Cover "B" 5% Slope, 1/20/92

5. Dunn Landfill Final Cover Design, Cover "B" 9% Slope, 1/24/92

6. Dunn Landfill Final Cover Design, Revised Cover "C" 3% Slope (For Use in Evaluation of Cover "B/C")
   - Poor Construction QA, 1/24/92
   - Average Construction QA, 1/24/92
   - Excellent Construction QA, 1/24/92

7. Dunn Landfill Final Cover Design, Revised Cover "C" 9% Slope (For Use in Evaluation of Cover "B/C")
   - Poor Construction QA, 1/24/92
   - Average Construction QA, 1/24/92
   - Excellent Construction QA, 1/24/92

8. Determination of Leakage Factor, 12/30/92

(WP5.1 3/19/92) 14D:M95200\CDCL-FSR.APP

EFFECTIVENESS OF CAPPING ALTERNATIVES

Cover	Construction QA	Estimated Infiltration Rate (Cubic Feet per Year)	Percent Reduction	Cover Total Present Worth ($)
Existing	N/A	460,000	--	--
A A A	Poor*1 Average*2 Excellent*3	34,900 988 22	92.4 99.8 99.99	2,733,000
B	N/A	111,100	75.8	2,753,000
B/C B/C B/C	Poor*1 Average*2 Excellent*3	91,100 91,100 91,100	80.2 80.2 80.2	2,434,000

Assumptions:

<u>Water Balance</u>

Maximum/Minimum Slopes of 9%/5% to 3% were used.

<u>Cost Analysis</u>

Landfill total acreage assumed to be 24.2, and 4.4 acres for Cells 6 and 12.

1/ Source control cost only. Does not include Groundwater Control costs.

*1 Poor QA assumed in HELP Model - Leakage Factor assumed to be 0.01.

*2 Average QA assumed in HELP Model - Leakage Factor assumed to be 0.00025.

*3 Excellent QA assumed in HELP Model - Leakage Factor assumed to be 0.00001.

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***********************************************************************
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 DUNN LANDFILL FINAL COVER DESIGN
 REVISED COVER "A" 3% SLOPE
 JANUARY 7, 1992     :J. BLAYNE KIRSCH

 POOR GEOMEMBRANE QA = 0.01 VALUE

***********************************************************************
***********************************************************************


                            FAIR GRASS


                             LAYER  1
                             --------
                     VERTICAL PERCOLATION LAYER
   THICKNESS                              =       6.00 INCHES
   POROSITY                               =       0.4530 VOL/VOL
   FIELD CAPACITY                         =       0.1901 VOL/VOL
   WILTING POINT                          =       0.0848 VOL/VOL
   INITIAL SOIL WATER CONTENT             =       0.1901 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY       =       0.002160000149 CM/SEC

                             LAYER  2
                             --------
                     VERTICAL PERCOLATION LAYER
   THICKNESS                              =      18.00 INCHES
   POROSITY                               =       0.4370 VOL/VOL
   FIELD CAPACITY                         =       0.1053 VOL/VOL
   WILTING POINT                          =       0.0466 VOL/VOL
   INITIAL SOIL WATER CONTENT             =       0.1053 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY       =       0.001700000023 CM/SEC

                              LAYER  3
                              --------
                       LATERAL DRAINAGE LAYER
   THICKNESS                              =      12.00 INCHES
   POROSITY                               =       0.4170 VOL/VOL
   FIELD CAPACITY                         =       0.0454 VOL/VOL
   WILTING POINT                          =       0.0200 VOL/VOL
   INITIAL SOIL WATER CONTENT             =       0.0454 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY       =       0.010000000708 CM/SEC
   SLOPE                                  =       3.00 PERCENT
   DRAINAGE LENGTH                        =     250.0 FEET
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LAYER 4

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3949 VOL/VOL
FIELD CAPACITY	=	0.2797 VOL/VOL
WILTING POINT	=	0.1875 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3949 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000003200000 CM/SEC
LINER LEAKAGE FRACTION	=	0.01000000

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.71
TOTAL AREA OF COVER	=	1055000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.8360 INCHES
INITIAL VEG. STORAGE	=	2.6148 INCHES
INITIAL SNOW WATER CONTENT	=	0.7586 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	8.3196 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR MADISON WISCONSIN

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	135
END OF GROWING SEASON (JULIAN DATE)	=	273

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
15.60	20.50	31.20	45.80	57.00	66.30
70.60	68.50	60.10	49.50	35.10	22.40

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.83	0.96	1.98	3.01	2.77	4.46
	3.34	3.48	3.24	2.43	1.91	1.46
STD. DEVIATIONS	0.35	0.50	0.97	1.29	1.02	1.92
	1.78	1.66	1.94	1.30	1.13	0.68
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.003	0.003	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.012	0.011	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.485	0.885	1.926	2.712	2.986	4.477
	3.669	3.303	2.334	1.766	1.014	0.512
STD. DEVIATIONS	0.101	0.287	0.549	0.747	0.837	1.156
	1.309	1.462	0.817	0.794	0.331	0.130
LATERAL DRAINAGE FROM LAYER 3						
TOTALS	0.2858	0.2645	0.3184	0.3555	0.3518	0.2902
	0.2909	0.2292	0.1716	0.2034	0.2187	0.2758
STD. DEVIATIONS	0.2399	0.2182	0.2029	0.2040	0.1830	0.1532
	0.1852	0.1664	0.1373	0.2431	0.2531	0.2406
PERCOLATION FROM LAYER 4						
TOTALS	0.0361	0.0327	0.0382	0.0406	0.0420	0.0392
	0.0404	0.0386	0.0355	0.0342	0.0320	0.0371
STD. DEVIATIONS	0.0149	0.0136	0.0128	0.0074	0.0056	0.0045
	0.0053	0.0045	0.0042	0.0121	0.0146	0.0123

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	29.88	(3.978)	2626598.	100.00
RUNOFF	0.005	(0.023)	458.	0.02
EVAPOTRANSPIRATION	26.068	(3.248)	2291851.	87.26
LATERAL DRAINAGE FROM LAYER 3	3.2558	(1.9322)	286240.	10.90
PERCOLATION FROM LAYER 4	0.4465	(0.0925)	39256.	1.49
CHANGE IN WATER STORAGE	0.100	(1.970)	8793.	0.33

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	3.19	280454.2
RUNOFF	0.053	4619.3
LATERAL DRAINAGE FROM LAYER 3	0.0326	2869.7
PERCOLATION FROM LAYER 4	0.0020	176.8
HEAD ON LAYER 4	10.2	
SNOW WATER	2.36	207108.9

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2646

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0577

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.20	0.1992
2	3.54	0.1968
3	1.60	0.1336
4	4.74	0.3949
SNOW WATER	0.00	

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DUNN LANDFILL FINAL COVER DESIGN
COVER "A" @ 3% SLOPES WITH AVERAGE QA = 0.00025
J. BLAYNE KIRSCH : JANUARY 24, 1992

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.4530 VOL/VOL
FIELD CAPACITY	=	0.1901 VOL/VOL
WILTING POINT	=	0.0848 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1901 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.002160000149 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	18.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.1053 VOL/VOL
WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1053 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.001700000023 CM/SEC

LAYER 3

LATERAL DRAINAGE LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0454 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.010000000708 CM/SEC
SLOPE	=	3.00 PERCENT
DRAINAGE LENGTH	=	250.0 FEET

LAYER 4

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3949 VOL/VOL
FIELD CAPACITY	=	0.2797 VOL/VOL
WILTING POINT	=	0.1875 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3949 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000003200000 CM/SEC
LINER LEAKAGE FRACTION	=	0.00025000

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.71
TOTAL AREA OF COVER	=	1055000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.8360 INCHES
INITIAL VEG. STORAGE	=	2.6148 INCHES
INITIAL SNOW WATER CONTENT	=	0.7586 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	8.3196 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR MADISON WISCONSIN

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	135
END OF GROWING SEASON (JULIAN DATE)	=	273

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
15.60	20.50	31.20	45.80	57.00	66.30
70.60	68.50	60.10	49.50	35.10	22.40

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.83	0.96	1.98	3.01	2.77	4.46
	3.34	3.48	3.24	2.43	1.91	1.46
STD. DEVIATIONS	0.35	0.50	0.97	1.29	1.02	1.92
	1.78	1.66	1.94	1.30	1.13	0.68
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.003	0.003	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.012	0.011	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.485	0.885	1.926	2.712	2.986	4.477
	3.669	3.303	2.334	1.766	1.014	0.512
STD. DEVIATIONS	0.101	0.287	0.549	0.747	0.837	1.156
	1.309	1.462	0.817	0.794	0.331	0.130
LATERAL DRAINAGE FROM LAYER 3						
TOTALS	0.3166	0.2958	0.3499	0.3845	0.3847	0.3265
	0.3292	0.2707	0.2123	0.2462	0.2544	0.3106
STD. DEVIATIONS	0.2442	0.2214	0.2099	0.2124	0.1902	0.1558
	0.1865	0.1664	0.1369	0.2440	0.2579	0.2437
PERCOLATION FROM LAYER 4						
TOTALS	0.0010	0.0009	0.0011	0.0011	0.0011	0.0010
	0.0010	0.0010	0.0009	0.0010	0.0010	0.0010
STD. DEVIATIONS	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001
	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	29.88	(3.978)	2626598.	100.00
RUNOFF	0.005	(0.023)	458.	0.02
EVAPOTRANSPIRATION	26.068	(3.248)	2291851.	87.26
LATERAL DRAINAGE FROM LAYER 3	3.6814	(1.9946)	323660.	12.32
PERCOLATION FROM LAYER 4	0.0121	(0.0014)	1063.	0.04
CHANGE IN WATER STORAGE	0.109	(1.973)	9566.	0.36

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	3.19	280454.2
RUNOFF	0.053	4619.3
LATERAL DRAINAGE FROM LAYER 3	0.0341	2995.4
PERCOLATION FROM LAYER 4	0.0001	4.5
HEAD ON LAYER 4	10.6	
SNOW WATER	2.36	207108.9
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2646	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0577	

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.20	0.1992
2	3.54	0.1968
3	1.78	0.1482
4	4.74	0.3949
SNOW WATER	0.00	

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 DUNN LANDFILL FINAL COVER DESIGN
 COVER "A" 3% SLOPE WITH EXCELLENT QA WITH A VALUE OF 0.00001
 J. BLAYNE KIRSCH : JANUARY 11, 1992

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                               FAIR GRASS

                                LAYER  1
                                --------

                        VERTICAL PERCOLATION LAYER
   THICKNESS                                 =      6.00 INCHES
   POROSITY                                  =      0.4530 VOL/VOL
   FIELD CAPACITY                            =      0.1901 VOL/VOL
   WILTING POINT                             =      0.0848 VOL/VOL
   INITIAL SOIL WATER CONTENT                =      0.1901 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY          =      0.002160000149 CM/SEC

                                LAYER  2
                                --------

                        VERTICAL PERCOLATION LAYER
   THICKNESS                                 =     18.00 INCHES
   POROSITY                                  =      0.4370 VOL/VOL
   FIELD CAPACITY                            =      0.1053 VOL/VOL
   WILTING POINT                             =      0.0466 VOL/VOL
   INITIAL SOIL WATER CONTENT                =      0.1053 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY          =      0.001700000023 CM/SEC

                                LAYER  3
                                --------

                          LATERAL DRAINAGE LAYER
   THICKNESS                                 =     12.00 INCHES
   POROSITY                                  =      0.4170 VOL/VOL
   FIELD CAPACITY                            =      0.0454 VOL/VOL
   WILTING POINT                             =      0.0200 VOL/VOL
   INITIAL SOIL WATER CONTENT                =      0.0454 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY          =      0.010000000708 CM/SEC
   SLOPE                                     =      3.00 PERCENT
   DRAINAGE LENGTH                           =    250.0 FEET
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LAYER 4

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3949 VOL/VOL
FIELD CAPACITY	=	0.2797 VOL/VOL
WILTING POINT	=	0.1875 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3949 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000003200000 CM/SEC
LINER LEAKAGE FRACTION	=	0.00001000

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.71
TOTAL AREA OF COVER	=	1055000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.8360 INCHES
INITIAL VEG. STORAGE	=	2.6148 INCHES
INITIAL SNOW WATER CONTENT	=	0.7586 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	8.3196 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR MADISON WISCONSIN

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	135
END OF GROWING SEASON (JULIAN DATE)	=	273

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
15.60	20.50	31.20	45.80	57.00	66.30
70.60	68.50	60.10	49.50	35.10	22.40

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.83	0.96	1.98	3.01	2.77	4.46
	3.34	3.48	3.24	2.43	1.91	1.46
STD. DEVIATIONS	0.35	0.50	0.97	1.29	1.02	1.92
	1.78	1.66	1.94	1.30	1.13	0.68
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.003	0.003	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.012	0.011	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.485	0.885	1.926	2.712	2.986	4.477
	3.669	3.303	2.334	1.766	1.014	0.512
STD. DEVIATIONS	0.101	0.287	0.549	0.747	0.837	1.156
	1.309	1.462	0.817	0.794	0.331	0.130
LATERAL DRAINAGE FROM LAYER 3						
TOTALS	0.3175	0.2966	0.3508	0.3853	0.3856	0.3275
	0.3301	0.2718	0.2133	0.2473	0.2554	0.3116
STD. DEVIATIONS	0.2442	0.2215	0.2100	0.2125	0.1903	0.1559
	0.1865	0.1664	0.1369	0.2440	0.2580	0.2438
PERCOLATION FROM LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	29.88	(3.978)	2626598.	100.00
RUNOFF	0.005	(0.023)	458.	0.02
EVAPOTRANSPIRATION	26.068	(3.248)	2291851.	87.26
LATERAL DRAINAGE FROM LAYER 3	3.6928	(1.9954)	324661.	12.36
PERCOLATION FROM LAYER 4	0.0005	(0.0001)	43.	0.00
CHANGE IN WATER STORAGE	0.109	(1.973)	9586.	0.36

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	3.19	280454.2
RUNOFF	0.053	4619.3
LATERAL DRAINAGE FROM LAYER 3	0.0341	2998.7
PERCOLATION FROM LAYER 4	0.0000	0.2
HEAD ON LAYER 4	10.6	
SNOW WATER	2.36	207108.9
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2646	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0577	

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.20	0.1992
2	3.54	0.1968
3	1.78	0.1486
4	4.74	0.3949
SNOW WATER	0.00	

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 DUNN LANDFILL FINAL COVER DESIGN
 COVER "A" @ 9% SLOPES WITH POOR QA = 0.01
 J. BLAYNE KIRSCH : JANUARY 24, 1992

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                              FAIR GRASS

                               LAYER  1
                               --------

                      VERTICAL PERCOLATION LAYER
   THICKNESS                            =       6.00 INCHES
   POROSITY                             =       0.4530 VOL/VOL
   FIELD CAPACITY                       =       0.1901 VOL/VOL
   WILTING POINT                        =       0.0848 VOL/VOL
   INITIAL SOIL WATER CONTENT           =       0.1901 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY     =       0.002160000149 CM/SEC


                               LAYER  2
                               --------

                      VERTICAL PERCOLATION LAYER
   THICKNESS                            =      18.00 INCHES
   POROSITY                             =       0.4370 VOL/VOL
   FIELD CAPACITY                       =       0.1053 VOL/VOL
   WILTING POINT                        =       0.0466 VOL/VOL
   INITIAL SOIL WATER CONTENT           =       0.1053 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY     =       0.001700000023 CM/SEC


                               LAYER  3
                               --------

                        LATERAL DRAINAGE LAYER
   THICKNESS                            =      12.00 INCHES
   POROSITY                             =       0.4170 VOL/VOL
   FIELD CAPACITY                       =       0.0454 VOL/VOL
   WILTING POINT                        =       0.0200 VOL/VOL
   INITIAL SOIL WATER CONTENT           =       0.0454 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY     =       0.010000000708 CM/SEC
   SLOPE                                =       9.00 PERCENT
   DRAINAGE LENGTH                      =     250.0 FEET
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LAYER 4

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3949 VOL/VOL
FIELD CAPACITY	=	0.2797 VOL/VOL
WILTING POINT	=	0.1875 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3949 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000003200000 CM/SEC
LINER LEAKAGE FRACTION	=	0.01000000

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.71
TOTAL AREA OF COVER	=	1055000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.8360 INCHES
INITIAL VEG. STORAGE	=	2.6148 INCHES
INITIAL SNOW WATER CONTENT	=	0.7586 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	8.3196 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR MADISON WISCONSIN

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	135
END OF GROWING SEASON (JULIAN DATE)	=	273

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
15.60	20.50	31.20	45.80	57.00	66.30
70.60	68.50	60.10	49.50	35.10	22.40

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.83	0.96	1.98	3.01	2.77	4.46
	3.34	3.48	3.24	2.43	1.91	1.46
STD. DEVIATIONS	0.35	0.50	0.97	1.29	1.02	1.92
	1.78	1.66	1.94	1.30	1.13	0.68
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.003	0.003	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.012	0.011	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.485	0.885	1.926	2.712	2.986	4.477
	3.669	3.303	2.334	1.766	1.014	0.512
STD. DEVIATIONS	0.101	0.287	0.549	0.747	0.837	1.156
	1.309	1.462	0.817	0.794	0.331	0.130
LATERAL DRAINAGE FROM LAYER 3						
TOTALS	0.3574	0.3000	0.4272	0.4598	0.2948	0.1581
	0.2545	0.0662	0.0467	0.3133	0.3007	0.4061
STD. DEVIATIONS	0.4050	0.3650	0.3990	0.3913	0.2596	0.1368
	0.4358	0.1239	0.0910	0.7684	0.4407	0.4596
PERCOLATION FROM LAYER 4						
TOTALS	0.0285	0.0265	0.0320	0.0341	0.0351	0.0333
	0.0347	0.0284	0.0215	0.0219	0.0226	0.0285
STD. DEVIATIONS	0.0126	0.0112	0.0098	0.0036	0.0012	0.0008
	0.0022	0.0063	0.0089	0.0116	0.0124	0.0119

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	29.88	(3.978)	2626598.	100.00
RUNOFF	0.005	(0.023)	458.	0.02
EVAPOTRANSPIRATION	26.068	(3.248)	2291851.	87.26
LATERAL DRAINAGE FROM LAYER 3	3.3848	(2.2047)	297581.	11.33
PERCOLATION FROM LAYER 4	0.3471	(0.0635)	30516.	1.16
CHANGE IN WATER STORAGE	0.070	(1.599)	6192.	0.24

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	3.19	280454.2
RUNOFF	0.053	4619.3
LATERAL DRAINAGE FROM LAYER 3	0.1168	10268.3
PERCOLATION FROM LAYER 4	0.0016	141.7
HEAD ON LAYER 4	5.8	
SNOW WATER	2.36	207108.9

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2646

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0577

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.20	0.1992
2	3.54	0.1968
3	1.01	0.0843
4	4.74	0.3949
SNOW WATER	0.00	

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 DUNN LANDFILL FINAL COVER DESIGN
 COVER "A" @ 9% SLOPES WITH AVERAGE QA = 0.00025
 J. BLAYNE KIRSCH : JANUARY 24, 1992

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                          FAIR GRASS

                           LAYER  1
                           --------

                  VERTICAL PERCOLATION LAYER
   THICKNESS                          =      6.00 INCHES
   POROSITY                           =      0.4530 VOL/VOL
   FIELD CAPACITY                     =      0.1901 VOL/VOL
   WILTING POINT                      =      0.0848 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.1901 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.002160000149 CM/SEC


                           LAYER  2
                           --------

                  VERTICAL PERCOLATION LAYER
   THICKNESS                          =     18.00 INCHES
   POROSITY                           =      0.4370 VOL/VOL
   FIELD CAPACITY                     =      0.1053 VOL/VOL
   WILTING POINT                      =      0.0466 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.1053 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.001700000023 CM/SEC


                           LAYER  3
                           --------

                    LATERAL DRAINAGE LAYER
   THICKNESS                          =     12.00 INCHES
   POROSITY                           =      0.4170 VOL/VOL
   FIELD CAPACITY                     =      0.0454 VOL/VOL
   WILTING POINT                      =      0.0200 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.0454 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.01000000708 CM/SEC
   SLOPE                              =      9.00 PERCENT
   DRAINAGE LENGTH                    =    250.0 FEET
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LAYER 4

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3949 VOL/VOL
FIELD CAPACITY	=	0.2797 VOL/VOL
WILTING POINT	=	0.1875 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3949 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000003200000 CM/SEC
LINER LEAKAGE FRACTION	=	0.00025000

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.71
TOTAL AREA OF COVER	=	1055000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.8360 INCHES
INITIAL VEG. STORAGE	=	2.6148 INCHES
INITIAL SNOW WATER CONTENT	=	0.7586 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	8.3196 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR MADISON WISCONSIN

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	135
END OF GROWING SEASON (JULIAN DATE)	=	273

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
15.60	20.50	31.20	45.80	57.00	66.30
70.60	68.50	60.10	49.50	35.10	22.40

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.83	0.96	1.98	3.01	2.77	4.46
	3.34	3.48	3.24	2.43	1.91	1.46
STD. DEVIATIONS	0.35	0.50	0.97	1.29	1.02	1.92
	1.78	1.66	1.94	1.30	1.13	0.68
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.003	0.003	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.012	0.011	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.485	0.885	1.926	2.712	2.986	4.477
	3.669	3.303	2.334	1.766	1.014	0.512
STD. DEVIATIONS	0.101	0.287	0.549	0.747	0.837	1.156
	1.309	1.462	0.817	0.794	0.331	0.130
LATERAL DRAINAGE FROM LAYER 3						
TOTALS	0.3838	0.3252	0.4565	0.4914	0.3290	0.1907
	0.2884	0.0973	0.0704	0.3350	0.3218	0.4310
STD. DEVIATIONS	0.4129	0.3714	0.4027	0.3949	0.2609	0.1373
	0.4371	0.1263	0.0945	0.7750	0.4480	0.4659
PERCOLATION FROM LAYER 4						
TOTALS	0.0009	0.0008	0.0009	0.0009	0.0009	0.0008
	0.0009	0.0009	0.0008	0.0009	0.0009	0.0009
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	29.88	(3.978)	2626598.	100.00
RUNOFF	0.005	(0.023)	458.	0.02
EVAPOTRANSPIRATION	26.068	(3.248)	2291851.	87.26
LATERAL DRAINAGE FROM LAYER 3	3.7205	(2.2583)	327097.	12.45
PERCOLATION FROM LAYER 4	0.0104	(0.0003)	910.	0.03
CHANGE IN WATER STORAGE	0.071	(1.604)	6282.	0.24

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	3.19	280454.2
RUNOFF	0.053	4619.3
LATERAL DRAINAGE FROM LAYER 3	0.1181	10379.5
PERCOLATION FROM LAYER 4	0.0000	3.6
HEAD ON LAYER 4	5.8	
SNOW WATER	2.36	207108.9

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2646

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0577

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.20	0.1992
2	3.54	0.1968
3	1.03	0.0860
4	4.74	0.3949
SNOW WATER	0.00	

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   DUNN LANDFILL FINAL COVER DESIGN
   COVER "A" @ 9% SLOPES WITH EXCELLENT QA = 0.00001
   J. BLAYNE KIRSCH : JANUARY 24, 1992

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                              FAIR GRASS

                               LAYER  1
                               --------

                      VERTICAL PERCOLATION LAYER
    THICKNESS                              =      6.00 INCHES
    POROSITY                               =      0.4530 VOL/VOL
    FIELD CAPACITY                         =      0.1901 VOL/VOL
    WILTING POINT                          =      0.0848 VOL/VOL
    INITIAL SOIL WATER CONTENT             =      0.1901 VOL/VOL
    SATURATED HYDRAULIC CONDUCTIVITY       =      0.002160000149 CM/SEC


                               LAYER  2
                               --------

                      VERTICAL PERCOLATION LAYER
    THICKNESS                              =     18.00 INCHES
    POROSITY                               =      0.4370 VOL/VOL
    FIELD CAPACITY                         =      0.1053 VOL/VOL
    WILTING POINT                          =      0.0466 VOL/VOL
    INITIAL SOIL WATER CONTENT             =      0.1053 VOL/VOL
    SATURATED HYDRAULIC CONDUCTIVITY       =      0.001700000023 CM/SEC


                               LAYER  3
                               --------

                        LATERAL DRAINAGE LAYER
    THICKNESS                              =     12.00 INCHES
    POROSITY                               =      0.4170 VOL/VOL
    FIELD CAPACITY                         =      0.0454 VOL/VOL
    WILTING POINT                          =      0.0200 VOL/VOL
    INITIAL SOIL WATER CONTENT             =      0.0454 VOL/VOL
    SATURATED HYDRAULIC CONDUCTIVITY       =      0.010000000708 CM/SEC
    SLOPE                                  =      9.00 PERCENT
    DRAINAGE LENGTH                        =    250.0 FEET
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LAYER 4

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3949 VOL/VOL
FIELD CAPACITY	=	0.2797 VOL/VOL
WILTING POINT	=	0.1875 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3949 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000003200000 CM/SEC
LINER LEAKAGE FRACTION	=	0.00001000

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.71
TOTAL AREA OF COVER	=	1055000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.8360 INCHES
INITIAL VEG. STORAGE	=	2.6148 INCHES
INITIAL SNOW WATER CONTENT	=	0.7586 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	8.3196 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR MADISON WISCONSIN

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	135
END OF GROWING SEASON (JULIAN DATE)	=	273

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
15.60	20.50	31.20	45.80	57.00	66.30
70.60	68.50	60.10	49.50	35.10	22.40

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.83	0.96	1.98	3.01	2.77	4.46
	3.34	3.48	3.24	2.43	1.91	1.46
STD. DEVIATIONS	0.35	0.50	0.97	1.29	1.02	1.92
	1.78	1.66	1.94	1.30	1.13	0.68
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.003	0.003	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.012	0.011	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.485	0.885	1.926	2.712	2.986	4.477
	3.669	3.303	2.334	1.766	1.014	0.512
STD. DEVIATIONS	0.101	0.287	0.549	0.747	0.837	1.156
	1.309	1.462	0.817	0.794	0.331	0.130
LATERAL DRAINAGE FROM LAYER 3						
TOTALS	0.3846	0.3260	0.4574	0.4922	0.3298	0.1916
	0.2892	0.0982	0.0712	0.3358	0.3226	0.4319
STD. DEVIATIONS	0.4129	0.3714	0.4027	0.3949	0.2609	0.1373
	0.4371	0.1263	0.0945	0.7750	0.4480	0.4659
PERCOLATION FROM LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	29.88	(3.978)	2626598.	100.00
RUNOFF	0.005	(0.023)	458.	0.02
EVAPOTRANSPIRATION	26.068	(3.248)	2291851.	87.26
LATERAL DRAINAGE FROM LAYER 3	3.7305	(2.2586)	327969.	12.49
PERCOLATION FROM LAYER 4	0.0004	(0.0000)	36.	0.00
CHANGE IN WATER STORAGE	0.071	(1.604)	6284.	0.24

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	3.19	280454.2
RUNOFF	0.053	4619.3
LATERAL DRAINAGE FROM LAYER 3	0.1181	10382.3
PERCOLATION FROM LAYER 4	0.0000	0.1
HEAD ON LAYER 4	5.8	
SNOW WATER	2.36	207108.9

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2646

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0577

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.20	0.1992
2	3.54	0.1968
3	1.03	0.0860
4	4.74	0.3949
SNOW WATER	0.00	

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 DUNN LANDFILL FINAL COVER DESIGN
 COVER "B" AT 5% SLOPES
 J. BLAYNE KIRSCH : JANUARY 20, 1992

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                              FAIR GRASS


                               LAYER  1
                               --------

                      VERTICAL PERCOLATION LAYER
   THICKNESS                               =       6.00 INCHES
   POROSITY                                =       0.4530 VOL/VOL
   FIELD CAPACITY                          =       0.1901 VOL/VOL
   WILTING POINT                           =       0.0848 VOL/VOL
   INITIAL SOIL WATER CONTENT              =       0.1901 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY        =       0.002160000149 CM/SEC


                               LAYER  2
                               --------

                        LATERAL DRAINAGE LAYER
   THICKNESS                               =      18.00 INCHES
   POROSITY                                =       0.4370 VOL/VOL
   FIELD CAPACITY                          =       0.1053 VOL/VOL
   WILTING POINT                           =       0.0466 VOL/VOL
   INITIAL SOIL WATER CONTENT              =       0.1053 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY        =       0.001700000023 CM/SEC
   SLOPE                                   =       5.00 PERCENT
   DRAINAGE LENGTH                         =     250.0 FEET


                               LAYER  3
                               --------

                          BARRIER SOIL LINER
   THICKNESS                               =      24.00 INCHES
   POROSITY                                =       0.4300 VOL/VOL
   FIELD CAPACITY                          =       0.3663 VOL/VOL
   WILTING POINT                           =       0.2802 VOL/VOL
   INITIAL SOIL WATER CONTENT              =       0.4300 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY        =       0.000000100000 CM/SEC
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GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.71
TOTAL AREA OF COVER	=	1055000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.8360 INCHES
INITIAL VEG. STORAGE	=	3.5711 INCHES
INITIAL SNOW WATER CONTENT	=	0.7586 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	13.3560 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR MADISON WISCONSIN

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	135
END OF GROWING SEASON (JULIAN DATE)	=	273

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
15.60	20.50	31.20	45.80	57.00	66.30
70.60	68.50	60.10	49.50	35.10	22.40

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.83	0.96	1.98	3.01	2.77	4.46
	3.34	3.48	3.24	2.43	1.91	1.46
STD. DEVIATIONS	0.35	0.50	0.97	1.29	1.02	1.92
	1.78	1.66	1.94	1.30	1.13	0.68
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.003	0.003	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.012	0.014	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.485	0.889	1.919	2.720	2.993	4.438
	4.186	3.372	2.341	1.762	1.010	0.512
STD. DEVIATIONS	0.101	0.283	0.559	0.752	0.807	1.162
	1.249	1.544	0.813	0.781	0.337	0.131
LATERAL DRAINAGE FROM LAYER 2						
TOTALS	0.1627	0.1574	0.1906	0.2021	0.1976	0.1739
	0.1487	0.1199	0.1091	0.1189	0.1163	0.1509
STD. DEVIATIONS	0.1224	0.1120	0.1100	0.1047	0.0960	0.0850
	0.0874	0.0698	0.0661	0.1155	0.1155	0.1250
PERCOLATION FROM LAYER 3						
TOTALS	0.1194	0.1073	0.1244	0.1280	0.1321	0.1247
	0.1242	0.1089	0.0939	0.0981	0.0962	0.1186
STD. DEVIATIONS	0.0355	0.0392	0.0348	0.0219	0.0169	0.0146
	0.0140	0.0312	0.0427	0.0527	0.0479	0.0347

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	29.88	(3.978)	2626598.	100.00
RUNOFF	0.006	(0.026)	512.	0.02
EVAPOTRANSPIRATION	26.627	(3.219)	2340922.	89.12
LATERAL DRAINAGE FROM LAYER 2	1.8480	(0.9630)	162472.	6.19
PERCOLATION FROM LAYER 3	1.3758	(0.3193)	120953.	4.60
CHANGE IN WATER STORAGE	0.020	(2.098)	1739.	0.07

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	3.19	280454.2
RUNOFF	0.062	5491.7
LATERAL DRAINAGE FROM LAYER 2	0.0181	1592.4
PERCOLATION FROM LAYER 3	0.0062	541.7
HEAD ON LAYER 3	19.5	
SNOW WATER	2.36	207067.5
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3862	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0577	

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.20	0.1992
2	4.84	0.2689
3	10.32	0.4300
SNOW WATER	0.00	

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DUNN LANDFILL FINAL COVER DESIGN
COVER "B" AT 9% SLOPES
J. BLAYNE KIRSCH : JANUARY 24, 1992

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.4530 VOL/VOL
FIELD CAPACITY	=	0.1901 VOL/VOL
WILTING POINT	=	0.0848 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1901 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.002160000149 CM/SEC

LAYER 2

LATERAL DRAINAGE LAYER

THICKNESS	=	18.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.1053 VOL/VOL
WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1053 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.001700000023 CM/SEC
SLOPE	=	9.00 PERCENT
DRAINAGE LENGTH	=	250.0 FEET

LAYER 3

BARRIER SOIL LINER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.71
TOTAL AREA OF COVER	=	1055000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.8360 INCHES
INITIAL VEG. STORAGE	=	3.5711 INCHES
INITIAL SNOW WATER CONTENT	=	0.7586 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	13.3560 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR MADISON WISCONSIN

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	135
END OF GROWING SEASON (JULIAN DATE)	=	273

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
15.60	20.50	31.20	45.80	57.00	66.30
70.60	68.50	60.10	49.50	35.10	22.40

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.83	0.96	1.98	3.01	2.77	4.46
	3.34	3.48	3.24	2.43	1.91	1.46
STD. DEVIATIONS	0.35	0.50	0.97	1.29	1.02	1.92
	1.78	1.66	1.94	1.30	1.13	0.68
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.003	0.003	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.012	0.012	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.485	0.886	1.927	2.710	2.990	4.467
	3.701	3.333	2.335	1.761	1.015	0.512
STD. DEVIATIONS	0.101	0.286	0.550	0.750	0.838	1.158
	1.320	1.525	0.817	0.790	0.334	0.130
LATERAL DRAINAGE FROM LAYER 2						
TOTALS	0.2700	0.2536	0.3099	0.3299	0.3027	0.2125
	0.2102	0.1140	0.0733	0.1217	0.1544	0.2518
STD. DEVIATIONS	0.2467	0.2389	0.2099	0.2096	0.2161	0.1439
	0.1989	0.1061	0.0740	0.2086	0.2082	0.2746
PERCOLATION FROM LAYER 3						
TOTALS	0.0959	0.0913	0.1113	0.1152	0.1179	0.1108
	0.1070	0.0862	0.0718	0.0753	0.0742	0.0948
STD. DEVIATIONS	0.0499	0.0417	0.0296	0.0149	0.0089	0.0059
	0.0270	0.0461	0.0498	0.0552	0.0510	0.0476

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	29.88	(3.978)	2626598.	100.00
RUNOFF	0.005	(0.024)	468.	0.02
EVAPOTRANSPIRATION	26.123	(3.320)	2296658.	87.44
LATERAL DRAINAGE FROM LAYER 2	2.6039	(1.5896)	228930.	8.72
PERCOLATION FROM LAYER 3	1.1516	(0.3247)	101241.	3.85
CHANGE IN WATER STORAGE	-0.008	(1.891)	-699.	-0.03

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	3.19	280454.2
RUNOFF	0.053	4684.6
LATERAL DRAINAGE FROM LAYER 2	0.0329	2895.4
PERCOLATION FROM LAYER 3	0.0054	472.3
HEAD ON LAYER 3	13.9	
SNOW WATER	2.36	207072.3

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3246

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0577

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.20	0.1992
2	4.22	0.2343
3	10.32	0.4300
SNOW WATER	0.00	

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DUNN LANDFILL FINAL COVER DESIGN
COVER "C" @ 3 % SLOPES WITH POOR QA = 0.01
J. BLAYNE KIRSCH : JANUARY 24, 1992

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.4530 VOL/VOL
FIELD CAPACITY	=	0.1901 VOL/VOL
WILTING POINT	=	0.0848 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1901 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.002160000149 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	18.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.1053 VOL/VOL
WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1053 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.001700000023 CM/SEC

LAYER 3

LATERAL DRAINAGE LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0454 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.010000000708 CM/SEC
SLOPE	=	3.00 PERCENT
DRAINAGE LENGTH	=	250.0 FEET

LAYER 4

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC
LINER LEAKAGE FRACTION	=	0.01000000

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.71
TOTAL AREA OF COVER	=	1055000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.8360 INCHES
INITIAL VEG. STORAGE	=	2.6148 INCHES
INITIAL SNOW WATER CONTENT	=	0.7586 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	13.9008 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR MADISON WISCONSIN

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	135
END OF GROWING SEASON (JULIAN DATE)	=	273

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
15.60	20.50	31.20	45.80	57.00	66.30
70.60	68.50	60.10	49.50	35.10	22.40

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.83	0.96	1.98	3.01	2.77	4.46
	3.34	3.48	3.24	2.43	1.91	1.46
STD. DEVIATIONS	0.35	0.50	0.97	1.29	1.02	1.92
	1.78	1.66	1.94	1.30	1.13	0.68
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.003	0.003	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.012	0.011	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.485	0.885	1.926	2.712	2.986	4.477
	3.668	3.303	2.334	1.766	1.014	0.512
STD. DEVIATIONS	0.101	0.287	0.549	0.747	0.837	1.156
	1.309	1.462	0.817	0.794	0.331	0.130
LATERAL DRAINAGE FROM LAYER 3						
TOTALS	0.3165	0.2957	0.3498	0.3844	0.3846	0.3264
	0.3290	0.2706	0.2121	0.2460	0.2543	0.3105
STD. DEVIATIONS	0.2442	0.2215	0.2099	0.2124	0.1902	0.1558
	0.1865	0.1664	0.1370	0.2441	0.2579	0.2438
PERCOLATION FROM LAYER 4						
TOTALS	0.0012	0.0011	0.0012	0.0012	0.0012	0.0011
	0.0012	0.0011	0.0011	0.0011	0.0011	0.0012
STD. DEVIATIONS	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	29.88	(3.978)	2626598.	100.00
RUNOFF	0.005	(0.023)	458.	0.02
EVAPOTRANSPIRATION	26.068	(3.248)	2291855.	87.26
LATERAL DRAINAGE FROM LAYER 3	3.6797	(1.9950)	323511.	12.32
PERCOLATION FROM LAYER 4	0.0138	(0.0009)	1210.	0.05
CHANGE IN WATER STORAGE	0.109	(1.973)	9564.	0.36

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	3.19	280454.2
RUNOFF	0.053	4619.3
LATERAL DRAINAGE FROM LAYER 3	0.0341	2995.1
PERCOLATION FROM LAYER 4	0.0000	4.3
HEAD ON LAYER 4	10.6	
SNOW WATER	2.36	207107.8
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2646	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0577	

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.20	0.1992
2	3.54	0.1968
3	1.78	0.1482
4	10.32	0.4300
SNOW WATER	0.00	

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 DUNN LANDFILL FINAL COVER DESIGN
 COVER "C" @ 3 % SLOPES WITH AVERAGE QA = 0.00025
 J. BLAYNE KIRSCH : JANUARY 24, 1992

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                              FAIR GRASS

                               LAYER  1
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                      VERTICAL PERCOLATION LAYER
   THICKNESS                           =       6.00 INCHES
   POROSITY                            =       0.4530 VOL/VOL
   FIELD CAPACITY                      =       0.1901 VOL/VOL
   WILTING POINT                       =       0.0848 VOL/VOL
   INITIAL SOIL WATER CONTENT          =       0.1901 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY    =       0.002160000149 CM/SEC


                               LAYER  2
                               --------

                      VERTICAL PERCOLATION LAYER
   THICKNESS                           =      18.00 INCHES
   POROSITY                            =       0.4370 VOL/VOL
   FIELD CAPACITY                      =       0.1053 VOL/VOL
   WILTING POINT                       =       0.0466 VOL/VOL
   INITIAL SOIL WATER CONTENT          =       0.1053 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY    =       0.001700000023 CM/SEC


                               LAYER  3
                               --------

                        LATERAL DRAINAGE LAYER
   THICKNESS                           =      12.00 INCHES
   POROSITY                            =       0.4170 VOL/VOL
   FIELD CAPACITY                      =       0.0454 VOL/VOL
   WILTING POINT                       =       0.0200 VOL/VOL
   INITIAL SOIL WATER CONTENT          =       0.0454 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY    =       0.01000000708 CM/SEC
   SLOPE                               =       3.00 PERCENT
   DRAINAGE LENGTH                     =     250.0 FEET
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LAYER 4

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	*24.00 INCHES*
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC
LINER LEAKAGE FRACTION	=	0.00025000

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.71
TOTAL AREA OF COVER	=	1055000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.8360 INCHES
INITIAL VEG. STORAGE	=	2.6148 INCHES
INITIAL SNOW WATER CONTENT	=	0.7586 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	13.9008 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR MADISON WISCONSIN

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	135
END OF GROWING SEASON (JULIAN DATE)	=	273

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
15.60	20.50	31.20	45.80	57.00	66.30
70.60	68.50	60.10	49.50	35.10	22.40

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.83	0.96	1.98	3.01	2.77	4.46
	3.34	3.48	3.24	2.43	1.91	1.46
STD. DEVIATIONS	0.35	0.50	0.97	1.29	1.02	1.92
	1.78	1.66	1.94	1.30	1.13	0.68
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.003	0.003	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.012	0.011	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.485	0.885	1.926	2.712	2.986	4.477
	3.668	3.303	2.334	1.766	1.014	0.512
STD. DEVIATIONS	0.101	0.287	0.549	0.747	0.837	1.156
	1.309	1.462	0.817	0.794	0.331	0.130
LATERAL DRAINAGE FROM LAYER 3						
TOTALS	0.3176	0.2966	0.3508	0.3854	0.3856	0.3275
	0.3301	0.2718	0.2133	0.2473	0.2554	0.3116
STD. DEVIATIONS	0.2442	0.2215	0.2100	0.2125	0.1904	0.1559
	0.1865	0.1664	0.1369	0.2440	0.2580	0.2438
PERCOLATION FROM LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	29.88	(3.978)	2626598.	100.00
RUNOFF	0.005	(0.023)	458.	0.02
EVAPOTRANSPIRATION	26.068	(3.248)	2291855.	87.26
LATERAL DRAINAGE FROM LAYER 3	3.6929	(1.9954)	324669.	12.36
PERCOLATION FROM LAYER 4	0.0003	(0.0000)	30.	0.00
CHANGE IN WATER STORAGE	0.109	(1.973)	9586.	0.36

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	3.19	280454.2
RUNOFF	0.053	4619.3
LATERAL DRAINAGE FROM LAYER 3	0.0341	2998.7
PERCOLATION FROM LAYER 4	0.0000	0.1
HEAD ON LAYER 4	10.6	
SNOW WATER	2.36	207107.8
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2646	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0577	

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.20	0.1992
2	3.54	0.1968
3	1.78	0.1486
4	10.32	0.4300
SNOW WATER	0.00	

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DUNN LANDFILL FINAL COVER DESIGN
COVER "C" @ 3 % SLOPES WITH EXCELLENT QA = 0.00001
J. BLAYNE KIRSCH : JANUARY 24, 1992

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.4530 VOL/VOL
FIELD CAPACITY	=	0.1901 VOL/VOL
WILTING POINT	=	0.0848 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1901 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.002160000149 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	18.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.1053 VOL/VOL
WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1053 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.001700000023 CM/SEC

LAYER 3

LATERAL DRAINAGE LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0454 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.01000000708 CM/SEC
SLOPE	=	3.00 PERCENT
DRAINAGE LENGTH	=	250.0 FEET

LAYER 4

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC
LINER LEAKAGE FRACTION	=	0.00001000

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.71
TOTAL AREA OF COVER	=	1055000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.8360 INCHES
INITIAL VEG. STORAGE	=	2.6148 INCHES
INITIAL SNOW WATER CONTENT	=	0.7586 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	13.9008 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR MADISON WISCONSIN

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	135
END OF GROWING SEASON (JULIAN DATE)	=	273

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
15.60	20.50	31.20	45.80	57.00	66.30
70.60	68.50	60.10	49.50	35.10	22.40

4.4.3 Soil Column Study

Column studies were initiated to obtain information on the degradation potential of the contaminants under conditions more indicative of field in-situ biotreatment than the well-mixed reactors. The three bench-scale columns were designed to evaluate the following parameters:

- Biodegradability of specific organic contaminants under subsurface conditions,
- Presence of indigenous microorganisms, and
- Requirement for an external source of microorganisms

Each of the 3.5 inch diameter soil columns contained compacted screened soil bounded by 3 to 4 inch upper and lower gravel beds. The reason that screened soils were used in the soil columns was to have identical soils in both soil columns and bioreactors so that results could be directly compared and correlated. The lower gravel beds rested on a felt geotextile, which in turn rested on a plastic support with drain holes. Figure 4.7 shows the three soil column setups. Each soil column was packed using 10 pounds of wet screened soil compacted with a weight to a density of approximately 150 lbs./cubic foot. Tap water was introduced to the top of each column to saturate the column and measure the column effluent rate. When a 4 inch head of water did not produce effluent from any of the three columns, a vacuum was applied to one column to force a flow. However, even with the applied vacuum, column effluent was virtually non-existent.

As a result, a smaller column (1 inch diameter) was set up with loosely packed soil to determine if water would flow under these conditions. A minimal water flow was seen in this loosely packed soil column. The column was then backflushed and allowed to settle to repack the soil. Again, no flow was observed from the column. As it appeared that the soil density as well as fraction of fines in the soil was significant enough to preclude sufficient water flow through the column for sampling, the soil column study was discontinued. Although these results indicate that the

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.83	0.96	1.98	3.01	2.77	4.46
	3.34	3.48	3.24	2.43	1.91	1.46
STD. DEVIATIONS	0.35	0.50	0.97	1.29	1.02	1.92
	1.78	1.66	1.94	1.30	1.13	0.68
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.003	0.003	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.012	0.011	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.485	0.885	1.926	2.712	2.986	4.477
	3.668	3.303	2.334	1.766	1.014	0.512
STD. DEVIATIONS	0.101	0.287	0.549	0.747	0.837	1.156
	1.309	1.462	0.817	0.794	0.331	0.130
LATERAL DRAINAGE FROM LAYER 3						
TOTALS	0.3176	0.2966	0.3509	0.3854	0.3856	0.3275
	0.3302	0.2718	0.2134	0.2473	0.2554	0.3116
STD. DEVIATIONS	0.2442	0.2215	0.2100	0.2125	0.1904	0.1559
	0.1865	0.1664	0.1369	0.2440	0.2580	0.2438
PERCOLATION FROM LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	29.88	(3.978)	2626598.	100.00
RUNOFF	0.005	(0.023)	458.	0.02
EVAPOTRANSPIRATION	26.068	(3.248)	2291855.	87.26
LATERAL DRAINAGE FROM LAYER 3	3.6932	(1.9954)	324698.	12.36
PERCOLATION FROM LAYER 4	0.0000	(0.0000)	1.	0.00
CHANGE IN WATER STORAGE	0.109	(1.973)	9586.	0.36

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	3.19	280454.2
RUNOFF	0.053	4619.3
LATERAL DRAINAGE FROM LAYER 3	0.0341	2998.8
PERCOLATION FROM LAYER 4	0.0000	0.0
HEAD ON LAYER 4	10.6	
SNOW WATER	2.36	207107.8

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2646

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0577

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.20	0.1992
2	3.54	0.1968
3	1.78	0.1486
4	10.32	0.4300
SNOW WATER	0.00	

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DUNN LANDFILL FINAL COVER DESIGN
COVER "C" @ 9 % SLOPES WITH POOR QA = 0.01
J. BLAYNE KIRSCH : JANUARY 24, 1992

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****

FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.4530 VOL/VOL
FIELD CAPACITY	=	0.1901 VOL/VOL
WILTING POINT	=	0.0848 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1901 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.002160000149 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	18.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.1053 VOL/VOL
WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1053 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.001700000023 CM/SEC

LAYER 3

LATERAL DRAINAGE LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0454 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.010000000708 CM/SEC
SLOPE	=	9.00 PERCENT
DRAINAGE LENGTH	=	250.0 FEET

LAYER 4

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC
LINER LEAKAGE FRACTION	=	0.01000000

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.71
TOTAL AREA OF COVER	=	1055000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.8360 INCHES
INITIAL VEG. STORAGE	=	2.6148 INCHES
INITIAL SNOW WATER CONTENT	=	0.7586 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	13.9008 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR MADISON WISCONSIN

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	135
END OF GROWING SEASON (JULIAN DATE)	=	273

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
15.60	20.50	31.20	45.80	57.00	66.30
70.60	68.50	60.10	49.50	35.10	22.40

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.83	0.96	1.98	3.01	2.77	4.46
	3.34	3.48	3.24	2.43	1.91	1.46
STD. DEVIATIONS	0.35	0.50	0.97	1.29	1.02	1.92
	1.78	1.66	1.94	1.30	1.13	0.68
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.003	0.003	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.012	0.011	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.485	0.885	1.926	2.712	2.986	4.477
	3.668	3.303	2.334	1.766	1.014	0.512
STD. DEVIATIONS	0.101	0.287	0.549	0.747	0.837	1.156
	1.309	1.462	0.817	0.794	0.331	0.130
LATERAL DRAINAGE FROM LAYER 3						
TOTALS	0.3836	0.3250	0.4563	0.4912	0.3288	0.1905
	0.2882	0.0971	0.0702	0.3348	0.3216	0.4308
STD. DEVIATIONS	0.4129	0.3714	0.4027	0.3949	0.2609	0.1373
	0.4371	0.1263	0.0945	0.7750	0.4480	0.4659
PERCOLATION FROM LAYER 4						
TOTALS	0.0011	0.0010	0.0011	0.0011	0.0011	0.0010
	0.0011	0.0011	0.0010	0.0011	0.0010	0.0011
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	29.88	(3.978)	2626598.	100.00
RUNOFF	0.005	(0.023)	458.	0.02
EVAPOTRANSPIRATION	26.068	(3.248)	2291855.	87.26
LATERAL DRAINAGE FROM LAYER 3	3.7182	(2.2584)	326889.	12.45
PERCOLATION FROM LAYER 4	0.0127	(0.0002)	1115.	0.04
CHANGE IN WATER STORAGE	0.071	(1.604)	6281.	0.24

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	3.19	280454.2
RUNOFF	0.053	4619.3
LATERAL DRAINAGE FROM LAYER 3	0.1181	10379.0
PERCOLATION FROM LAYER 4	0.0000	3.7
HEAD ON LAYER 4	5.8	
SNOW WATER	2.36	207107.8

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2646

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0577

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.20	0.1992
2	3.54	0.1968
3	1.03	0.0860
4	10.32	0.4300
SNOW WATER	0.00	

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 DUNN LANDFILL FINAL COVER DESIGN
 COVER "C" @ 9% SLOPES WITH AVERAGE QA = 0.00025
 J. BLAYNE KIRSCH : JANUARY 24, 1992

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                              FAIR GRASS

                              LAYER  1
                              --------

                    VERTICAL PERCOLATION LAYER
   THICKNESS                              =      6.00 INCHES
   POROSITY                               =      0.4530 VOL/VOL
   FIELD CAPACITY                         =      0.1901 VOL/VOL
   WILTING POINT                          =      0.0848 VOL/VOL
   INITIAL SOIL WATER CONTENT             =      0.1901 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY       =      0.002160000149 CM/SEC


                              LAYER  2
                              --------

                    VERTICAL PERCOLATION LAYER
   THICKNESS                              =     18.00 INCHES
   POROSITY                               =      0.4370 VOL/VOL
   FIELD CAPACITY                         =      0.1053 VOL/VOL
   WILTING POINT                          =      0.0466 VOL/VOL
   INITIAL SOIL WATER CONTENT             =      0.1053 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY       =      0.001700000023 CM/SEC


                              LAYER  3
                              --------

                      LATERAL DRAINAGE LAYER
   THICKNESS                              =     12.00 INCHES
   POROSITY                               =      0.4170 VOL/VOL
   FIELD CAPACITY                         =      0.0454 VOL/VOL
   WILTING POINT                          =      0.0200 VOL/VOL
   INITIAL SOIL WATER CONTENT             =      0.0454 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY       =      0.010000000708 CM/SEC
   SLOPE                                  =      9.00 PERCENT
   DRAINAGE LENGTH                        =    250.0 FEET
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LAYER 4

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC
LINER LEAKAGE FRACTION	=	0.00025000

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.71
TOTAL AREA OF COVER	=	1055000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.8360 INCHES
INITIAL VEG. STORAGE	=	2.6148 INCHES
INITIAL SNOW WATER CONTENT	=	0.7586 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	13.9008 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR MADISON WISCONSIN

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	135
END OF GROWING SEASON (JULIAN DATE)	=	273

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
15.60	20.50	31.20	45.80	57.00	66.30
70.60	68.50	60.10	49.50	35.10	22.40

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.83	0.96	1.98	3.01	2.77	4.46
	3.34	3.48	3.24	2.43	1.91	1.46
STD. DEVIATIONS	0.35	0.50	0.97	1.29	1.02	1.92
	1.78	1.66	1.94	1.30	1.13	0.68
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.003	0.003	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.012	0.011	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.485	0.885	1.926	2.712	2.986	4.477
	3.668	3.303	2.334	1.766	1.014	0.512
STD. DEVIATIONS	0.101	0.287	0.549	0.747	0.837	1.156
	1.309	1.462	0.817	0.794	0.331	0.130
LATERAL DRAINAGE FROM LAYER 3						
TOTALS	0.3846	0.3260	0.4574	0.4922	0.3298	0.1916
	0.2892	0.0982	0.0712	0.3358	0.3226	0.4319
STD. DEVIATIONS	0.4129	0.3714	0.4027	0.3949	0.2609	0.1373
	0.4371	0.1263	0.0945	0.7750	0.4480	0.4659
PERCOLATION FROM LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	29.88	(3.978)	2626598.	100.00
RUNOFF	0.005	(0.023)	458.	0.02
EVAPOTRANSPIRATION	26.068	(3.248)	2291855.	87.26
LATERAL DRAINAGE FROM LAYER 3	3.7305	(2.2585)	327973.	12.49
PERCOLATION FROM LAYER 4	0.0003	(0.0000)	28.	0.00
CHANGE IN WATER STORAGE	0.071	(1.604)	6284.	0.24

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	3.19	280454.2
RUNOFF	0.053	4619.3
LATERAL DRAINAGE FROM LAYER 3	0.1181	10382.2
PERCOLATION FROM LAYER 4	0.0000	0.1
HEAD ON LAYER 4	5.8	
SNOW WATER	2.36	207107.8
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2646	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0577	

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.20	0.1992
2	3.54	0.1968
3	1.03	0.0860
4	10.32	0.4300
SNOW WATER	0.00	

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DUNN LANDFILL FINAL COVER DESIGN
COVER "C" @ 9 % SLOPES WITH EXCELLENT QA = 0.00001
J. BLAYNE KIRSCH : JANUARY 24, 1992

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.4530 VOL/VOL
FIELD CAPACITY	=	0.1901 VOL/VOL
WILTING POINT	=	0.0848 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1901 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.002160000149 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	18.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.1053 VOL/VOL
WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1053 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.001700000023 CM/SEC

LAYER 3

LATERAL DRAINAGE LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0454 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.01000000708 CM/SEC
SLOPE	=	9.00 PERCENT
DRAINAGE LENGTH	=	250.0 FEET

LAYER 4

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC
LINER LEAKAGE FRACTION	=	0.00001000

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.71
TOTAL AREA OF COVER	=	1055000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.8360 INCHES
INITIAL VEG. STORAGE	=	2.6148 INCHES
INITIAL SNOW WATER CONTENT	=	0.7586 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	13.9008 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR MADISON WISCONSIN

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	135
END OF GROWING SEASON (JULIAN DATE)	=	273

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
15.60	20.50	31.20	45.80	57.00	66.30
70.60	68.50	60.10	49.50	35.10	22.40

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.83	0.96	1.98	3.01	2.77	4.46
	3.34	3.48	3.24	2.43	1.91	1.46
STD. DEVIATIONS	0.35	0.50	0.97	1.29	1.02	1.92
	1.78	1.66	1.94	1.30	1.13	0.68
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.003	0.003	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.012	0.011	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.485	0.885	1.926	2.712	2.986	4.477
	3.668	3.303	2.334	1.766	1.014	0.512
STD. DEVIATIONS	0.101	0.287	0.549	0.747	0.837	1.156
	1.309	1.462	0.817	0.794	0.331	0.130
LATERAL DRAINAGE FROM LAYER 3						
TOTALS	0.3846	0.3260	0.4574	0.4923	0.3298	0.1916
	0.2893	0.0982	0.0712	0.3359	0.3226	0.4319
STD. DEVIATIONS	0.4129	0.3714	0.4027	0.3949	0.2609	0.1373
	0.4371	0.1263	0.0945	0.7750	0.4480	0.4659
PERCOLATION FROM LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	29.88	(3.978)	2626598.	100.00
RUNOFF	0.005	(0.023)	458.	0.02
EVAPOTRANSPIRATION	26.068	(3.248)	2291855.	87.26
LATERAL DRAINAGE FROM LAYER 3	3.7308	(2.2585)	328000.	12.49
PERCOLATION FROM LAYER 4	0.0000	(0.0000)	1.	0.00
CHANGE IN WATER STORAGE	0.071	(1.604)	6284.	0.24

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	3.19	280454.2
RUNOFF	0.053	4619.3
LATERAL DRAINAGE FROM LAYER 3	0.1181	10382.3
PERCOLATION FROM LAYER 4	0.0000	0.0
HEAD ON LAYER 4	5.8	
SNOW WATER	2.36	207107.8

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2646

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0577

****
****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.20	0.1992
2	3.54	0.1968
3	1.03	0.0860
4	10.32	0.4300
SNOW WATER	0.00	

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Foth & Van Dyke	
	Client: Scope I.D.:
	Project: Page: 1/3
	Prepared by: J.B. Kiml Date: 12/30/91
	Checked by: N.P Date: 1-2-92

DETERMINATION OF LEAKAGE FACTOR

PURPOSE: DETERMINE LEAKAGE FACTOR FOR HELP MODEL

REFERENCE: SCHROEDER, P.R., PEYTON, R.M., McENROE, B.M. AND SJUSTROM, J.W., (1988) HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE (HELP) Model, Vol IV, DOCUMENTATION FOR VERSION 2, HAZARDOUS WASTE ENGINEERING RESEARCH LABORATORY OFFIC OF RESEARCH AND DEVELOPMENT, USEPA, CINCINNATI, OH, p. 72.

SOLUTION: USING FIGURE 5 (SEE PAGE 3)

ASSUMPTIONS: 100' GRID SPACING OF HOLES (4 HOLES/ACRE)
1cm-DIAMETER HOLES (≈ 1/2 inch dia)
4" - LEACHATE HEAD AVERAGE
3.4×10^{-7} cm/sec - HYDRAULIC CONDUCTIVITY

RESULT:
LEAKAGE FACTOR = 2.5×10^{-4}

Foth & Van Dyke	Client:	Scope I.D.:
	Project:	Page: 2/2
	Prepared by: R. Kipsik	Date: 12/30/91
	Checked by: N-P	Date: 1-2-92

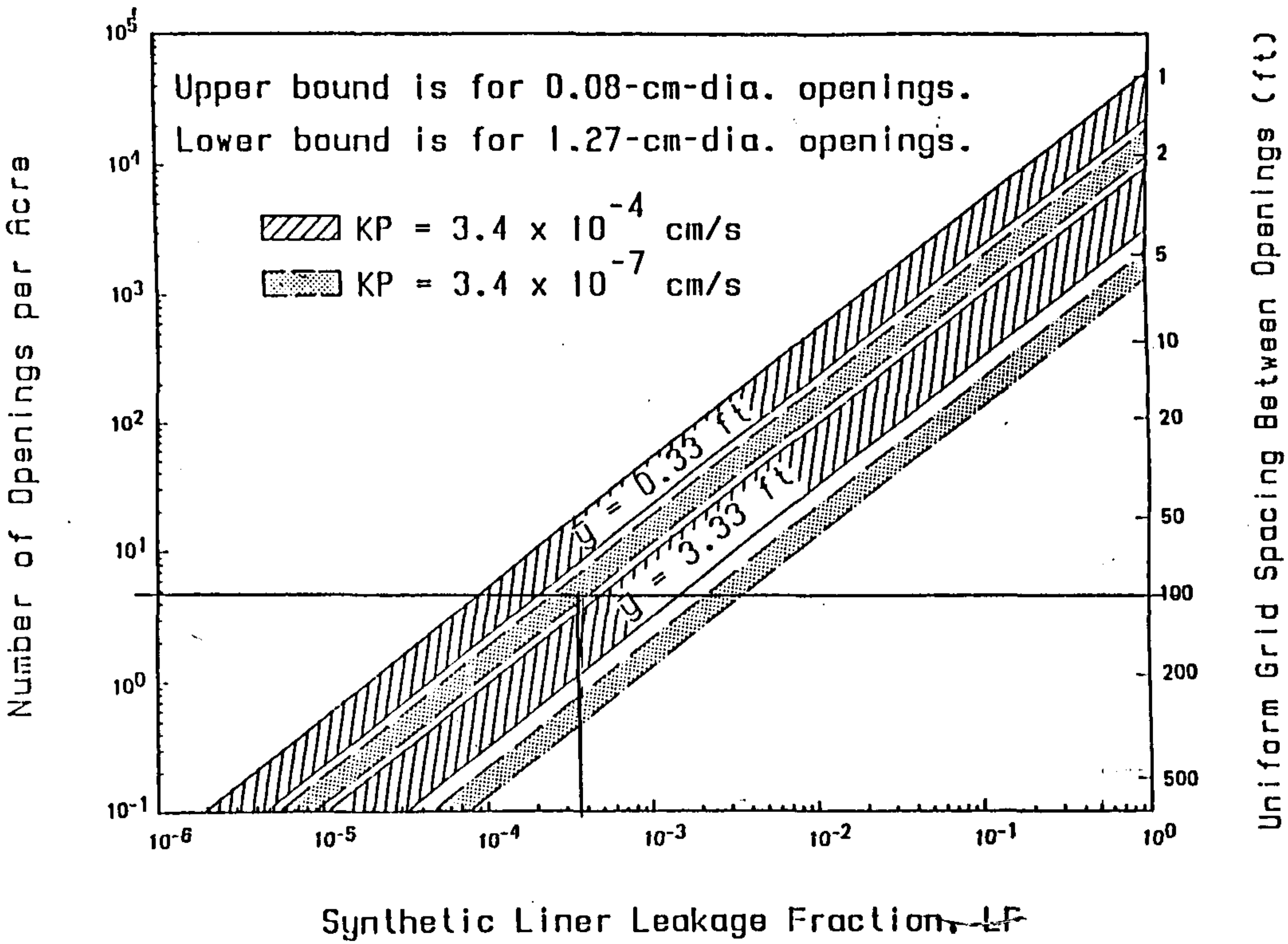
A NARRATIVE DESCRIPTION FOR "LEAKAGE FRACTION" HAS BEEN ADAPTED FROM "HELP MODEL DOCUMENTATION VOL. IV (SEE REFERENCE ON PREVIOUS PAGE)

The leakage fraction allows the model to simulate leaking synthetic liners. Leakage fraction is defined as the fraction of the horizontal area of soil through which percolation is occurring under the leaking synthetic liner.

Brown et al. (1987) conducted laboratory experiments and developed predictive equations to quantify leakage rates through various size holes through synthetic liners over soil. They assumed a uniform vertical percolation rate equal to the saturated hydraulic conductivity through a circular cross-sectional area of the soil liner directly beneath the hole. They developed predictive equations for the radius of this flow cross section as a function of hole size, depth of leachate ponding and saturated hydraulic conductivity of the soil. They found that this radius of saturated flow was significantly greater than the radius of the hole in the synthetic liner. For this report, the cross-sectional area of saturated flow was multiplied by the number of holes per unit area of synthetic liner to compute the synthetic liner leakage fraction. Figure 5 presents these results. This figure provides guidance in choosing synthetic liner leakage fractions for landfill modelling given a specific level of synthetic liner degradation such as number of openings per unit area or average spacing between openings.

REFERENCE FROM ABOVE:

Brown, K. W., J. C. Thomas, R. L. Lytton, P. Jayawikrama, and S. C. Bahrt. 1987. Quantification of Leak Rates Through Holes in Landfill Liners. EPA/600/ S2-87-062. U.S. Environmental Protection Agency, Cincinnati, OH.



$\overline{Y}$ = AVERAGE DEPTH OF LEACHATE HEAD ON LINER.

Figure 5. Synthetic liner leakage faction as a function of number of openings per acre and uniform grid spacing between openings.

FROM: HELP MODEL DOCUMENTATION Vol. IV

35

JBKirsch 2/30/91

PELA

APPENDIX C

TREATABILITY STUDY

TYPE OF DOCUMENT	DATE ISSUED	ADDRESSED TO/ SUBJECT MATTER	ADDRESSEE	NO. OF PAGES
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and

FINAL REPORT
TREATABILITY STUDY
CONTAMINATED SOIL AND GROUNDWATER
HAGEN FARM SUPERFUND SITE
STOUGHTON, WISCONSIN
PROJECT NUMBER 110CO
September 24, 1991

Waste Management of North America, Inc.
Midwest Region
Two Westbrook Corporate Center • Suite 1000
P.O. Box 7070
Westchester, Illinois 60154
708/409-0700

JUN 24 1991

June 11, 1991

Mr. Charles Wilk
City Disposal Corporation
Hazardous Waste Enforcement Branch
U.S.EPA Region V
230 S. Dearborn Street
Chicago, Illinois 60604

Mr. Mike Schmoller
Project Coordinator
City Disposal Corporation
Wisconsin Dept. of Natural Resources
3911 Fish Hatchery Road
Fitchburg, Wisconsin 53711

Dear Mr. Wilk and Mr. Schmoller:

The purpose of this letter is to inform you that in the near future data and information will be available which has potential benefits for the City Disposal site and associated RI/FS.

Currently, Waste Management of Wisconsin (WMWI) is conducting treatability studies for the groundwater operable unit at the Hagen Farm Landfill site in Stoughton, Wisconsin. Hagen Farm is approximately 10 miles southeast of City Disposal. Records indicate that similar transporters and generators used both City Disposal and Hagen Farm. As a result, the contaminants found in the groundwater at both sites are similar. For this reason the conclusions regarding groundwater treatability at Hagen Farm could potentially be applied to City Disposal.

WMWI has recently submitted City Disposal groundwater data to the consultant conducting the treatability studies for Hagen Farm. Their review of the data supports the premise that the Hagen Farm studies can be applied to City Disposal. If applied, the Groundwater Operable Unit Feasibility Study for City Disposal can be submitted with a greater certainty that the remedy USEPA and WDNR selects will be effective.

WMWI is hereby requesting that USEPA and WDNR allow the Hagen Farm Treatability Studies to be applied at City Disposal. By doing so, however, it should be recognized that the deliverable Technical Memorandum No. 9B, Detailed Analysis of

Alternatives (GCOU) will be delayed until September 1991 (it was originally scheduled for July 25, 1991). The delay is necessary for the Hagen Farm treatability studies to be completed, the data compiled and the final report issued. However, WMWI feels that the benefits to the City Disposal project and subsequent remedy selection warrant the schedule delay.

I have attached for your review the Hagen Farm Treatability Study Work Plan. After you review it, please call me at 708--409-0700 with your comments and indicate whether or not you approve of WMWI's proposal.

Sincerely,

March Smith

March Smith
Remedial Projects Manager
Waste Management of North America

attachments

MS:js

cc: Lois George, PELA (w/ attach.)
Dee Brncich, WMNA (w/o attach.)
Rich O'Hara, WMNA (w/o attach.)
Bill Schubert, WMNA (w/o attach.)
Don Otter, WMWI (w/o attach.)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
230 SOUTH DEARBORN ST.
CHICAGO, ILLINOIS 60604

JUL 12 1991

REPLY TO ATTENTION OF:
5HS-11

Mr. March Smith
Remedial Projects Manager
Waste Management of North America, Inc.
Midwest Region
Two Corporate Center, Suite 1000
P.O. Box 7070
Westchester, Illinois 60154

Re: City Disposal Corp. Landfill Technical Memorandum 3a
Technical Memorandum 9b.

Dear Mr. Smith

The United States Environmental Protection Agency (U.S. EPA) has completed its review of Technical Memorandum 3a of the Remedial Investigation/Feasibility Study (RI/FS) for the City Disposal Corporation Landfill "Superfund" site.

Based on the review of Technical Memorandum 3a, the U.S. EPA finds that the information available for this site is generally sufficient to continue with the drafting of an Endangerment Assessment, Remedial Investigation Report and Feasibility Reports for the site. One aspect of the project that needs further analysis concerns the direction of ground water flow at the eastern portion of the site. Specific comments concerning this aspect are included in the enclosed comments from our oversight contractor and the Wisconsin Department of Natural Resources. The draft Remedial Investigation Report should address the enclosed comments.

The U.S. EPA is also in receipt to your June 11, letter concerning the a treatability study being conducted at the Hagen Farm site and its relevance to this site. Your letter proposes that submittal to Technical Memorandum 9b be delayed to September 1991 in order to include the results of this treatability study in Technical Memorandum 9b for this site. The U.S. EPA considers your proposal to hold merit and we shall be discussing your proposal as well as schedule revisions with you shortly.

If you have any questions concerning this letter please telephone me at (312) 353-1331.

Sincerely,

Charles Wilk
Remedial Project Manager

cc: Mike Schmoller, WDNR

October 21, 1991

TO: Dee Brncich
March Smith

FROM: Kevin O'Leary KO'L

SUBJECT: **CITY DISPOSAL CORPORATION LANDFILL TREATABILITY MEMO**

Per your request, the following memo analyzes treatment alternatives for City Disposal Corporation Landfill (CDCL) located in Dunn, Wisconsin. As part of the Feasibility Study work, alternatives for the remediation of contaminated groundwater will be analyzed. This memorandum evaluates the available groundwater analytical data and previous RI work to assess groundwater quality and analyze treatment/remediation alternatives to provide data for use in the Feasibility Study.

The technical bases of this memorandum are supplied by the following documents:

1. "Technical Memorandum 3A for Remedial Investigation/Feasibility Study, City Disposal Corporation Landfill, "P.E. LaMoreaux & Associates, April 1991 (including Appendices G, H, and I).

2. "Remedial Investigation/Feasibility Study Hagen Farm Site, Technical Memorandum Number 1, "Warzyn Engineering, March 1989.

3. "Treatability Study Report, Hagen Farm Site", Waste Management of North America, September 1991.

4. Correspondence with Peroxidation Systems, Inc. concerning chemical oxidation of CDCL groundwater, July - September 1991.

The attached Table 1 provides a comparison of groundwater quality for the CDCL and Hagen Farm sites. The geometric means from groundwater/source characterization wells for the two sites are provided for different parameters. The CDCL data presented was determined by taking the individual geometric averages from shallow groundwater wells in the two zones of contamination and taking a flow weighted average of the two zones (based on a 10 percent flow from Cell 6 and 90 percent flow from Cell 12). The following can be concluded from Table 1 and other available RI/FS information:

- Both site groundwaters have volatile organic contaminants with THF, ketones (acetone, MEK), and toluene or xylenes as the most prevalent constituents.

- Both site groundwaters have iron and manganese levels that exceed NR 140 PAL. However, the background groundwater at CDCL exceeds NR 140 PAL for iron and manganese.

- The Hagen Farm site has substantially more contamination from semi-volatile organic compounds than CDCL. Also, review of Hagen Farm and CDCL RI/FS documents indicate that Hagen Farm has a higher concentration of organics as measured by TOC/COD than CDCL.

Based on the similarities of the CDCL and Hagen Farm groundwater, as well as the similar types of wastes accepted at the sties, the extensive treatability study performed at Hagen Farm can be extrapolated for analysis of CDCL. As determined in the Hagen Farm Treatability Study, there are four practical alternatives for successful CDCL groundwater treatment:

- Metals Precipitation (by Chemical Precipitation) + Air Stripping + GAC Adsorption

- Metals Precipitation (by Air Oxidation) + GAC Adsorption

- Metals Precipitation (by Air Oxidation) + Activated Sludge Treatment

- Metals Precipitation (by Oxidation) + Chemical Oxidation

In the Hagen Farm Treatability Study, all four alternatives were demonstrated to effectively treat the groundwater. For CDCL groundwater, this also should be the case. However, there are relative process advantages/disadvantages, as well as secondary process considerations to consider for each alternative. Activated Sludge treatment of CDCL groundwater will require substrate addition in order to keep the process stable. This is due to the low organic content (TOC) of CDCL groundwater. An activated sludge process would not readily allow pulsed or variable groundwater pumping schemes. Also, given the complex hydrogeology of the CDCL site, the secondary advantage of using activated sludge treatment in conjunction with in-situ bioremediation is not present at CDCL, as it is with the Hagen Farm Site.

The GAC alternatives and chemical oxidation alternative for CDCL groundwater treatment allow for use of pulsed or variable groundwater schemes. These processes are stable even with the anticipated reduction of organic constituent levels as site remediation progresses with time. The presences of the THF and ketones create process concerns for the GAC options. THF and ketones are very weakly adsorbed on GAC due to their high solubility and small molecular size. The high solubility of these constituents limits the efficiency of air stripping. The removed organics from the groundwater are not destroyed, but rather adsorbed. A residual is created with GAC treatment that requires off-site management, either by regeneration or land disposal. Chemical Oxidation is a preferred technology because it degrades the organic constituents into mineralized components (such as carbon dioxide). Although the presence of the THF and ketones affects the process, chemical oxidation destroys a very wide range of organic compounds.

Table 2 presents the design basis for CDCL groundwater treatment alternatives, and is based on the process performance data from the Hagen Farm Study, vendor consultation, and projected groundwater quality for the CDCL site. Based on Table 2, preliminary construction and operating cost estimates were developed for the different groundwater options.

Table 3 provides installed costs for the various options, while Table 4 presents operating costs for treatment of CDCL groundwater. Activated sludge treatment of CDCL groundwater has the highest installed capital costs ($2,495,000) with the lowest total operating costs (fixed and variable) of $717,000 per year. Granular Activated Carbon Treatment has the lowest installed capital costs of the four options ($1,825,700) and a relatively high operating cost ($976,400 per year). The Air Stripping/Granular Activated Carbon option would have an installed cost of $2,053,000, with a total operating cost of $1,066,000 per year for treatment of CDCL groundwater. The higher operating cost for the Air Stripping/GAC option is a result of using vapor phase carbon in conjunction with the air stripper. The high operating costs for both the GAC and Air Stripping/GAC options are related to the low adsorption capacity of GAC for THF and ketones. Treatment utilizing chemical oxidation would require a facility with an installed. cost of $2,375,000 and a total operating cost of $928,400 per year. As contaminant levels decrease over time, the Chemical Oxidation and GAC options develop cost advantages (relative to Activated Sludge Treatment) because less power and chemical reagents will be necessary. (Reagent and power costs are the highest variable costs for these options.)

Based on process cost and performance concerns, the following conclusion/recommendations are made regarding treatment of CDCL groundwater:

- The Air Stripping/GAC option is not recommended for the CDCL groundwater treatment due cost and performance issues related to the solubility and low adsorption tendencies of the principal contaminants of CDCL groundwater (namely the THF, ketones).

- Treatment of CDCL groundwater with GAC only is not preferred again due to cost/process concerns related to groundwater contaminants.

- Activated Sludge processing may be cost effective; however, process stability concerns remain due to low organic substrate levels. Also, secondary benefits for the activated sludge process that exist at the Hagen Farm site, such as incorporation of the process into in-situ bioremediation, are not present at the City Disposal site because of CDCL's complex hydrogeology.

- Chemical Oxidation is recommended for treatment of CDCL groundwater because: it is a destructive treatment technology, it will not be affected by the low organic concentration in CDCL groundwater, it will reduce in operating costs as the CDCL groundwater quality improves in time, and it can be operated in an intermittent manner to accommodate variable or pulsed groundwater pumping.

- A pilot chemical oxidation unit should be operated at the CDCL site to develop operating cost and design data. If pilot operation indicates substantially worse than anticipated results, it is recommended that activated sludge be used at CDCL.

KO:hrr
KO6091.51

TABLE 1
SHALLOW GROUDWATER QUALITY COMPARISON
CDCL/HAGEN FARM SITES

CONSTITUENT, ug/l:	CDCL	HAGEN FARM	NR 140 PAL
VOLATILE ORGANIC COMPOUNDS			
ACETONE	297		
BENZENE	1.6		0.067
CARBON TETRACHLORIDE	0.3		0.5
CHLOROETHANE	0.6		
1,1-DICHLOROETHANE	3.7		85
1,2-TRANS-DICHLOROETHENE	7		20
ETHYL BENZENE	16.7	99	272
METHYLENE CHLORIDE	27.6		15
METHYL ISOBUTYL KETONE	10.6		
METHYL ETHYL KETONE	260	2620	
TETRACHLOROETHENE	0.6		0.1
TETRAHYDROFURAN	5274	5698	10
TOLUENE	282	20	68.6
TRICHLOROETHENE	2.4		0.18
VINYL CHLORIDE	1.5		0.0015
XYLENES	44.3	1066	124
SEMIVOLATILE ORGANIC COMPOUNDS			
BENZOIC ACID	2.1	780	
2,4-DIMETHYL PHENOL		153	
4-METHYL PHENOL	3.5	243	
PHENOL		3816	(1200)
1,4-DICHLOROBENZENE		10	(15)
BENZYL ALCOHOL		26	
BIS-(2-CHLOROISOPROPYL)ETHER		19	
NAPHTHALENE	1.5	8	(8)
4-CHLORO-3-METHYL PHENOL		7	
DIETHYL PHTHALATE		4.5	
BIS-(2-ETHYL HEXYL)PHTHALATE		18	(0.3)
DI-N-OCTYL PHTHALATE		5	
METALS, CONVENTIONALS			
CADMIUM	1.4		1
IRON	6034	451	150
MANGANESE	393	1473	25
TOTAL DISSOLVED SOLIDS	659100		250000

TABLE 2
CDCL SITE
GROUNDWATER TREATMENT
BASIS OF DESIGN

ITEM	VALUE
FLOW	155 GPM*
NUMBER OF RECOVERY WELLS	3
METHOD OF EFFLUENT DISCHARGE	SURFACE WATER
EFFLUENT QUALITY PERFORMANCE	HAGEN FARM TREATABILITY RESULTS
FACILITY OPERATING FREQUENCY	7 DAYS/WEEK
INFLUENT CONDITIONS	
—CHEMICAL OXYGEN DEMAND	150 mg/l
—TOTAL SUSPENDED SOLIDS	60 mg/l
—IRON	10 mg/l
—MANGANESE	4 mg/l
—BARIUM	1 mg/l
—ACETONE	297 ug/l
—METHYL ETHYL KETONE	260 ug/l
—TETRAHYDROFURAN	5274 ug/l
AIR STRIPPER INFORMATION	
—AIR/WATER RATIO	100
—REMOVAL EFFICIENCIES,VOLATILES	>90
—REMOVAL EFFICIENCY,THF & MEK	30
—REMOVAL EFFICIENCY, ACETONE	0
GRANULAR ACTIVATED CARBON INFORMATION	
—ABSORPTION	10mgTHF/gGAC
ACTIVATED SLUDGE INFORMATION	
—LOADING,F/M	0.1gCOD/gVSS-day
—SLUDGE YIELD	0.15gVSS/gCOD
—MIXED LIQUOR CONCENTRATION,MLVSS	2250 mg/l
—MLVSS/MLTSS RATIO	0.7
—AERATION TYPE	FINE BUBBLE
CHEMICAL OXIDATION INFORMATION	
—SYSTEM TYPE	PEROXIDE+UV LIGHT
—CHEMICAL DOSAGE	30 mg/l H2O2
—POWER REQUIREMENT	350 kW

NOTES:* FLOW CHOSEN BASED ON CURRENT RI/FS ESTIMATES

TABLE 3
CDCL SITE
TREATMENT FACILITY COST ESTIMATE

ITEM	OPTION 1 AIR STRIP+GAC	OPTION 2 GAC	OPTION 3 ASP	OPTION 4 CHEM-OX
GROUNDWATER RECOVERY WELLS(3,INSTALLED)	$60,000	$60,000	$60,000	$60,000
PROCESS EQUIPMENT	$995,400	$861,600	$1,088,100	$1,194,000
INSTALLATION(@30%OF PROCESS EQUIPMENT)	$298,620	$258,480	$326,430	$358,200
BUILDING/CIVIL WORK	$262,500	$257,500	$490,000	$257,500
FACILITY COST(FC)	$1,616,520	$1,437,580	$1,964,530	$1,869,700
ENGINEERING,PERMITTING(@12% FC)	$193,982	$172,510	$235,744	$224,364
CONTINGENCY,INSURANCE(@15% FC)	$242,478	$215,637	$294,680	$280,455
TOTAL INSTALLED FACILITY COSTS	$2,052,980	$1,825,727	$2,494,953	$2,374,519

TABLE 4
CDCL SITE
GROUNDWATER TREATMENT
ANNUAL OPERATING COST ESTIMATE

ITEM	BASIS	AIRSTR.+GAC TREATMENT	GAC TREATMENT	ASP TREATMENT	CHEM-OX TREATMENT
LABOR	$16/HR WAGE,1.33 FRINGE MULT.	$66,400	$66,400	$88,500	$66,400
ANALYTICAL	RCRA,QRTLY PRI.POL,MTHLY VOC's,	$40,400	$40,400	$44,400	$40,400
CHEMICAL					
POLYMER	$2.00/#,FOR METALS,BIOLOGICAL	$40,800	$40,800	$61,100	$40,800
GAC-LIQUID	$1.25/#,REGENERATION+SERVICE	$282,300	$447,800	$0	$0
GAC-VAPOR	$1.25/#,REGENERATION+SERVICE	$121,000	$0	$0	$0
LIME	$90/TON;1.5g/l DOSAGE	$46,700	$0	$0	$0
HYDROCHLORIC ACID	$76/TON;1.7g/l DOSAGE	$38,700	$0	$0	$0
PHOSPHORIC ACID	$0.18/#	$0	$0	$300	$0
ANTIFOAM	$2.00/#,FOR BIOLOGICAL	$0	$0	$20,400	$0
SULFURIC ACID	$0.06/#	$0	$0	$0	$25,900
CAUSTIC	$0.15/#	$0	$0	$0	$84,600
HYDROGEN PEROXIDE	VENDOR QUOTE	$0	$0	$0	$26,000
DISPOSAL	$350/TON	$36,800	$36,800	$47,700	$36,800
UTILITIES	HISTORICAL DATABASE	$78,000	$52,100	$82,300	$250,700
MAINTENANCE	@3% TOTAL FACILITY COSTS	$61,600	$54,800	$74,900	$71,300
MISCELLANEOUS	@1.5% OF TOTAL FACILITY COSTS	$30,800	$27,400	$37,400	$35,600
DEPRECIATION	30 YEAR, STRAIGHT LINE	$68,400	$60,900	$83,200	$79,200
INTEREST	10% ANNUAL BOOK VALUE	$106,100	$94,300	$128,900	$122,700
ADMINISTRATION	HISTORICAL DATABASE	$48,000	$48,000	$48,000	$48,000
TOTAL COSTS		$1,066,000	$969,700	$717,100	$928,400
PROCESSING COSTS,$/GALLON		*$0.0131*	*$0.0119*	*$0.0088*	*$0.0114*

Waste Management of North America, Inc.
3003 Butterfield Road • Oak Brook, Illinois 60521

REPORT
TREATABILITY STUDY
CONTAMINATED SOIL AND GROUNDWATER
HAGEN FARM SUPERFUND SITE
STOUGHTON, WISCONSIN
PROJECT NUMBER 110CO

Prepared for:

WASTE MANAGEMENT OF NORTH AMERICA, INC. - MIDWEST REGION
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AQUEOUS PROCESS DEVELOPMENT - RESEARCH AND DEVELOPMENT
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SEPTEMBER 24, 1991

Final Report

Treatability Study of Contaminated Groundwater

and Soil from

Hagen Farm Superfund Site,

Stoughton, Wisconsin

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EXECUTIVE SUMMARY

The Hagen Farm Superfund Site, located in Stoughton, WI, is a closed landfill in which industrial and municipal wastes had been previously disposed. The site is currently undergoing a Remedial Investigation/Feasibility Study (RI/FS) by Warzyn Inc., of Madison, WI, under contract to Waste Management of North America (WMNA).

Based on preliminary information, remediation of the Hagen Farm site would probably involve three areas: the main disposal site; the contaminated groundwater; and soils in the saturated zone. WMNA has indicated that the remediation of the main disposal area will involve capping of the area and vapor extraction for the unsaturated (vadose) zone soils and waste for source control. Remediation mechanisms for the contaminated groundwater and the saturated zone soils were evaluated.

A treatability study was performed by the Department of Research and Development of Chemical Waste Management (CWM) to evaluate various treatment technologies and to assist U.S. EPA and the Wisconsin Department of Natural Resources (WDNR) in the selection of a proper treatment process for the remediation of contaminated groundwater and saturated soil at the Hagen Farm site. Two remedial alternatives were investigated; pump and treat, and in-situ bioremediation.

In the pump and treat alternative, groundwater is pumped to the surface through a series of recovery wells and is treated in a groundwater treatment plant prior to discharge to a receiving water or a POTW. This method will provide containment of the site as well as provide proper treatment and disposal of the contaminated groundwater.

In-situ bioremediation is a method involving not only groundwater treatment (pump and treat) but also reinjection of the treated groundwater back into the aquifer to clean up the contaminated soil and groundwater in the saturated zone. Oxygen, nutrients, and if necessary, microorganisms are added to the groundwater to promote biological activity in the saturated subsurface to degrade organics in the soil.

The treatability study for the pump and treat alternative employed conventional technologies used in water and wastewater treatment including metal precipitation, air stripping, aerobic biological treatment carbon adsorption, and UV/chemical oxidation. The treatability study results from both raw groundwater and groundwater spiked with various organics indicate that the groundwater can be effectively treated by a system consisting of metals precipitation and activated sludge treatment. A 100 gpm facility consisting of these unit operations, as well as influent/effluent storage and discharge would have a capital cost of $2,359,000, with a total processing cost of 1.19¢/gallon.

To evaluate the possibility of in-situ bioremediation for the Hagen Farm site, soil from the site was characterized for various physical, chemical and biological parameters to provide background soil information since none was available. At the same time, both soil bioreactor and soil column studies were conducted to evaluate the biodegradability of the organic contaminants in the Hagen Farm soil and to develop correlation on the rate and the extent of biodegradation between a bioreactor condition and a subsurface (column) environment.

The characterization results for the saturated zone soil sample used for the treatability studies showed little or no contamination with any of the 126 compounds on the Target Compound List. Although this soil sample may or may not be representative of the site soils, the results indicate that little or no water-insoluble and recalcitrant organics are present. Most of the organics in soil are probably the ones found in the groundwater which are biodegradable.

If saturated zone soils are not contaminated, then only groundwater would need remediation. However, if the site saturated zone soils are contaminated, then bioremediation is a potential methodology for soils treatment based on the following observations: the oxygen uptake rate (OUR) was high for the reactor receiving microbial supplement; there was sufficient total organic carbon (TOC) in the soils to support the growth of microorganisms; contaminants currently found at the site are biodegradable; and there was no metal toxicity observed during soil testing performed. If the recommended soil characterization shows that significant saturated zone organic contamination exists, an on-site field in-situ bioremediation study should be performed to better evaluate the biodegradability of the saturated zone soil and the site hydrogeology prior to full scale implementation.

1.0 INTRODUCTION

The Hagen Farm Superfund Site, located in Stoughton, Wisconsin, is owned by Waste Management of Wisconsin, Inc (WMWI). The site is now undergoing Remedial Investigation/Feasibility Study (RI/FS) for remediation and eventual closure. Warzyn Inc., of Madison, WI, is conducting the RI/FS.

The main disposal area of the Hagen Farm site is a 5.5 acre landfill which disposal of a variety of industrial and municipal wastes including paint sludge, grease, and plastic sheeting. The site is located in an area composed primarily of silty sand and gravel with a zone of clay-like material in the southeastern area of the site. Bedrock is located at depths between 46 and 80 feet below the surface. The minimum separation between refuse and the groundwater was observed to be 5 feet. Groundwater appears to be primary transport media for contaminants at the site.

Based upon information prepared by Warzyn Inc., in the June 1990 Conceptual Site Model RI/FS report, it appears that contaminants in the wastes disposed of on-site have already migrated to the underlying site soils and groundwater. The report indicates that organic compounds (primarily petrochemicals and tetrahydrofuran) are the dominant contaminants found in the groundwater, with a smaller number of inorganics (metals) also present.

The Remedial Design/Remedial Action (RD/RA) for the Hagen Farm site source control has begun and involves waste consolidation, capping of the landfill, and in-situ vapor extraction. Remediation mechanisms for contaminated groundwater and saturated zone soils have yet to be determined. At the request of WMNA and the approval of USEPA and WDNR, the Department of Research and Development (R&D) of Chemical Waste Management, Inc. (CWM) investigated the feasibility of various treatment options to remove the contaminants of concern in the groundwater and in the saturated zone soil. WMNA personnel have indicated that two remedial alternatives are to be considered for the remediation of groundwater and saturated zone soil at the Hagen Farm site. They are:

1. Groundwater pump-and-treat method
2. In-situ bioremediation

In the pump-and-treat method, groundwater is pumped to the surface through a series of recovery wells and is treated in a treatment plant prior to discharge to receiving waters or a Publicly Owned Treatment Works (POTW) (see Figure 1.1). The advantages of pump-and-treat include containment of the site and proper treatment and disposal of the contaminated groundwater. However, in many cases, this method may not treat the soil if that soil contains insoluble organics. Generally, the treatment process employs conventional technologies used in wastewater treatment, such as air stripping, aerobic biological treatment, granular activated carbon (GAC) adsorption, UV/chemical oxidation.

The second remedial alternative, in-situ bioremediation, would involve reinjection of the treated groundwater back into the aquifer in order to remediate the contaminated soil and groundwater in the saturated zone (see Figure 1.2). Oxygen, nutrients, and if necessary, microorganisms, would be added to the groundwater to promote the biological activity and degrade the insoluble organic contaminants in the soil.

In-situ bioremediation has the advantage of being able to treat the subsurface soil without excavation. However, its success depends not only upon the biodegradability of the organics in soil, but also upon the site hydrogeology. In fact, the site hydrogeology will significantly influence the oxygen and nutrient availability to the microorganisms, and is thus important to the success of the project. Therefore, field testing of this alternative is a necessary step prior to full-scale implementation.

Although site information indicates that two classes of spent nonhalogenated solvent wastes (F003 and F005) were disposed on site, the U.S. EPA has indicated that the groundwater will not be considered hazardous by the multi-source hazard code F039 (See Appendix A for correspondence regarding this matter). Therefore, residuals from any treatment or remediation will not be classified as hazardous by the F039 code.

This report describes the potential treatment processes for remediation of Hagen Farm groundwater and saturated zone soil, justifies and selects the processes analyzed for the treatability study, and discusses the procedures and results of the treatability study. Additionally, the report supplies conceptual design and process economic analyses for the remedial alternatives.

2.0 OBJECTIVES

The objectives of the treatability study were as follows:

1. Evaluate the various treatment technologies and select a proper treatment process for the remediation of contaminated Hagen Farm groundwater and saturated zone soil.

2. Propose and develop conceptual designs of the selected treatment processes for contaminated Hagen Farm groundwater and saturated zone soil, based on the results of Objective 1.

3.0 TREATABILITY STUDY APPROACH

This section analyzes potential treatment options for contaminated groundwater and saturated zone soils, and provides the basis for unit operations studied in the Treatability Study.

3.1 Pump-and-Treat (Groundwater Treatment)

Based on the initial groundwater characterization provided by Warzyn Inc., (see Table 3.1), the contaminants potentially requiring treatment in the groundwater are generally characterized as organic compounds (volatile organic compounds [VOCs], semi-volatile organic compounds) and metals.

3.1.1 Organic Compound Treatment Processes Description

The most commonly used processes for the treatment of organic compounds include air stripping, granular activated carbon (GAC), ultraviolet (UV)/chemical oxidation, and biological treatment. Each of these processes will be discussed in the following paragraphs.

3.1.1.1 Air Stripping

Removal of volatile organic compounds (VOCs) is usually accomplished by air stripping. In air stripping, organic compounds dissolved in the liquid phase are transferred to the vapor phase by the increase of the contact area between liquid and stripping gas, which is generally air. This process is most effective for compounds that are volatile and can be stripped into the vapor phase easily. The counter-current packed column is the most common type of air stripper. In the counter-current packed column, contaminated groundwater is pumped to the top of the column, distributed across its diameter and allowed to flow downward, while air is simultaneously forced upward through the column. The exhaust air from the process may require treatment with vapor phase carbon or catalytic oxidation prior to discharge.

Air stripping cannot remove nonvolatile organic compounds or volatile compounds that are very water soluble. For example, volatiles such as toluene and xylenes are easily stripped while 2-butanone (MEK) and tetrahydrofuran (THF) are not. Other treatment processes, such as GAC adsorption, are generally used in conjunction with air stripping for removal of these compounds.

3.1.1.2 Granular Activated Carbon (GAC) Adsorption

GAC is an effective treatment process for removing organics from various waste-waters because GAC adsorbs a wide variety of organic compounds. Many of the volatile and semi-volatile organics in Table 3.1 are adsorbable by GAC. However, the two main constituents, 2-butanone (MEK) and tetrahydrofuran (THF), are not as readily adsorbable as other constituents like phenol. Adsorbability is related to the compound's solubility, molecular size, and affinity for the carbon. Thus, the cost effectiveness of GAC depends on its adsorption capacity of the specific organic compounds such as THF. GAC column testing of actual waste-water is necessary to evaluate the efficiency of the process to develop design parameters.

3.1.1.3 Chemical Oxidation

Chemical oxidation uses strong oxidizing agents to react and destroy organics in groundwater. Among the generally considered oxidizing agents are chlorine, ozone, hydrogen peroxide, chlorine dioxide, and potassium permanganate. In most cases, ultraviolet (UV) light is used in conjunction with the oxidizing agents (such as hydrogen peroxide and/or ozone) to improve the oxidation process efficiency.

Recent technological innovations have increased the applications for chemical oxidation. However, chemical oxidation/UV treatment still has several limitations. The process is very slow on alcohols, ketones and aliphatic compounds and saturated volatiles. In addition, the high cost of the chemicals used and the problems with scaling and blinding of the UV lamps have yet to be resolved. The groundwater at Hagen Farm contains 2-butanone (MEK), phenol and benzyl alcohol which are difficult to treat by UV, and also contains considerable amounts of iron, calcium, and magnesium which can cause scaling on the lamps. A treatability will evaluate the feasibility of UV/H_2O_2 treatment.

3.1.1.4 Biological Treatment

Biological oxidation processes are widely used in the treatment of municipal and industrial wastewaters because of their ability to treat a large variety of water-soluble organics and the cost effectiveness of the process. Given the nature of the contamination of Hagen Farm groundwater (low concentration of substrate and high removal requirements), aerobic biological processes would provide the best results.

The most widely used aerobic technology is the activated sludge process (ASP). Process modifications, such as adding powdered activated carbon (PAC) have been used with ASP to enhance its performance with certain wastewaters. However, given the low affinity of certain constituents in Hagen Farm groundwater (namely tetrahydrofuran [THF], xylene, and ethylbenzene) to be adsorbed onto carbon, it is not believed that the use of PAC will dramatically improve the ASP process. Other process modifications for the aerobic technology are the fixed-film reactors, in which biomass attaches to the surface of packing material and forms thin films.

Anaerobic biological processes are not generally capable of removing organics to very low levels and will not be considered for this study.

3.1.2 Metals Treatment

Depending on the discharge requirements for the groundwater (NPDES, POTW, or recharge), it may be necessary to remove metals from the Hagen Farm groundwater. Also, it may be necessary to remove metals (and solids) from a wastewater to improve the efficiency of organic treatment processes. Groundwater metals data for Hagen Farm are provided in Table 3.2. The metals which might cause treatment/ discharge concerns detected in the initial characterization of Hagen Farm groundwater include iron and manganese. Commonly used treatment methods for these metals are chemical precipitation and air oxidation precipitation, ion exchange, and reverse osmosis.

3.1.2.1 Metals Precipitation

Metals removal can be accomplished through hydroxide, sufide, carbonate or phosphate precipitation. The most common form is hydroxide precipitation, which typically uses chemicals such as lime or sodium hydroxide. Lime and sodium hydroxide raise the pH, forming relatively insoluble metal hydroxides which can be removed by settling and filtration.

For removal of manganese and iron, precipitation by air oxidation can also be used. In many groundwaters, the iron is normally all in the ferrous (Fe^{+2}) form and the manganese is in the bivalent state (Mn^{+2}). The ferrous (Fe^{+2}) form and bivalent manganese (Mn^{+2}) form are soluble and readily converted to the more insoluble ferric (Fe^{+3}) and quadrivalent manganese (Mn^{+4}) salts through aeration. They can then be removed in subsequent treatment processes such as sedimentation or filtration.

3.1.2.2 Ion Exchange

Ion exchange is a process in which ions, held by electrostatic forces to charged functional groups on the surface of a solid are exchanged for ions or similar charge in a solution in which the solid is immersed. Ion exchange is used for ultra high quality water treatment, primarily as a secondary or tertiary metals treatment process for water. Synthetic resins are presently used for most ion exchange applications. The potentially large flow and relatively high metals concentrations of the Hagen Farm groundwater make the use of ion exchange uneconomical.

3.1.2.3 Reverse Osmosis

Reverse osmosis (RO) is a process in which water is separated from dissolved salts in solution by filtration through a semi-permeable membrane at a pressure greater than the osmotic pressure caused by the dissolved salt in water. RO has the advantage of removing dissolved solids such as chloride and metals that are less selectively removed by other techniques. RO's principal disadvantages are that it is not designed specifically to remove metals, it generates waste brine that requires further processing prior to disposal, and it is expensive. Since the predominant metals in Hagen Farm groundwater can be removed by less expensive processes, RO was not considered for Hagen Farm groundwater treatment.

3.1.3 Groundwater Treatment Technology Summary

Based upon the above available treatment technologies, the following conclusions can be drawn regarding the treatment of Hagen Farm groundwater:

1. The potentially viable groundwater organic treatment technologies for Hagen Farm include air stripping, GAC adsorption, biological treatment, and UV/chemical oxidation.

2. Metals precipitation by chemical addition or air oxidation may be needed to remove iron, manganese, arsenic, barium and lead from Hagen Farm groundwater.

The treatability study performed analyzes these technologies for their treatment efficiency and economic viability.

3.2 In-situ Bioremediation

There are a variety of remediation options for the clean-up of contaminated groundwater/soil which include such general technologies as biological, physical/chemical, immobilization, thermal, and in-situ treatment. Even for in-situ treatment of soils alone, there are various technologies available including vapor extraction, soil flushing, in-situ solidification/stabilization, in-situ vitrification, and bioremediation. Selection of treatment options depends on various factors including site characterization data such as types of contaminants and their concentrations, types of soils and corresponding hydrogeological conditions, and applicability and cost effectiveness of the technologies. In-situ bioremediation has the advantage over a simple pump-and-treat system because it has the potential to remove more of the insoluble organics adsorbed to the soil.

Soils at the Hagen Farm site which have been in contact with contaminated groundwater from the disposal area may contain a variety of the organics. Some preliminary soil tests had been performed on selected Hagen Farm soil borings (see Warzyn report number 13452 - RI/FS Technical Memorandum - Number 1, 3/89). However, the results were limited to only soil moisture, type of soil, etc. Evaluation of the available soils characterization data indicate that in-situ bioremediation appears to be a viable treatment option based upon the following facts regarding the Hagen Farm site:

1. The depths of the soils in the saturated zones, which range from a minimum of 5 ft to a maximum of 46 to 80 ft below surface, dictate the use of in-situ treatment technology.

2. The major contaminants in the groundwater (and possibly the soils) include volatiles such as 2-butanone (MEK) and THF and semivolatiles such as phenol which are all very biodegradable.

3. Preliminary soil permeability tests indicate a favorable soil hydraulic conductivity for the transfer of nutrients and oxygen and/or surfactants into the saturated zone soils. In addition, soil flushing is not needed since pump and treat will already provide flushing of the organics.

4. Reinjection of treated groundwater from an on-site above-ground biological

treatment system could possibly provide a source of bioaugmented, nutrient supplemented water source for an in-situ treatment of the soils in the saturated zone.

5. In-situ bioremediation, if applicable, is very cost effective, compared to other soil remediation technologies.

Bioremediation processes are biological treatment processes that improve or stimulate the metabolic capabilities of microbial populations to degrade organic residues. The processes take into consideration the factors that affect microbial activity and modify the existing conditions so that microbial degradation can occur. For example, if inadequate nitrogen or phosphorus are available, such nutrients can be added to assure satisfactory microbial degradation. If the residues are too toxic, addition of other chemicals or uncontaminated soil may reduce the toxicity to the point that microbial degradation can occur. If inadequate type or numbers of microorganisms are naturally present, acclimated organisms can be added.

Generally, in-situ soil bioremediation uses treated water to introduce bacterial culture directly into contaminated soils and aquifers. Nutrients (nitrogen and phosphorus) and oxygen in the form of H_2O_2 are also added to provide the essential ingredients for microbial biodegradation of organics in the subsurface. The site hydrogeology significantly affects the transfer and the availability of the nutrients and oxygen as well as the availability of microorganisms for the biodegradation of organics in saturated zone soils. A treatability study in the laboratory can only evaluate the possibility of metals inhibition, the biodegradability of the organics, the requirement for nutrients, and the need for the addition of bacterial cultures to enhance biodegradation. It can not evaluate the site hydrogeology. Thus, field testing is a necessary step prior to full-scale implementation, if in-situ bioremediation is a viable alternative.

4.0 TREATABILITY STUDY PROTOCOL

This section describes the sampling, equipment operating and analytical procedures, as well as the quality assurance/quality control policy used during the performance of the treatability study. The treatability study involved investigation of the treatment processes selected for consideration for remediation of groundwater and saturated zone soil. Groundwater treatability work utilized both spiked and nonspiked (with site target compounds) Hagen Farm samples. The soil treatment study was conducted using screened nonspiked soils. The soil samples were not spiked for the following reasons: (1) there was no previous contamination history upon which to determine the spiked concentration; and (2) it would not be appropriate to spike the soils with the major organic compounds found in Hagen Farm groundwater (such as tetrahydrofuran and phenol) because these compounds are water soluble and would be treated in the groundwater treatment scheme.

4.1 Quality Assurance/Quality Control (QA/QC) Analytical Procedures

In order to ensure accurate, valid data, QA/QC procedures were used throughout the study. CWM has developed and implemented a QA/QC program to provide defensible data on a timely basis. All company laboratory and sampling personnel are required to participate in this program. The CWM R&D laboratory performs instrument control checks daily and uses quality control samples for instrumentation and wet chemistry for bench scale process monitoring parameters. Samples were analyzed in accordance with EPA Test Method for Evaluating Solid Waste (SW-846), Third Edition and Standard Methods, 17th Edition.

Contract laboratories employed by CWM must also demonstrate quality control practices certified by CWM at least as stringent as CWM's program. EMS Heritage Laboratories, Inc., in Romeoville, Illinois was contracted for all nonroutine analytical work.

The groundwater quality varied widely during the treatability study. However, no adjustment was made for the study because the fluctuation in groundwater quality was identical to the full-scale situation.

4.2 Pump and Treat with Non-Spiked Groundwater

Several bench scale studies were performed to investigate metal and organic treatment of the Hagen Farm groundwater. As mentioned in the previous sections, air stripping, carbon adsorption, biological treatment, UV/chemical oxidation and metal precipitation were studied. A description of the procedures used in studying these candidate unit operations follow.

4.2.1 Sampling

The groundwater sampling, which was performed every two weeks for 14 weeks, produced 7 sets of samples. All samples were taken from Monitoring Well 22 by Warzyn Inc., personnel. During each sampling event, groundwater was pumped for about 10 minutes before collection to allow water quality to stabilize. Two 40 ml samples were collected for volatile organics analysis and 105 gallons were collected for the treatability studies.

Seven 15-gallon buckets were used for each sampling. Each bucket was sealed with tape and placed inside a 30-gallon drum overpack for shipment. The overpacks were filled with an absorbent material (corn cobs) and shipped to CWM's Geneva Research Center (GRC). The VOC samples were shipped in a cooler packed with ice packs and accompanied the drum shipment.

4.2.2 Air Stripping

Groundwater underwent air stripping tests in a bench-scale packed tower air stripper as diagrammed in Figure 4.1. The packed tower stripper was filled with contaminated groundwater and air was blown up through the packing in the tower. The design of the bench scale stripping test (size, packing type, height/width ratio, reactor/packing diameter ratio, and air/water flow ratio) enabled the scale-up of the results for the design of a full-scale packed bed air stripper.

The inlet air flow rate to the air stripper was controlled at 20 cubic feet per hour (CFH) to the seven-liter glass reactor. The packing media in the bench-scale air stripper was 5/8" pall rings with a specific surface area of 104 ft^2/ft^3. This resulted in a reactor/packing diameter ratio of about 10 to 1.

The performance of the stripper was evaluated over a range of 25 to 200 cubic feet of air to cubic feet of water. Each test lasted about 2 hours. The differences between influent and effluent VOC concentrations were used to estimate the VOCs in the vapor phase and to design a vapor phase carbon unit. Samples were taken of the tower initially and after treatment and analyzed for VOCs (see Table 4.1 for specific VOCs analyzed). Very little semi-volatile organic compounds were expected to be removed by air stripping and thus were not analyzed.

4.2.3 Aqueous Phase Carbon Adsorption

Untreated groundwater from the Hagen Farm site was treated in a fixed-bed GAC column as shown in Figure 4.2. Groundwater was applied at a constant rate to the top of a 2-inch diameter reactor containing approximately 500 ml of GAC. The effluent was collected over the 1 week test period for each sample and analyzed for the VOCs, semi-VOCs, and inorganic compounds listed in Table 4.1. In addition, the initial and final samples were analyzed for the parameters listed in the Target Compound List (Appendix B) as well as for alkalinity, chloride and sulfate. The adsorptive capacity of the carbon was determined from the breakthrough curve data generated from the column study.

4.2.4 UV/Peroxide Oxidation

Groundwater from Hagen Farm site was treated in a bench-scale UV test apparatus as shown in Figure 4.3. Peroxide was added at a dosage of 500 mg/l to a reservoir containing the groundwater to be tested. The feed pump was then started which circulated the groundwater through the UV reactor and back into the reservoir thus providing continuous mixing of the feed tank. For certain tests, the groundwater pH was adjusted to approximately 5 and catalyst in the form of ferrous ammonium sulfate was added to promote chemical oxidation reaction.

For each test run, samples of tested groundwater were collected at predetermined retention times and characterized for the VOC's and semi-VOC's listed in Table 4.1.

Samples from Hagen Farm were also sent to two UV/peroxide system vendors, PURUS, Inc. and Peroxidation System, Inc., for treatability testing. The results from these tests were used to provide cost information for a full scale system for Hagen Farm groundwater treatment.

4.2.5 Biological Treatment

Groundwater was treated in a bench-scale continuous flow activated sludge biological reactor as shown in Figure 4.4. Air was supplied to a 6.4 liter reactor through an air diffuser at the bottom. The reactor was operated for more than 12 weeks to evaluate the treatability of the groundwater and to develop scale-up information for full-scale design. The effluent was analyzed for all the VOCs, semi-VOCs, and inorganic *compounds listed in Table 4.1. In addition, the initial and final samples were analyzed* for the parameters listed in the Target Compound List (Appendix B) as well as for alkalinity, chloride and sulfate.

4.2.6 Metal Precipitation

Groundwater was tested in a series of batch tests for metal removal as shown in Figure 4.5. Samples were taken prior to and after treatment, and analyzed for metal contaminants (see Table 4.1 for the list of metal constituents to be analyzed). Three additional metals (manganese, calcium and magnesium) were also analyzed. Two chemicals, sodium hydroxide and lime, were used to form and precipitate insoluble metal salts. Chemical dosages were optimized during these tests to determine the most effective dosage(s) of chemicals for metals removal.

In order to investigate iron and manganese removals by air oxidation, samples of groundwater were purged with air. Samples were then taken at 15, 30, 45, 60, 75 and 120 minutes of aeration time and analyzed for total suspended solids (TSS), pH, iron, and manganese measurements.

4.3 Pump and Treat with Spiked Groundwater

Since groundwater quality can vary widely from one location and one sample to another, the groundwater sample used for the treatability study might not reflect the actual characteristics in the groundwater. The treatability study was repeated with the groundwater spiked with the representative concentrations of organics found in the Hagen Farm groundwater. All experimental procedures remained the same using groundwater spiked with organics at concentrations listed in Table 4.2. Since the samples were not spiked with metals, no further metal precipitation testing was performed. The concentrations of these spiked compounds were selected from the higher value of the historic concentrations in the initial characterization by Warzyn Inc., or Wisconsin Public Health Groundwater Quality Standards - NR 140 PAL.

4.4 In-situ Bioremediation

Bench-scale treatability studies for the bioremediation of saturated soils contaminated with organics are normally conducted to provide information concerning the feasibility of their biodegradation. This study utilized bench-scale soil bioreactors to obtain information on the biodegradability (rate and extent of biodegradation) of contaminants in Hagen Farm soil within a relatively short period of time. Soil bioreactors can provide results much more quickly than can other laboratory tests such as land treatment studies (soil tilling) or composting studies because an optimum growth environment is provided in the reactor. In addition to the soil bioreactors, soil columns were set up to obtain information on the degradation potential of the contaminants under conditions more indicative of those encountered in field in-situ treatment than in the well-mixed reactors. Soil column treatment using Hagen Farm soil would provide some information on the availability of soil contaminants in subsurface conditions for in-situ treatment.

The soil bioreactor and soil column studies were designed to evaluate the following parameters in two different growth environments (a bioreactor condition and a subsurface condition):

- Rate and extent of biodegradation for various organic contaminants such as THF, xylene, phenols, etc.
- Nutrient requirement (nitrogen and phosphorus)
- Oxygen source (aeration versus H_2O_2)
- Microorganism requirement (addition of commercially available bacterial culture)

The rate and the extent of bioremediation for the major contaminants in two different environments are of significant value. Not only would the feasibility of bioremediation, the time and other requirements necessary for the successful biodegradation of organics be determined, but also the relative rate of degradation between a bioreactor condition and a subsurface environment could be established. The oxygen source requires evaluation since both aeration and hydrogen peroxide addition have been successfully used in in-situ bioremediations. Bacterial populations were monitored to see the effect of oxygen source and nutrient addition on indigenous and supplemental microorganisms. With sufficient nutrient and oxygen, a microbial population size will respond to available biodegradable substrate(s). The study was also designed to evaluate the change in biodegradability due to the addition of supplemental microorganisms. Finally, the need for nutrient addition (nitrogen and phosphorus) to the indigenous microorganisms alone was evaluated.

The information from these bench-scale treatability studies should be used in conjunction with site hydrogeological and soil characterization information in order to develop the field pilot-scale testing requirements for in-situ bioremediation. Site characterization, which includes soil characteristics, subsurface hydrogeology, and microbial characteristics may limit the rate and/or extent of treatment of the contaminated zone even when a bench scale biodegradation study shows promising results. Therefore a thorough site characterization may be necessary to determine both the extent of contamination as well as engineering constraints and opportunities.

4.4.1 Soil Collection and Characterization

The soil sample received at the Geneva Research Center (GRC) from the Hagen farm site was collected from bore hole BTB-1 at depths of 10 to 30 feet by Warzyn Inc. As previously noted in Section 3.2, the sampling methodology did not require the retention of volatile constituents of concern in the sample, as the feasibility of in-situ biodegradation is governed by the slower degradation rates of more recalcitant and generally less water soluble, less volatile organic compounds. The soils were collected at the site using an auger and delivered to the GRC in 3 x 5 gallon buckets (approximately 2 cu. ft. total soil volume). This soil was subsequently screened through a 1/4 inch mesh screen to remove coarse material which could not be suspended in the soil bioreactor. Two-thirds of the soil by weight passed the screen (90 kg) and the remaining one-third (gravel) was retained on the screen. Material passing the screen was used for the soil characterization and for the bioreactor and soil column treatability studies.

The screened soils were characterized for the physical, chemical and microbiological parameters listed in Table 4.3. Information from these tests was used for several purposes. The hydraulic conductivity (or permeability) of the soil determines the ability for liquid transport through the soil to deliver nutrients or oxygen to the saturated soils and allow movement of microbes. As the hydraulic conductivity of a soil is directly related to its texture (e.g. sandy soils generally have higher saturated conductivities

4.4.3 Soil Column Study

Column studies were initiated to obtain information on the degradation potential of the contaminants under conditions more indicative of field in-situ biotreatment than the well-mixed reactors. The three bench-scale columns were designed to evaluate the following parameters:

- Biodegradability of specific organic contaminants under subsurface conditions,
- Presence of indigenous microorganisms, and
- Requirement for an external source of microorganisms

Each of the 3.5 inch diameter soil columns contained compacted screened soil bounded by 3 to 4 inch upper and lower gravel beds. The reason that screened soils were used in the soil columns was to have identical soils in both soil columns and bioreactors so that results could be directly compared and correlated. The lower gravel beds rested on a felt geotextile, which in turn rested on a plastic support with drain holes. Figure 4.7 shows the three soil column setups. Each soil column was packed using 10 pounds of wet screened soil compacted with a weight to a density of approximately 150 lbs./cubic foot. Tap water was introduced to the top of each column to saturate the column and measure the column effluent rate. When a 4 inch head of water did not produce effluent from any of the three columns, a vacuum was applied to one column to force a flow. However, even with the applied vacuum, column effluent was virtually non-existent.

As a result, a smaller column (1 inch diameter) was set up with loosely packed soil to determine if water would flow under these conditions. A minimal water flow was seen in this loosely packed soil column. The column was then backflushed and allowed to settle to repack the soil. Again, no flow was observed from the column. As it appeared that the soil density as well as fraction of fines in the soil was significant enough to preclude sufficient water flow through the column for sampling, the soil column study was discontinued. Although these results indicate that the screened soil would not provide conducive environment for in-situ bioremediation, the original unscreened soil sample (which consisted of a third of gravel larger than 1/4 inch diameter) may have different characteristics for in-situ applications. The preliminary field hydraulic conductivity results from Warzyn's investigation seem to indicate that is the case. Field testing of this process is recommended.

5.0 RESULTS AND DISCUSSIONS

5.1 Pump-and-Treat with Non-spiked Groundwater

The treatability study was conducted on groundwater samples every two weeks shipped from the Hagen Farm Superfund site. The study results are presented and discussed in the following sections:

5.1.1 Groundwater Characterization

Table 5.1 shows the results of the initial characterization of the Hagen Farm groundwater. Only the parameters with concentrations above detection limits are discussed here. The COD value of 390 mg/L is much higher than the previously reported value of 75 mg/L. The ammonia and phosphorus concentrations indicate that phosphorus may be limiting if the groundwater is to be treated by a biological treatment unit.

Metal results show that the high calcium (200mg/L), iron (27mg/L) and magnesium (80mg/L) concentrations could cause plugging problems for air stripping, carbon adsorption, and/or attached-growth biological processes if not properly removed. As a result, pre-treatment for metal removal may be necessary. In an aerobic suspended-growth biological unit, iron and manganese may be oxidized and precipitated, thus no pre-treatment may be required. However, if metals accumulate to high levels in the reactor, then pretreatment may still be needed to ensure process stability.

Only three VOCs were detected in the groundwater sample, which confirms the previous finding that ethylbenzene, tetrahydrofuran and xylene (total) are of significant quantity in the groundwater. All three compounds are highly biodegradable and should be easily removed biologically.

5.1.2 Air Stripping

The analytical results of the bench-scale air stripping test are attached as Appendix D and summarized in Table 5.2. Table 5.2 shows that only tetrahydrofuran (THF) and xylene (total) were of significant concentrations in the groundwater tested. In Table 5.2, 97% of xylene was stripped at an air/water ratio of 25 and 99.9% at a ratio of 150, whereas THF was only removed by 40% at an air/water ratio of 150. Figure 5.1 shows the VOC concentrations versus different air/water ratios. This test further confirmed that soluble compounds, such as THF, cannot be stripped easily.

The presence of the soluble organic compounds, (e.g. THF), makes it necessary to add an additional treatment process after the air stripper, if air stripping is to be used. However, these soluble organic compounds are fairly biodegradable and should be easily removed by a biological unit, such as an activated sludge unit or liquid phase GAC. A vapor-phase GAC adsorption or catalytic oxidation unit may be needed to reduce VOC emissions and would raise the overall cost for the treatment. Furthermore, the possibility of plugging by metal precipitates means that pre-treatment may be required that could make this process less economical.

5.1.3 GAC Adsorption

A lab-scale GAC column was used to evaluate the GAC adsorption capacity for the Hagen Farm groundwater. The GAC study was conducted to study the breakthrough characteristics of contaminants of concern in the groundwater. The reactor design was based on an empty bed contact time (EBCT) of 30 minutes and a total GAC volume of 500 ml.

The test was designed to treat the Hagen Farm groundwater which had received no pre-treatment. The test was terminated after only 1 day of operation because the flow was severely restricted to half of its original rate in a day. It became apparent that suspended solids or metals had plugged the GAC and reduced the reactor capacity. Therefore, a pre-treatment unit would be needed to remove suspended solids in a GAC column influent to preserve GAC adsorption capacity. The suspended solids in the groundwater can be retained by a clarifier or a sand filter. Metal precipitation would be required to remove the metals in the groundwater prior to the

GAC unit.

A GAC pump test for the Hagen Farm groundwater was conducted previously by Warzyn Inc., in December, 1990. Raw groundwater with no pre-treatment was used for the test, which occurred over ten days. Results of the test showed that GAC can effectively polish the groundwater and that the GAC adsorptive capacity for THF is about 4.5 mg THF/g GAC.

Since the groundwater contains suspended solids and metals that plugged the GAC column in the bench test, the test was repeated with groundwater pre-treated with air oxidation and filtration. In addition, the filtered groundwater was spiked to ensure that all contaminants were properly considered in the test. This test was completed and the results of which are presented in Section 5.2.3 of this report.

5.1.4 *Biological Treatment*

A 6.4 liter bench-scale activated sludge reactor was used for the Hagen Farm groundwater. The reactor was operated at a food-to-microorganism (F/M) ratio of about 0.1 gCOD/gVSS·d. The solids retention time (SRT) of the reactor was controlled at 65 days.

Phosphorus was added for microbial nutritional requirements in the form of phosphoric acid, which was also used to adjust the reactor pH to below 8.0. The reactor was monitored daily for temperature, DO and pH. Influent and effluent CODs were measured every other day, while influent and effluent BODs were monitored once every two weeks. Two sets of data shown in Table 5.3 were collected after the reactor reached steady-state operation.

BOD removals were over 92% with an effluent BOD of less than 4 mg/L indicating a good system performance. TSS in the effluent was also very low in the single digit range reflecting a well-operated high SRT system. Table 5.3 shows the good removals of VOCs and semi-VOCs. Two major compounds, THF and xylenes, were removed to below detection limits.

Figure 5.2 shows data for the mixed liquor suspended solids (MLSS) and mixed liquor volatile suspended solid (MLVSS). The MLSS increased from 6000 mg/L to about 16,000 mg/L, while MLVSS only increased by about 1000 mg/L. According to Figure 5.2, the rate of inert solids accumulation was about 270mg/L·day, which will interfere with aeration if not controlled properly. The most likely source of these inert solids are inorganic particulates in influent, such as clay particles, and/or iron and manganese precipitates. It is likely that a shorter SRT may reduce the solids build-up in the reactor. However, the shorter SRT will result in a higher F/M ratio and compromise the effluent quality. Consequently, a pre-treatment unit such as coagulation, flocculation and clarification for efficient TSS removal, is recommended prior to the activated sludge system. This pretreatment may also be used for metal removal by adding pH chemicals such as lime and NaOH, or allowing for air oxidation to induce metal precipitation.

5.1.5 UV/Chemical Oxidation

Two UV/peroxide tests were conducted on the Hagen Farm groundwater. The test conditions for these 2 runs are shown in Table 5.4. In both tests, a peroxide dosage of 500 mg/l was used. The reason that this dosage was selected was that oxidation of organics only improved lightly with a dosage about 500 mg/l. In Test 2, pH was adjusted to 5 and ferrous ammonium sulfate was added as a catalyst at a dosage of 3.6 mg/l as Fe to promote oxidation reaction.

The data are summarized in Table 5.5. The analytical results show that none of the 59 VOCs and 78 semi-VOCs analyzed were above detection limits and only acetone and bio(2-thylhexyl) phthalate were detected in the treated effluent. These values are inconsistent with previous work and with the characterization results from the two UV/peroxide system vendors who had detected a high level of THF and xylenes in the

Hagen Farm groundwater samples. After careful evaluation, it is deemed that the description of these results is probably a result of laboratory errors and the analytical data will not be used.

The data from vendors show that UV/peroxide oxidation of THF and xylenes were feasible. These results are summarized in Table 5.6. The test conditions to achieve these results included pre-filtration of the groundwater and UV/oxidation at a pH of 5.0 with a H_2O_2 concentration of 200 mg/l. It also showed that there was very little benefit to using catalyst. These operating conditions will be used for sizing a full scale UV/peroxide system and for developing cost estimates for a UV/peroxide system for comparisons with other treatment technologies in Chapter 6.

5.1.6 Metal Removal

Metal precipitation tests were conducted with sodium hydroxide and lime. The test was performed with sodium hydroxide using a jar test apparatus. Table 5.4 summarizes the test results at various hydroxide dosages and indicates that iron and manganese can be removed to acceptable levels at pHs between 8.4 and 9.3. Since sodium hydroxide is more costly, the test was repeated with lime (see Table 5.5). Table 5.5 shows comparable results for iron and manganese in the pH range tested.

Based on the test results, a metal precipitation process operated with lime addition to pH 9 or above should sufficiently remove inorganics such as Fe and Mn (and other metals) as well as inert solids from the groundwater and prevent them from contributing to the inert solids build up, or plugging problems.

An air oxidation test was also conducted to evaluate the feasibility of simple aeration *to oxidize* Fe^{+2} *to* Fe^{+3} *which can then be removed by precipitation and/or filtration.* Thus, samples were taken over the aeration time of 120 minutes for iron analysis and the results are shown in Figure 5.3. The results show that at least 60 minutes of aeration time would be required to oxidize and remove over 25 mg/L of Fe to below

3 mg/L.

5.1.7 Non-Spiked Groundwater Treatability Study Summary

The experimental results can be summarized as follows:

1. Results of initial characterization of Hagen Farm groundwater show that THF, xylenes and ethylbenzene are detected in significant concentrations. In addition, iron and manganese are the two metals which have high concentrations and may cause difficulties for subsequent treatment processes.

2. Air stripping alone cannot remove the major contaminant, THF, and thus is not a preferred process in Hagen Farm groundwater treatment without additional treatment processes.

3. Due to the solid plugging problem, GAC column testing was stopped prior to test completion. A separate test involving air oxidation and clarification pretreatment followed by GAC column adsorption for the spiked groundwater was subsequently conducted. The results of this second test are presented in Section 5.2.3 of this report. A previous treatability study showed that the adsorptive capacity of GAC is about 4.5 mg THF/g GAC, which is a relatively low adsorption capacity for organics.

4. An activated sludge unit which was operated at 0.1 gCOD/gVSS·d (65 days SRT) removed most organics from the Hagen Farm groundwater. BOD and TSS values in the effluent were consistently less than 10 mg/L indicating good operation and good performance. However, inert solids appeared to accumulate in the reactor and they may hamper the treatment operation in the long run. Thus, a pre-treatment unit to precipitate metals, (mainly Fe and Mn), and TSS is required.

5. Metal precipitation tests exhibited good removal of metals. In the test

conducted with lime, iron and manganese were removed to low levels. In addition, arsenic and barium were both removed to satisfactory concentrations. Air oxidation induced precipitation also performed well on Hagen Farm groundwater.

5.2 Pump-and-Treat with Spiked Groundwater

The treatability study was repeated with Hagen Farm groundwater spiked with various organics at concentrations listed in Table 4.2. The purpose of spiking was to simulate the worst case scenario of the groundwater chemical constituent concentration. The results are presented and discussed in the following sections.

5.2.1 Spiked Groundwater Characterization

The Hagen Farm groundwater was spiked using concentrated stock solution prior to the treatability testing. Groundwater concentrations before and after the spike are listed in Table 5.9 for compounds of concern. Table 5.9 shows the similar concentrations for both the target and the actual measurements. It also shows the difficulties of spiking to low levels, because the detection limits of several compounds are higher than the added concentration. In addition, the volatile nature of some compounds made emission losses unavoidable during the preparation process.

5.2.2 Air Stripping

The analytical results of the spiked air stripping test are summarized in Table 5.10. THF was present at high concentrations. Unlike the previous (unspiked) test, MEK was also present in significant concentrations. Even at an air/water ratio of 150, THF and MEK were only partially removed, confirming that air stripping cannot adequately remove soluble VOC's such as THF and ketones from the Hagen Farm groundwater.

Figure 5.4 shows the THF and MEK concentrations in the effluent of the air stripping test using spiked groundwater. Concentrations of both organics decreased at the beginning and stabilized after 60 minutes of operation. Results of this test show the same trend as those of the tests conducted with non-spiked groundwater.

5.2.3 GAC Adsorption

Prior to the GAC adsorption test, the groundwater was pretreated with air oxidation to remove iron in order to minimize the plugging problem previously encountered in the unspiked GAC tests. Groundwater samples were aerated for four hours and followed by settling to remove the solids which eliminated the potential for GAC column clogging.

The results of the GAC test are shown in Table 5.11. The results show that THF was the only VOC and bis(2-ethylhexyl) phthalate the only semi-VOC detected in the effluent. Bis(2-ethylhexyl)phthalate appeared to be non-adsorbable since there was an immediate breakthrough of this organics in the carbon column. Therefore, GAC might not be suitable for the groundwater if bis (2-ethylhexyl) phthalate concentration is present above the discharge limit.

The breakthrough curve for THF is plotted in Figure 5.5. The corresponding THF adsorptive capacity for GAC is calculated to be 19 mg THF/g GAC at an influent concentration of 55,000 µg/l. The THF adsorption capacity determined in this study, along with the value of 4.5 mg THF/g GAC for an influent of 18,500 µg/l, determined in the previous pump test study, will be used to design a GAC adsorber. A value of 10 mg THF/g GAC will be used for the design of the GAC system for Hagen Farm groundwater. Since the adsorptive capacity of GAC increases linearly with the influent THF concentration, 10 mg THF/g GAC is selected for the process design. This value is an estimate interpolated from the two experimental values.

5.2.4 *Biological Treatment*

The bench-scale activated sludge reactor was operated with spiked groundwater for over one month under the same conditions as those for the non-spiked groundwater. After achieving steady-state, two sets of samples were collected. The results of this test are summarized in Table 5.12. The results were very similar to the non-spiked test: BOD concentrations in the effluent were lower than 5 mg/l, indicating good treatment efficiency. No VOCs were detected in the effluent, and bis(2-ethylhexyl) phthalate was the only semi-VOC detected in the effluent. However, the phthalate concentration was very low.

The biological sludge was not characterized for TCLP compounds. However, the full-scale treatment system design was based on the assumption that the sludge was hazardous.

5.2.5 Spiked Groundwater Treatability Study Summary

The experimental results can be summarized as follows:

1. The spiked concentrations were fairly close to the target concentrations for the Hagen Farm groundwater.
2. The air stripping test confirmed the previous findings that soluble VOC's such as tetrahydrofuran and methyl ethyl ketone are not very strippable. Thus, air stripping is not a preferred process for treating Hagen Farm groundwater without additional treatment processes.
3. The GAC column study showed that the adsorption capacity of GAC for THF is low at a high concentration. The study confirms our previous results for non-spiked groundwater. Bis(2-ethylhexyl)phthalate was found to be non-adsorbable even at a low concentration (10 μg/L or less).
4. The activated sludge study for the spiked groundwater resulted in BOD concentration of less than 5 mg/L and TSS less than 10 mg/L, indicating a very good process performance.

5.2.6 Groundwater Treatability Study Conclusions

Based on the results from both studies, four possible treatment trains can properly treat the Hagen Farm groundwater. They are as follows:

1. Metal Precipitation + Air Stripping + GAC Adsorption

2. Metal Precipitation + GAC Adsorption
3. Metal Precipitation + Activated Sludge
4. Metal Precipitation + UV/Chemical Oxidation

The cost analysis for these three options will be discussed in Chapter 6 of this report. Actual water quality of extracted groundwater during full-scale operation may be less contaminated than the water sample used in the treatability study, because groundwater will be collected over a much larger area having lower concentrations of certain compounds than were observed at monitoring well MW22. The actual water quality and treatment costs will determine which treatment train to choose and if individual unit processes, such as metal precipitation, are necessary.

5.3 In-situ Bioremediation

5.3.1 Soil Characterization

Physical Characteristics

Laboratory hydraulic conductivity (permeability) studies were conducted at the Geneva Research Center to estimate the permeability of soil from the Hagen Farm site which was used in the column studies. Measurements were obtained in triplicate for the screened Hagen Farm soil using the triaxial-cell method with backpressure (SW-846 Method 9100, Section 2.8). The data tables for the three hydraulic conductivity measurements are attached in Appendix E.

The hydraulic conductivity of the screened soil as determined by this method was in the range of 10^{-4} cm/sec. This range is within the range of values for unconsolidated deposits such as glacial till, silty sand and silt (loess)[1]. However, it is an order of magnitude lower than the average of the values for the 18 wells at the Hagen Farm Site by Warzyn Inc. in March, 1989 (compare 1×10^{-4} cm/sec to the average value

[1]Freeze, R. Allan and John A. Cherry. Groundwater. Prentice-Hall, Inc., Englewood Cliffs, NJ, 1979. p 29.

of 4.1 x 10^{-3} cm/sec). The screening of the soil sample to remove coarse pebbles larger than 1/4" during the study might have impacted the permeability since the lab soil columns did not produce effluent at a permeability in the 10^{-4} cm/sec range. Normally a permeability value of approximately 10^{-3} cm/sec is conducive to in-situ bioremediation. It is recommended that field hydraulic conductivities be performed as part of any in-situ field bioremediation studies.

The average bulk density of the soil used in the triaxial cells was measured at 2.12 g/cm^3 (132 lbs/ft^3). This value is comparable to the earlier density value of 150 lbs/ft^3 to which the soils were compacted in the columns (see Section 4.3.3).

A combined sieve/hydrometer analysis was performed on the soil using ASTM D-422 procedure for particle size analysis of soils (see Appendix F). Particle size sieving was used to determine the percentage of gravel, the various sand fractions and a combined silt/clay fraction. The hydrometer analysis was used to determine the separate percentages of sand, silt and clay. Sieve size was chosen based on the United States Department of Agriculture (USDA) soil particle classification. Approximately 83 percent of the soil was sand and gravel, 14 percent was silt, and 3 percent was clay, which classifies the soil as a loamy sand based on the USDA soil texture triangle classification. This again is an indication of the good potential for in-situ bioremediation application at the Hagen Farm Site.

Table 5.13 summarizes the results discussed above for soil characterization.

<u>Chemical Characteristics</u>

The soil sample received at the Geneva Research Center (GRC) from the Hagen farm site was collected from bore hole BTB-1 at depths of 10 to 30 feet by Warzyn Inc. As previously noted in Section 3.2, the sampling methodology did not require the retention of volatile constituents of concern in the sample, as the feasibility of in-situ biodegradation is governed by the slower degradation rates of more recalcitant and generally less water soluble, less volatile organic compounds.

The screened soil sample was characterized for the 126 compounds in the Target Compound List. Analytical results for the compounds detected in the screened soil sample are presented in Table 5.14. These results show there is little or no detectable concentrations of insoluble and recalcitrant organics in the original screened soil sample; all organic parameters except for acetone (measured at 70 μg/kg wet weight basis) and bis (2-ethylhexyl) phthalate (measured at 360 μg/kg wet weight basis) were below detection limits. However, this single sample should not be considered as representative of site soils. A more comprehensive soil survey may be performed to determine soil contaminants and concentration levels in the saturated zone. Some heavy metals were present in the soil, however, as discussed in later sections, no metal toxicity was seen during the bioreactor study. Unfortunately, due to the time constraint of the study, both the soil biodegradation study and the column study were initiated before the results of the original soil concentrations were available.

Microbiological Enumeration

Microbial populations need to be monitored to see the effect of oxygen source and nutrient addition on indigenous and supplemental microorganisms. With sufficient nutrient and oxygen, the heterotrophic population should respond to available substrate(s). These substrates can include organic compounds on the Target Compound List (TCL), as well as existing biodegradable soil organic matter such as sugars or proteins. 'As there was very little or no contamination of the soil with compounds on the TCL, total heterotrophs (aerobic and facultative anaerobic microorganisms which can degrade a wide variety of organics) were analyzed to determine the general bacterial population density. Results of a total heterotrophic plate count on the original soil sample collected in the saturated zone at a 10 - 30 foot depth showed there to be some microbiological activity in the soils for oxygen-utilizing bacteria. The total plate count was 1.6×10^5 cfu/g dry soil. There appears to be a significant bacterial population in the soil sample collected from the Hagen Farm site at a level comparable to literature values for population densities found in several shallow water table aquifers[2].

5.3.2 Soil Biodegradation Study

The four soil bioreactors were set up, monitored and sampled as detailed in Section 4.3.2. Monitoring and sampling were discontinued after 30 days when the results showed little or no biological activity in the reactors. Reactor conditions are summarized in a schematic in Figure 4.5 and operating parameters are listed in Table 4.3. *The following is a presentation and discussion of the results of the soil* biodegradation study.

Organic Removal Efficiency

The analytical results of the performance of the soil bioreactors for contaminant removal are given in Table 5.15 (soils) and 5.16 (liquids) (see also Appendices G and H for detailed results). As with the initial soil sample, the liquid and soil samples from the bioreactors for both sampling events showed there to be little or no existing organic contamination. Total VOC and Semi-VOC's were less than 500 μg/kg initially in the reactor. After 12 days of operation, the first sample indicated little or no organics left.

The TOCs for the soil fractions sampled on Day 12 *were substantially less than that* of the initial values, indicating some degradation activity (see Figures 5.6 through 5.9 for Reactors 1, 2, 3, and 4, respectively). The TOC of Reactor 4 was substantially lower (3,800 mg/L as compared to 31,000); it also had the highest OURs during the study. Variability in the Day 12 TOC values for Reactors 1, 2, and 3 may be a result of inadvertent nonhomogenization of the soil during the sampling event.

[2]Canter, L. W. and R. C. Knox. Ground Water Pollution Control. Lewis Publishers, Inc., Chelsea, MI, 1985. p 130.

Low levels of some heavy metals were detected in the samples (As, Cr, Cu, Pb, Hg, and Zn). However, these did not appear to impact the existing microbial population in the original soil sample or in the bioreactors.

Oxygen Uptake Rate

The oxygen uptake rate (OUR), as determined from dissolved oxygen measurements, provides a quick and valuable indication of biological activity and hence biodegradation rates. Dissolved oxygen levels were measured on days 8, 16, 25, and 32 for all four reactors (see Figure 5.10 for Day 8 results and Appendix I for figures showing Day 16, 25, and 32 results). The data from the dissolved oxygen levels for these four days were used to calculate the oxygen uptake rates for each of the reactors (see Figure 5.11). The OURs approached zero for Reactors 1 and 2 during these four periods. The OUR for Reactor 3 (which received air and microbes) was 0.6 mg O_2/L/hr on the first day and decreased to zero for the remainder of the study. The OUR for Reactor 4 (which received H_2O_2 and microbes) had the highest values of all four reactors throughout the study, indicating the highest biological activity.

Microbiological Enumeration

This study was designed to evaluate the effects on biodegradation rate(s) of oxygen source and nutrient addition for indigenous and supplemental microorganisms. With sufficient nutrient and oxygen, indigenous heterotrophic populations may increase in size in response to available substrate(s). Limitations to a sustained population increase are generally the presence of toxic compounds (e.g., heavy metals, very high levels of substrate, or production of a toxic metabolite). However, the rate of population increase of indigenous microorganisms may be sufficiently slow to warrant an initial addition of supplemental microorganisms which can utilize existing substrate(s).

Microbiological enumerations were done on the initial soil sample, as well as on initial and Days 12 and 26 soils and liquids for all four reactors. Figures 5.12 through 5.15

show the results of the combined bacterial enumeration/mL of soil slurry for Reactors 1 - 4, respectively.

In summary, the bacterial population densities for those reactors which had not received supplemental microorganisms (Reactors 1 and 2) decreased or remained the same from initial levels after 26 days of operation. However, the bacterial densities increased significantly for those reactors which received supplemental microorganisms (Reactors 3 and 4). The bacterial counts for Reactor 3 and 4 by Day 26 of the study were 1 to 3×10^{10} as compared to 2 to 3×10^{9} for R1 and R2, a tenfold increase. The results supported the previous OUR data that supplemental microorganisms would be required to promote the biological activity for Hagen Farm saturated soils. They also indicated that very little difference in oxygen source, (air or H_2O_2) on bacterial growth.

5.3.3 Soil Treatability Summary

The following conclusions can be drawn regarding the feasibility of in-situ biodegradation of organic contamination in Hagen Farm soils:

1. The saturated soil sample received for treatability studies was not contaminated with compounds on the Target Compound List. This soil sample may or may not be representative of on-site soils since the soil samples were screened through 1/4" mesh to remove coarse gravel for the soil bioreactor study. A comprehensive survey/characterization of saturated soils may be performed to determine the contamination profile, strength, location and other characteristics.

2. If the saturated soils are contaminated, then bioremediation is a potential on-site treatment method based on the following observations: the OUR was high for the reactor receiving microbial supplement; there is sufficient TOC in the soils to support the growth of microorganisms; contaminants currently found

at the site are biodegradable; and there was no metal toxicity observed for the sample tested.

3. If in-situ bioremediation is selected, results from the TOC degradation, oxygen uptake rates and bacterial enumeration indicate that supplemental microorganisms may enhance the biological activity in Hagen Farm saturated soils.

4. The low flow rates found in the soil column test indicate that laboratory column studies for these soils will not provide information for an evaluation of the biodegradability of the organic compounds. On-site field tests could be performed in order to evaluate the permeabilities of the subsurface materials.

5. Field in-situ biodegradation studies are needed if this option is selected as an alternative for site remediation. If a groundwater pump-and-treat system (with on-site biological treatment units) is installed, the effluent from the biological treatment units could serve as an influent for an in-situ field bioremediation test. The effluent would also provide acclimated microorganisms for a supplemental source of organisms.

6.0 CONCEPTUAL PROCESS DESIGN/ECONOMICS

6.1 Groundwater Treatment

Section 5.1 listed four alternatives for successful treatment of Hagen Farm groundwater:

Option 1: Metals Precipitation + Air Stripping + GAC Adsorption
Option 2: Metals Precipitation + GAC Adsorption
Option 3: Metals Precipitation + Activated Sludge
Option 4: Metals Precipitation + UV/Chemical Oxidation

This section describes these alternatives in greater detail and provides estimates on construction and operating costs for the various alternatives. Table 6.1 lists the basis for design for all treatment options. The design flow of 100 gpm is based on preliminary results of the pumping test conducted by Warzyn Inc., and is intended for cost comparison purposes among different treatment options.

6.1.1 Option 1: Metal Precipitation (Lime Precipitation) + Air Stripping + GAC Adsorption

The process flow sheet for this option is given in Figure 6.1. The process consists of pumping groundwater from recovery wells into a mixed equalization tank. The groundwater is pumped to a metals precipitation tank where lime is added to raise the pH. Lime precipitation is necessary to remove calcium and magnesium in the groundwater to prevent scaling. The groundwater, which has polymer flocculant injected into it, is then pumped into a clarifier to settle the inert suspended solids and metal precipitates. Hydrochloric acid is then added to lower the groundwater pH. The clarified liquid passes into an air stripper which utilizes vapor phase carbon, and then into GAC columns. The effluent is pumped into a holding tank and is ultimately reinjected into the site via an injection well system. Sludge is dewatered prior to off-site disposal in a filter press.

The total installed capital cost for this treatment option (100 gpm) is $2,142,000 as is indicated in Table 6.2. Table 6.3 provides an operating cost estimate. The total operating cost is estimated to be $0.0169/gallon (which includes variable and fixed costs).

6.1.2 Option 2: Metals Precipitation (Air Oxidation) + GAC Adsorption

The process flow sheet for this option is shown in Figure 6.2. The process consists of pumping groundwater from recovery wells into a mixed equalization tank, which also has aeration to oxidize and precipitate metals. The groundwater which has flocculant injected into it is then pumped into a flocculation chamber which flows into a clarifier to settle the inert and metal suspended solids. The effluent from the metals/ solids removal is passed through GAC columns prior to discharge into a holding tank with subsequent reinjection into the ground. The solids are dewatered prior to off-site disposal.

The total installed capital facility cost for this option is $1,897,000 and these costs are detailed in Table 6.2. As indicated in Table 6.3, the total operating cost is $0.0158/gallon.

6.1.3 Option 3: Metals Precipitation (Air Oxidation) + Activated Sludge

The process flow sheet for the option utilizing activated sludge treatment of the Hagen Farm groundwater is given in Figure 6.3. The flow train consists of equalization and air oxidation/solids clarification (as previously described in Section 6.1.2), and aerobic biological treatment via the activated sludge process. The final processed effluent would be pumped into a holding tank prior to reinjection into the ground via a reinjection well system. The solids produced during treatment would be dewatered on site using a filter press and sent off site for disposal.

The total installed facility cost for this groundwater processing option would be

$2,359,000, as indicated in Table 6.2. The total groundwater processing cost would be $0.0119/gallon as indicated in Table 6.3.

6.1.4 Option 4: Metal Precipitation (Air Oxidation) + UV/Chemical Oxidation

The process flow sheet for the UV/chemical oxidation is shown in Figure 6.4. The process flow train consists of the previously discussed equalization and air oxidation/solids clarification, and UV/peroxide treatment. The process requires pH adjustment of influent and effluent to the UV/peroxide process. The final processed effluent would be pumped into an effluent holding tank prior to reinjection. The solids produced during treatment would be dewatered on-site using a filter press and disposed off site.

As indicated in Table 6.2, the total installed facility cost for this option is $514,000 while the total operating costs would be $0.0039/gallon as indicated in Table 6.3.

6.1.5 Groundwater Treatment Comparative Process Analysis

Table 6.4 summarizes the capital and total operating cost for the feasible treatment alternatives for Hagen Farm groundwater. The Activated Sludge Process (ASP), while having the highest capital cost, has the lowest operating costs. The ASP option could also provide necessary micro-organisms for in-situ soil bioremediation. It is, therefore, the recommended treatment option for the Hagen Farm Site.

6.2 Field Demonstration of In-Situ Bioremediation

This section discusses the conceptual design for an in-situ bioremediation field demonstration study for Hagen Farm site soils based on results from the soil bioremediation study. The system design presented here is general in nature, as a more detailed design incorporating injection wells/trenches and extraction wells would need the following information (which is to be developed later during the RD/RA phase):

1. Nature and extent of soil contamination at the site;
2. Characterization of site geology and hydrogeology (to optimize the location and type of injection system (e.g. shallow trench, well), and to insure that this location will not be influenced by the of source control measures); and
3. Installation of an above-ground contaminated groundwater pump-and-treat system (which would serve as a source of water for the injection wells).

The in-situ field demonstration at the Hagen Farm site may consist of one or two trials to be done concurrently: one to test the feasibility of in-situ biodegradation using the injection and recovery wells and the other as a control with no injection. Alternatively, the pump and treat/reinjection system could be operated and monitored without nutrient, oxygen or microorganisms for a control period. Then the nutrient, oxygen or microorganisms could be added to the reinjection water while observing the soil remediation effect. The advantages gained by the use of in-situ bioremediation can then be defined after comparing the results from the study to the control.

6.2.1 Conceptual Design

The in-situ bioremediation field study will involve reinjection of the effluent from the above-ground groundwater pump and treat system. All or a portion of the treated effluent from the above-ground groundwater system could be used for reinjection. The effluent would need to meet any applicable water quality standards for reinjection into a groundwater aquifer. Oxygen, in the form of hydrogen peroxide, and nutrients (nitrogen and phosphorous) will be added to the effluent prior to reinjection to stimulate aerobic microbial degradation. Results from the laboratory bioreactor treatability studies indicate that supplemental microorganisms are probably required to enhance the biological activity in Hagen Farm saturated soils. However, addition of commercial microorganisms may not be needed since the treated effluent will contain microorganisms which have been acclimated to the contaminants in the groundwater.

6.2.2 Sampling and Monitoring

The injection/extraction system is expected to be operated while baseline and routine monitoring of the subsurface soils and groundwater will be conducted to provide data for evaluating the system's performance (e.g. contaminant reduction, nutrient transport, biological activity) and to control its operation. The number of samples, sampling frequency, and analytical requirements for both soils and groundwater will be developed in the detailed design when site characterization data becomes available.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the treatability study and conceptual design developed in this report, the following conclusions and recommendations are made for the Hagen Farm site remediation:

7.1 Pump and Treat Remedial Alternative

1. Initial groundwater characterization indicated that three organic compounds (THF, xylene and ethylbenzene) as well as eight metals (arsenic, barium, lead, mercury, iron, manganese, magnesium and calcium) are a concern in the Hagen Farm groundwater. Iron and manganese are of concern because of the potential plugging of treatment processes such as air stripping and carbon adsorption. Iron and manganese can be removed by either air oxidation or metal precipitation. Calcium and magnesium are a concern because these metals can cause scaling and plugging in the air stripping tower. They can be removed by chemical precipitation only.

2. Based on initial analysis of potential groundwater treatment unit operations considered in the treatability study, air stripping, granular activated carbon, biological treatment using the activated sludge process and UV/peroxide oxidation are the selected treatment candidates for organic treatment, while conventional metal precipitation and air oxidation are the selected options for metals treatment.

3. Treatability study results and subsequent conceptual design of the four groundwater treatment options indicate that metals precipitation, followed by biological treatment of the site contaminated groundwater is the recommended groundwater remediation option because of its high treatment efficiency for Hagen Farm groundwater and lower cost. The activated sludge process could also provide acclimated supplemental microorganisms for in-situ bioremediation. The installed cost of a 100 gpm facility is estimated at $2,359,000 with the

total processing cost (including capital and operating) at 1.19¢/gal.

7.2 In-Situ Bioremediation Alternative

1. The soil sample received for treatability studies was not contaminated with compounds on the Target Compound List. Because of random variation, sampling difficulties and the screening of the samples through 1/4" mesh to remove coarse solids for bioreactor testing, the soil sample may not be representative of site saturated zone soils. A comprehensive survey/ characterization of these soils may be performed to determine the extent of contamination and need for remediation.

2. If the saturated zone soils are contaminated, then bioremediation has good potential as an on-site treatment methodology based on the following observations: the oxygen uptake rate (OUR) was high for the reactor receiving microbial supplement; there is sufficient organic material in the soils to support the growth of microorganisms; contaminants found at the site currently are biodegradable; and testing performed indicated no evidence of metal toxicity.

3. Field in-situ bioremediation studies would be the most optimum approach to evaluate the combined effort of site characteristics, including hydrogeology, soil profiles, and biodegradation and will be necessary to confirm laboratory results for Hagen Farm site.

LIST OF TABLES

PRELIMINARY CERTIFICATE

Service Location	Received	Lab ID
EMS HERITAGE LABORATORIES, INC. 1319 MARQUETTE DRIVE ROMEOVILLE, IL 60441 (708)378-1600	06-FEB-91	C127991
	Complete	**PO Number**
	22-FEB-91	WI. PROJECT-HAGEN...
	Printed	**Sampled**
	22-FEB-91	06-FEB-91 14:00

Report To

CHEMICAL WASTE MANAGEMENT, INC
BILL LIU
GENEVA RESEARCH CENTER
1950 S BATAVIA AVENUE
GENEVA, IL 60134

Bill To

CHEMICAL WASTE MANAGEMENT, INC
ACCOUNTING
GENEVA RESEARCH CENTER
1950 S BATAVIA AVENUE
GENEVA, IL 60134

Sample Description

PROJECT: STATE OF WISCONSIN PROJECT-HAGEN FARM
SAMPLE ID.: 026
DESCRIPTION: GW CHARACTERIZATION

CYANIDE TOTAL (AUTOMATED) SW846-9012

Analyst: J. GRIFFIN Analysis Date: 08-FEB-91 Instrument: AUTO-ANALYZER Test: 0101.4. 0
Prep: CYANIDE DISTILLATION SW846-9010

Parameter	Result	Det. Limit	Units
CYANIDE	BDL	0.25	mg/kg

PCB/PESTICIDE SCAN GC:ECD SW846-8080

Analyst: L. DOBBINS Analysis Date: 15-FEB-91 Instrument: GC/ECD Test: 0305.1. 0
Prep: GC SEPARATORY FUNNEL LIQUID-LIQUID EXTRACTION SW846-3510

Parameter	Result	Det. Limit	Units
ALPHA-BHC	BDL	0.00005	mg/L
BETA-BHC	BDL	0.00005	mg/L
DELTA-BHC	BDL	0.00005	mg/L
GAMMA-BHC (LINDANE)	BDL	0.00005	mg/L
HEPTACHLOR	BDL	0.00005	mg/L
ALDRIN	BDL	0.00005	mg/L
HEPTACHLOR EPOXIDE	BDL	0.00005	mg/L
ENDOSULFAN I	BDL	0.00005	mg/L
DIELDRIN	BDL	0.0001	mg/L
4,4'-DDE	BDL	0.0001	mg/L
ENDRIN	BDL	0.0001	mg/L
ENDOSULFAN II	BDL	0.0001	mg/L
4,4'-DDD	BDL	0.0001	mg/L
ENDOSULFAN SULFATE	BDL	0.0001	mg/L
4,4'-DDT	BDL	0.0001	mg/L
METHOXYCHLOR	BDL	0.0005	mg/L
ENDRIN KETONE	BDL	0.0001	mg/L
ALPHA-CHLORDANE	BDL	0.0005	mg/L
GAMMA-CHLORDANE	BDL	0.0005	mg/L
TOXAPHENE	BDL	0.001	mg/L
PCB AROCHLOR 1016	BDL	0.0005	mg/L
PCB AROCHLOR 1221	BDL	0.0005	mg/L
PCB AROCHLOR 1232	BDL	0.0005	mg/L
PCB AROCHLOR 1242	BDL	0.0005	mg/L
PCB AROCHLOR 1248	BDL	0.0005	mg/L
PCB AROCHLOR 1254	BDL	0.0010	mg/L

EMS HERITAGE LABORATORIES, INC.

Lab Sample ID: C127991

Parameter	Result	Det. Limit	Units
PCB AROCHLOR 1260	BDL	0.0010	mg/L
DBC	54		% Rec

GC SEPARATORY FUNNEL LIQUID-LIQUID EXTRACTION SW846-3510
Analyst: M. KEEZER Analysis Date: 11-FEB-91 Test: P233.1. 0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	990		mL
FINAL VOLUME	10		mL

CYANIDE DISTILLATION SW846-9010
Analyst: D. JOSEPH Analysis Date: 08-FEB-91 Test: P101.4. 0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	10		Grams
FINAL VOLUME	250		mL

MERCURY CVAA ACID DIGESTION OF AQUEOUS SAMPLES SW846-7470
Analyst: J. WARE Analysis Date: 11-FEB-91 Test: P131.6. 0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	100		mL
FINAL VOLUME	100		mL

MERCURY CVAA SW846-7470
Analyst: J. WARE Analysis Date: 12-FEB-91 Instrument: CVAA Test: M120.1. 0
Prep: MERCURY CVAA ACID DIGESTION OF AQUEOUS SAMPLES SW846-7470

Parameter	Result	Det. Limit	Units
MERCURY	BDL	0.0005	mg/L

GFAA ACID DIGESTION OF AQUEOUS SAMPLES SW846-3020
Analyst: B. HAHN Analysis Date: 12-FEB-91 Test: P130.6. 0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	50		mL
FINAL WEIGHT OR VOLUME	50		mL

ARSENIC GFAA SW846-7060
Analyst: W. WATNESS Analysis Date: 13-FEB-91 Instrument: GFAA Test: M103.2. 1
Prep: GFAA ACID DIGESTION OF AQUEOUS SAMPLES SW846-3020

Parameter	Result	Det. Limit	Units
ARSENIC	0.036	0.010	mg/L

SELENIUM GFAA SW846-7740
Analyst: P. SIMS Analysis Date: 13-FEB-91 Instrument: GFAA Test: M128.2. 0
Prep: GFAA ACID DIGESTION OF AQUEOUS SAMPLES SW846-3020

Parameter	Result	Det. Limit	Units
SELENIUM	BDL	0.0050	mg/L

FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005
Analyst: A. DATTILO Analysis Date: 09-FEB-91 Test: P130.4. 0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	50		mL
FINAL WEIGHT OR VOLUME	50		mL

EMS HERITAGE LABORATORIES, INC. Lab Sample ID: C127991

ALUMINUM ICP SW846-6010
Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M101.3. 0
Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
ALUMINUM	BDL	0.050	mg/L

ANTIMONY ICP SW846-6010
Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M102.3. 0
Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
ANTIMONY	BDL	0.030	mg/L

BERYLLIUM ICP SW846-6010
Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M105.3. 0
Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
BERYLLIUM	BDL	0.0050	mg/L

BARIUM ICP SW846-6010
Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M104.3. 0
Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
BARIUM	0.49	0.010	mg/L

CADMIUM ICP SW846-6010
Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M108.3. 0
Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
CADMIUM	BDL	0.0050	mg/L

CALCIUM ICP SW846-6010
Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M109.3. 0
Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
CALCIUM	200	0.20	mg/L

CHROMIUM ICP SW846-6010
Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M110.3. 0
Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
CHROMIUM	BDL	0.010	mg/L

COBALT ICP SW846-6010
Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M111.3. 0
Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
COBALT	BDL	0.010	mg/L

COPPER ICP SW846-6010
Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M112.3. 0
Prep: FAA CR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
COPPER	BDL	0.020	mg/L

EMS HERITAGE LABORATORIES, INC. Lab Sample ID: C127991

IRON ICP SW846-6010
Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M115.3. 0
Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
IRON	27.	0.020	mg/L

LEAD ICP SW846-6010
Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M116.3. 0
Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
LEAD	BDL	0.050	mg/L

MAGNESIUM ICP SW846-6010
Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M118.3. 0
Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
MAGNESIUM	80.	0.20	mg/L

MANGANESE ICP SW846-6010
Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M119.3. 0
Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
MANGANESE	0.077	0.010	mg/L

NICKEL ICP SW846-6010
Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M122.3. 0
Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
NICKEL	0.033	0.010	mg/L

POTASSIUM ICP SW846-6010
Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M126.3. 0
Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
POTASSIUM	21.	0.20	mg/L

SILVER ICP SW846-6010
Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M130.3. 0
Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
SILVER	BDL	0.010	mg/L

SODIUM ICP SW846-6010
Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M131.3. 0
Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
SODIUM	38.	0.20	mg/L

THALLIUM ICP SW846-6010
Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M134.3. 0
Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
THALLIUM	BDL	0.30	mg/L

EMS HERITAGE LABORATORIES, INC.

Lab Sample ID: C127991

VANADIUM ICP SW846-6010

Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M138.3. 0

Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
VANADIUM	BDL	0.010	mg/L

ZINC ICP SW846-6010

Analyst: M. JAO Analysis Date: 12-FEB-91 Instrument: ICP Test: M139.3. 0

Prep: FAA OR ICP ACID DIGESTION OF AQUEOUS SAMPLES SW846-3005

Parameter	Result	Det. Limit	Units
ZINC	0.036	0.020	mg/L

ALCOHOLS BY GC:FID SW846-8015

Analyst: J. SMITH Analysis Date: 18-FEB-91 Instrument: GC/FID Test: 0490.0. 0

Parameter	Result	Det. Limit	Units
ISOBUTYL ALCOHOL	BDL	5.0	mg/L
METHANOL	BDL	0.5	mg/L
N-BUTYL ALCOHOL	BDL	5.0	mg/L
CYCLOHEXANONE	BDL	0.5	mg/L

VOLATILE ORGANICS SW846-8240

Analyst: S. SHARP Analysis Date: 16-FEB-91 Instrument: GC/MS VOA Test: 0510.3. 0

Parameter	Result	Det. Limit	Units
ACETONE	BDL	2000	ug/L
BENZENE	BDL	500	ug/L
BROMODICHLOROMETHANE	BDL	500	ug/L
BROMOFORM	BDL	500	ug/L
BROMOMETHANE	BDL	1000	ug/L
CARBON DISULFIDE	BDL	500	ug/L
CARBON TETRACHLORIDE	BDL	500	ug/L
CHLOROBENZENE	BDL	500	ug/L
CHLOROETHANE	BDL	1000	ug/L
CHLOROFORM	BDL	500	ug/L
CHLOROMETHANE	BDL	1000	ug/L
DIBROMOCHLOROMETHANE	BDL	500	ug/L
CIS-1,3-DICHLOROPROPENE	BDL	500	ug/L
1,1-DICHLOROETHANE	BDL	500	ug/L
1,2-DICHLOROETHANE	BDL	500	ug/L
1,1-DICHLOROETHENE	BDL	500	ug/L
1,2-DICHLOROPROPANE	BDL	500	ug/L
ETHYLBENZENE	3200	500	ug/L
2-HEXANONE	BDL	1000	ug/L
METHYLENE CHLORIDE	BDL	500	ug/L
METHYL ETHYL KETONE	BDL	1000	ug/L
4-METHYL-2-PENTANONE	BDL	1000	ug/L
STYRENE	BDL	500	ug/L
1,1,2,2-TETRACHLOROETHANE	BDL	500	ug/L
TETRACHLOROETHENE	BDL	500	ug/L
TETRAHYDROFURAN	65000	2500	ug/L
TOLUENE	BDL	500	ug/L
1,2-DICHLOROETHENE (TOTAL)	BDL	500	ug/L
TRANS-1,3-DICHLOROPROPENE	BDL	500	ug/L
1,1,1-TRICHLOROETHANE	BDL	500	ug/L
1,1,2-TRICHLOROETHANE	BDL	500	ug/L
TRICHLOROETHENE	BDL	500	ug/L
VINYL ACETATE	BDL	1000	ug/L
VINYL CHLORIDE	BDL	1000	ug/L
XYLENE (TOTAL)	20000	500	ug/L

EMS HERITAGE LABORATORIES, INC.

Lab Sample ID: C127991

Parameter	Result	Det. Limit	Units
SURROGATE RECOVERY			
DICHLOROETHANE-D4	101		% Rec
TOLUENE-D8	101		% Rec
BROMOFLUOROBENZENE	96		% Rec
ALSO DETECTED			
ETHYL ETHER	BDL	5	ug/L

GC/MS SEPARATORY FUNNEL LIQUID-LIQUID EXTRACTION SW846-3510

Analyst: C. CIESIELSKI Analysis Date: 07-FEB-91 Test: P233.4. 0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	965		mL
FINAL VOLUME	1		mL

SEMI-VOLATILE ORGANICS (BASE/NEUTRAL ACID FRACTIONS) SW846-8270

Analyst: A. BRADBURN Analysis Date: 08-FEB-91 Instrument: GC/MS SVOA Test: 0505.3. 0

Prep: GC/MS SEPARATORY FUNNEL LIQUID-LIQUID EXTRACTION SW846-3510

Parameter	Result	Det. Limit	Units
ACENAPHTHENE	BDL	10	ug/L
ACENAPHTHYLENE	BDL	10	ug/L
ANTHRACENE	BDL	10	ug/L
BENZ(A)ANTHRACENE	BDL	10	ug/L
BENZO(A)PYRENE	BDL	10	ug/L
BENZO(B)FLUORANTHENE	BDL	10	ug/L
BENZO(G,H,I)PERYLENE	BDL	10	ug/L
BENZO(K)FLUORANTHENE	BDL	10	ug/L
BENZYL ALCOHOL	BDL	10	ug/L
BENZYLBUTYLPHTHALATE	BDL	10	ug/L
BIS(2-CHLOROETHOXY)METHANE	BDL	10	ug/L
BIS(2-CHLOROETHYL)ETHER	BDL	10	ug/L
BIS(2-CHLOROISOPROPYL)ETHER	BDL	10	ug/L
BIS(2-ETHYLHEXYL)PHTHALATE	BDL	10	ug/L
4-BROMOPHENYLPHENYLETHER	BDL	10	ug/L
4-CHLOROANILINE	BDL	10	ug/L
2-CHLORONAPHTHALENE	BDL	10	ug/L
4-CHLOROPHENYLPHENYLETHER	BDL	10	ug/L
CHRYSENE	BDL	10	ug/L
DIBENZ(A,H)ANTHRACENE	BDL	10	ug/L
DIBENZOFURAN	BDL	10	ug/L
1,2-DICHLOROBENZENE	BDL	10	ug/L
1,3-DICHLOROBENZENE	BDL	10	ug/L
1,4-DICHLOROBENZENE	BDL	10	ug/L
3,3'-DICHLOROBENZIDINE	BDL	20	ug/L
DIETHYLPHTHALATE	15	10	ug/L
DIMETHYLPHTHALATE	BDL	10	ug/L
DI-N-BUTYLPHTHALATE	BDL	10	ug/L
2,4-DINITROTOLUENE	BDL	10	ug/L
2,6-DINITROTOLUENE	BDL	10	ug/L
DI-N-OCTYLPHTHALATE	BDL	10	ug/L
FLUORANTHENE	BDL	10	ug/L
FLUORENE	BDL	10	ug/L
HEXACHLOROBENZENE	BDL	10	ug/L
HEXACHLOROBUTADIENE	BDL	10	ug/L
HEXACHLOROCYCLOPENTADIENE	BDL	10	ug/L

EMS HERITAGE LABORATORIES, INC.

Lab Sample ID: C127991

Parameter	Result	Det. Limit	Units
HEXACHLOROETHANE	BDL	10	ug/L
INDENO(1,2,3-CD)PYRENE	BDL	10	ug/L
ISOPHORONE	BDL	10	ug/L
2-METHYLNAPHTHALENE	BDL	10	ug/L
NAPHTHALENE	EST 8	10	ug/L
2-NITROANILINE	BDL	50	ug/L
3-NITROANILINE	BDL	50	ug/L
4-NITROANILINE	BDL	50	ug/L
NITROBENZENE	BDL	10	ug/L
N-NITROSO-DIPHENYLAMINE	BDL	10	ug/L
N-NITROSO-DI-N-PROPYLAMINE	BDL	10	ug/L
PHENANTHRENE	BDL	10	ug/L
PYRENE	BDL	10	ug/L
PYRIDINE	BDL	50	ug/L
1,2,4-TRICHLOROBENZENE	BDL	10	ug/L
BENZOIC ACID	BDL	50	ug/L
4-CHLORO-3-METHYLPHENOL	BDL	10	ug/L
2-CHLOROPHENOL	BDL	10	ug/L
2,4-DICHLOROPHENOL	BDL	10	ug/L
2,4-DIMETHYLPHENOL	BDL	10	ug/L
4,6-DINITRO-2-METHYLPHENOL	BDL	50	ug/L
2,4-DINITROPHENOL	BDL	50	ug/L
2-METHYLPHENOL	BDL	10	ug/L
4-METHYLPHENOL	BDL	10	ug/L
2-NITROPHENOL	BDL	10	ug/L
4-NITROPHENOL	BDL	50	ug/L
PENTACHLOROPHENOL	BDL	50	ug/L
PHENOL	BDL	10	ug/L
2,4,5-TRICHLOROPHENOL	BDL	10	ug/L
2,4,6-TRICHLOROPHENOL	BDL	10	ug/L
SURROGATE RECOVERY			
2-FLUOROPHENOL	0		% Rec
PHENOL-D5	44		% Rec
NITROBENZENE-D5	133		% Rec
2-FLUOROBIPHENYL	82		% Rec
2,4,6-TRIBROMOPHENOL	62		% Rec
TERPHENYL-D14	68		% Rec

Poor surrogate recovery due to sample matrix.

ALKALINITY TOTAL EPA 310.1

Analyst: E. TILLMAN Analysis Date: 18-FEB-91 Test: G605.2. 0

Parameter	Result	Det. Limit	Units
ALKALINITY	910	4	mg/L

CHLORIDE SM 407A

Analyst: L. DIAZ Analysis Date: 15-FEB-91 Test: G102.4. 0

Parameter	Result	Det. Limit	Units
CHLORIDE	41	1.0	mg/L

EMS HERITAGE LABORATORIES, INC. Lab Sample ID: C127991

SULFATE TURBIDIMETRIC EPA 375.4
Analyst: L. DIAZ Analysis Date: 15-FEB-91 Test: G108.5. 0

Parameter	Result	Det. Limit	Units
SULFATE	BDL	5	mg/L

BIOCHEMICAL OXYGEN DEMAND EPA 405.1
Analyst: D. RINELLA-SIEKERMAN Analysis Date: 08-FEB-91 Test: G801.4. 0

Parameter	Result	Det. Limit	Units
BIOCHEMICAL OXYGEN DEMAND	53	24	mg/L

CHEMICAL OXYGEN DEMAND (LOW LEVEL) EPA 410.2
Analyst: C. SKLENAR Analysis Date: 08-FEB-91 Test: G301.2. 0

Parameter	Result	Det. Limit	Units
CHEMICAL OXYGEN DEMAND	390	40	mg/L

PHOSPHORUS EPA 365.2
Analyst: D. RINELLA-SIEKERMAN Analysis Date: 20-FEB-91 Test: M424.1. 0

Parameter	Result	Det. Limit	Units
PHOSPHORUS	0.40	0.05	mg/L

AMMONIA DISTILLATION EPA 350.3
Analyst: D. RINELLA-SIEKERMAN Analysis Date: 18-FEB-91 Test: P203.4. 0

Parameter	Result	Det. Limit	Units
INITIAL WEIGHT OR VOLUME	200		mL
FINAL VOLUME	200		mL

AMMONIA NITROGEN EPA 350.3
Analyst: D. RINELLA-SIEKERMAN Analysis Date: 19-FEB-91 Test: G203.4. 0
Prep: AMMONIA DISTILLATION EPA 350.3

Parameter	Result	Det. Limit	Units
NITROGEN, AMMONIA	30	0.5	mg/L

KJELDAHL NITROGEN TOTAL (TKN) EPA 351.3
Analyst: D. RINELLA-SIEKERMAN Analysis Date: 14-FEB-91 Test: G202.4. 0

Parameter	Result	Det. Limit	Units
NITROGEN, KJELDAHL	23	6	mg/L

Sample Comments

Sample splits were properly preserved at EMS Labs. A marked color change was observed after the addition of preservatives compared to the unpreserved splits.

BDL Below Detection Limit
EST Estimated Value

Preliminary Certificate : ______________

APPENDIX D

Analytical Results for Air Stripping Test

CERTIFICATE OF ANALYSIS

Service Location	Received	Lab ID
EMS HERITAGE LABORATORIES, INC. 1319 MARQUETTE DRIVE ROMEOVILLE, IL 60441 (708)378-1600	25-FEB-91	C128411
	Complete: 04-MAR-91	PO Number: WI.PROJECT-HAGEN...
	Printed: 05-MAR-91	Sampled: 25-FEB-91

Report To

CHEMICAL WASTE MANAGEMENT, INC
~~WENDY MOUCHE~~ Bill Lane
GENEVA RESEARCH CENTER
1950 S BATAVIA AVENUE
GENEVA, IL 60134

Bill To

CHEMICAL WASTE MANAGEMENT, INC
ACCOUNTING
GENEVA RESEARCH CENTER
1950 S BATAVIA AVENUE
GENEVA, IL 60134

Sample Description

PROJECT: STATE OF WISCONSIN PROJECT-HAGEN FARM
SAMPLE ID.: 052-02-25-91-00

VOLATILE ORGANICS SW846-8240

Analyst: S. BUSSEY Analysis Date: 28-FEB-91 Instrument: GC/MS VOA Test: 0510.3. 0

Parameter	Result	Det. Limit	Units
ACETONE	BDL	20	ug/L
BENZENE	57	5	ug/L
CHLOROBENZENE	BDL	5	ug/L
DIBROMOCHLOROMETHANE	BDL	5	ug/L
ETHYLBENZENE	BDL	5	ug/L
METHYLENE CHLORIDE	BDL	5	ug/L
METHYL ETHYL KETONE	BDL	10	ug/L
TETRAHYDROFURAN	* 52000	5000	ug/L
TOLUENE	BDL	5	ug/L
1,2-DICHLOROETHENE (TOTAL)	BDL	5	ug/L
VINYL CHLORIDE	11	10	ug/L
XYLENE (TOTAL)	* 11000	2500	ug/L
ETHYL ETHER	10	5	ug/L
SURROGATE RECOVERY			
DICHLOROETHANE-D4	95		% Rec
TOLUENE-D8	100		% Rec
BROMOFLUOROBENZENE	89		% Rec

**Quantitated from 1:500 dilution analyzed on 3/1/91.*

Sample Comments

* *See Note for Parameter*
BDL Below Detection Limit

Quality Assurance Officer: Christine Sa... Last Page 1

C E R T I F I C A T E   O F   A N A L Y S I S

Service Location	Received	Lab ID
EMS HERITAGE LABORATORIES, INC. 1319 MARQUETTE DRIVE ROMEOVILLE, IL 60441 (708)378-1600	25-FEB-91	C128412
	Complete	**PO Number**
	04-MAR-91	WI.PROJECT-HAGEN...
	Printed	**Sampled**
	05-MAR-91	25-FEB-91

Report To

CHEMICAL WASTE MANAGEMENT, INC
WENDY MOUCHE
GENEVA RESEARCH CENTER
1950 S BATAVIA AVENUE
GENEVA, IL 60134

Bill To

CHEMICAL WASTE MANAGEMENT, INC
ACCOUNTING
GENEVA RESEARCH CENTER
1950 S BATAVIA AVENUE
GENEVA, IL 60134

Sample Description

PROJECT: STATE OF WISCONSIN PROJECT-HAGEN FARM
SAMPLE ID.: 059-02-25-91-00

ALCOHOLS BY GC:FID SW846-8015

Analyst: J. SMITH   Analysis Date: 01-MAR-91   Instrument: GC/FID   Test: 0490.0. 0

Parameter	Result	Det. Limit	Units
ISOBUTYL ALCOHOL	BDL	2.5	mg/L
METHANOL	BDL	0.50	mg/L
N-BUTYL ALCOHOL	BDL	2.5	mg/L
CYCLOHEXANONE	BDL	0.25	mg/L

Sample Comments

BDL   Below Detection Limit

Quality Assurance Officer: [signature]

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CERTIFICATE OF ANALYSIS

Service Location	Received	Lab ID
EMS HERITAGE LABORATORIES, INC. 1319 MARQUETTE DRIVE ROMEOVILLE, IL 60441 (708)378-1600	25-FEB-91	C128413
	Complete: 04-MAR-91	PO Number: WI.PROJECT-HAGEN....
	Printed: 05-MAR-91	Sampled: 25-FEB-91

Report To

CHEMICAL WASTE MANAGEMENT, INC
WENDY MOUCHE
GENEVA RESEARCH CENTER
1950 S BATAVIA AVENUE
GENEVA, IL 60134

Bill To

CHEMICAL WASTE MANAGEMENT, INC
ACCOUNTING
GENEVA RESEARCH CENTER
1950 S BATAVIA AVENUE
GENEVA, IL 60134

Sample Description

PROJECT: STATE OF WISCONSIN PROJECT-HAGEN FARM
SAMPLE ID.: 053-02-25-91-15

VOLATILE ORGANICS SW846-8240

Analyst: S. BUSSEY Analysis Date: 26-FEB-91 Instrument: GC/MS VOA Test: 0510.3. 0

Parameter	Result	Det. Limit	Units
ACETONE	BDL	20	ug/L
BENZENE	BDL	5	ug/L
CHLOROBENZENE	BDL	5	ug/L
DIBROMOCHLOROMETHANE	BDL	5	ug/L
ETHYLBENZENE	BDL	5	ug/L
METHYLENE CHLORIDE	BDL	5	ug/L
METHYL ETHYL KETONE	BDL	10	ug/L
TETRAHYDROFURAN	* 46000	5000	ug/L
TOLUENE	BDL	5	ug/L
1,2-DICHLOROETHENE (TOTAL)	BDL	5	ug/L
VINYL CHLORIDE	BDL	10	ug/L
XYLENE (TOTAL)	330	5	ug/L
ETHYL ETHER	BDL	5	ug/L
SURROGATE RECOVERY			
DICHLOROETHANE-D4	96		% Rec
TOLUENE-D8	100		% Rec
BROMOFLUOROBENZENE	95		% Rec

**Compound quantitated from 1:500 dilution analyzed on 3/1/91.*

Sample Comments

* *See Note for Parameter*
BDL *Below Detection Limit*

Quality Assurance Officer: [signature]

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CERTIFICATE OF ANALYSIS

Service Location	Received	Lab ID
EMS HERITAGE LABORATORIES, INC. 1319 MARQUETTE DRIVE ROMEOVILLE, IL 60441 (708)378-1600	25-FEB-91	C128414
	Complete	**PO Number**
	04-MAR-91	WI.PROJECT-HAGEN....
	Printed	**Sampled**
	05-MAR-91	25-FEB-91

Report To

CHEMICAL WASTE MANAGEMENT, INC
WENDY MOUCHE
GENEVA RESEARCH CENTER
1950 S BATAVIA AVENUE
GENEVA, IL 60134

Bill To

CHEMICAL WASTE MANAGEMENT, INC
ACCOUNTING
GENEVA RESEARCH CENTER
1950 S BATAVIA AVENUE
GENEVA, IL 60134

Sample Description

PROJECT: STATE OF WISCONSIN PROJECT-HAGEN FARM
SAMPLE ID.: 060-02-25-91-30

ALCOHOLS BY GC:FID SW846-8015

Analyst: J. SMITH Analysis Date: 01-MAR-91 Instrument: GC/FID Test: 0490.0. 0

Parameter	Result	Det. Limit	Units
ISOBUTYL ALCOHOL	BDL	2.5	mg/L
METHANOL	BDL	0.50	mg/L
N-BUTYL ALCOHOL	BDL	2.5	mg/L
CYCLOHEXANONE	BDL	0.25	mg/L

Sample Comments

BDL Below Detection Limit

Quality Assurance Officer: [signature]

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CERTIFICATE OF ANALYSIS

Service Location	Received	Lab ID
EMS HERITAGE LABORATORIES, INC. 1319 MARQUETTE DRIVE ROMEOVILLE, IL 60441 (708)378-1600	25-FEB-91	C128415
	Complete	**PO Number**
	04-MAR-91	WI.PROJECT-HAGEN...
	Printed	**Sampled**
	05-MAR-91	25-FEB-91

Report To	Bill To
CHEMICAL WASTE MANAGEMENT, INC WENDY MOUCHE GENEVA RESEARCH CENTER 1950 S BATAVIA AVENUE GENEVA, IL 60134	CHEMICAL WASTE MANAGEMENT, INC ACCOUNTING GENEVA RESEARCH CENTER 1950 S BATAVIA AVENUE GENEVA, IL 60134

Sample Description

PROJECT: STATE OF WISCONSIN PROJECT-HAGEN FARM
SAMPLE ID.: 054-02-25-91-30

VOLATILE ORGANICS SW846-8240

Analyst: S. BUSSEY   Analysis Date: 28-FEB-91   Instrument: GC/MS VOA   Test: 0510.3. 0

Parameter	Result	Det. Limit	Units
ACETONE	BDL	20	ug/L
BENZENE	BDL	5	ug/L
CHLOROBENZENE	BDL	5	ug/L
DIBROMOCHLOROMETHANE	BDL	5	ug/L
ETHYLBENZENE	BDL	5	ug/L
METHYLENE CHLORIDE	BDL	5	ug/L
METHYL ETHYL KETONE	BDL	10	ug/L
TETRAHYDROFURAN	* 39000	5000	ug/L
TOLUENE	BDL	5	ug/L
1,2-DICHLOROETHENE (TOTAL)	BDL	5	ug/L
VINYL CHLORIDE	BDL	10	ug/L
XYLENE (TOTAL)	27	5	ug/L
ETHYL ETHER	BDL	5	ug/L
SURROGATE RECOVERY			
DICHLOROETHANE-D4	88		% Rec
TOLUENE-D8	100		% Rec
BROMOFLUOROBENZENE	107		% Rec

**Compound quantitated from 1:500 dilution analyzed on 3/1/91.*

Sample Comments

*   *See Note for Parameter*
BDL   Below Detection Limit

Quality Assurance Officer: [signature]   Last Page 1

CERTIFICATE OF ANALYSIS

Service Location	Received	Lab ID
EMS HERITAGE LABORATORIES, INC. 1319 MARQUETTE DRIVE. ROMEOVILLE, IL 60441 (708)378-1600	25-FEB-91	C128416
	Complete	**PO Number**
	04-MAR-91	WI.PROJECT-HAGEN...
	Printed	**Sampled**
	05-MAR-91	25-FEB-91

Report To	Bill To
CHEMICAL WASTE MANAGEMENT, INC WENDY MOUCHE GENEVA RESEARCH CENTER 1950 S BATAVIA AVENUE GENEVA, IL 60134	CHEMICAL WASTE MANAGEMENT, INC ACCOUNTING GENEVA RESEARCH CENTER 1950 S BATAVIA AVENUE GENEVA, IL 60134

Sample Description

PROJECT: STATE OF WISCONSIN PROJECT-HAGEN FARM
SAMPLE ID.: 061-02-25-91-60

ALCOHOLS BY GC:FID SW846-8015

Analyst: J. SMITH   Analysis Date: 01-MAR-91   Instrument: GC/FID   Test: 0490.0. 0

Parameter	Result	Det. Limit	Units
ISOBUTYL ALCOHOL	BDL	2.5	mg/L
METHANOL	BDL	0.50	mg/L
N-BUTYL ALCOHOL	BDL	2.5	mg/L
CYCLOHEXANONE	BDL	0.25	mg/L

Sample Comments

BDL   Below Detection Limit

Quality Assurance Officer: [signature]

Last Page 1

CERTIFICATE OF ANALYSIS

Service Location	Received	Lab ID
EMS HERITAGE LABORATORIES, INC. 1319 MARQUETTE DRIVE ROMEOVILLE, IL 60441 (708)378-1600	25-FEB-91	C128417
	Complete	PO Number
	04-MAR-91	WI.PROJECT-HAGEN....
	Printed	Sampled
	05-MAR-91	25-FEB-91

Report To	Bill To
CHEMICAL WASTE MANAGEMENT, INC WENDY MOUCHE GENEVA RESEARCH CENTER 1950 S BATAVIA AVENUE GENEVA, IL 60134	CHEMICAL WASTE MANAGEMENT, INC ACCOUNTING GENEVA RESEARCH CENTER 1950 S BATAVIA AVENUE GENEVA, IL 60134

Sample Description

PROJECT: STATE OF WISCONSIN PROJECT-HAGEN FARM
SAMPLE ID.: 055-02-25-91-60

VOLATILE ORGANICS SW846-8240

Analyst: S. BUSSEY Analysis Date: 28-FEB-91 Instrument: GC/MS VOA Test: 0510.3. 0

Parameter	Result	Det. Limit	Units
ACETONE	BDL	20	ug/L
BENZENE	BDL	5	ug/L
CHLOROBENZENE	BDL	5	ug/L
DIBROMOCHLOROMETHANE	BDL	5	ug/L
ETHYLBENZENE	BDL	5	ug/L
METHYLENE CHLORIDE	BDL	5	ug/L
METHYL ETHYL KETONE	BDL	10	ug/L
TETRAHYDROFURAN	* 36000	5000	ug/L
TOLUENE	BDL	5	ug/L
1,2-DICHLOROETHENE (TOTAL)	BDL	5	ug/L
VINYL CHLORIDE	BDL	10	ug/L
XYLENE (TOTAL)	19	5	ug/L
ETHYL ETHER	BDL	5	ug/L
SURROGATE RECOVERY			
DICHLOROETHANE-D4	93		% Rec
TOLUENE-D8	102		% Rec
BROMOFLUOROBENZENE	101		% Rec

**Compound quantitated from 1:500 dilution analyzed on 3/1/91.*

Sample Comments

* *See Note for Parameter*
BDL Below Detection Limit

Quality Assurance Officer: [signature] Last Page 1

CERTIFICATE OF ANALYSIS

Service Location	Received	Lab ID
EMS HERITAGE LABORATORIES, INC. 1319 MARQUETTE DRIVE ROMEOVILLE, IL 60441 (708)378-1600	25-FEB-91	C128418
	Complete	**PO Number**
	04-MAR-91	WI.PROJECT-HAGEN....
	Printed	**Sampled**
	05-MAR-91	25-FEB-91

Report To

CHEMICAL WASTE MANAGEMENT, INC
WENDY MOUCHE
GENEVA RESEARCH CENTER
1950 S BATAVIA AVENUE
GENEVA, IL 60134

Bill To

CHEMICAL WASTE MANAGEMENT, INC
ACCOUNTING
GENEVA RESEARCH CENTER
1950 S BATAVIA AVENUE
GENEVA, IL 60134

Sample Description

PROJECT: STATE OF WISCONSIN PROJECT-HAGEN FARM
SAMPLE ID.: 062-02-25-91-90

ALCOHOLS BY GC:FID SW846-8015

Analyst: J. SMITH Analysis Date: 01-MAR-91 Instrument: GC/FID Test: 0490.0. 0

Parameter	Result	Det. Limit	Units
ISOBUTYL ALCOHOL	BDL	2.5	mg/L
METHANOL	BDL	0.50	mg/L
N-BUTYL ALCOHOL	BDL	2.5	mg/L
CYCLOHEXANONE	BDL	0.25	mg/L

Sample Comments

BDL Below Detection Limit

Quality Assurance Officer: [signature]

Last Page 1

CERTIFICATE OF ANALYSIS

Service Location	Received	Lab ID
EMS HERITAGE LABORATORIES, INC. 1319 MARQUETTE DRIVE ROMEOVILLE, IL 60441 (708)378-1600	25-FEB-91	C128419
	Complete	**PO Number**
	04-MAR-91	WI.PROJECT-HAGEN....
	Printed	**Sampled**
	05-MAR-91	25-FEB-91

Report To

CHEMICAL WASTE MANAGEMENT, INC
WENDY MOUCHE
GENEVA RESEARCH CENTER
1950 S BATAVIA AVENUE
GENEVA, IL 60134

Bill To

CHEMICAL WASTE MANAGEMENT, INC
ACCOUNTING
GENEVA RESEARCH CENTER
1950 S BATAVIA AVENUE
GENEVA, IL 60134

Sample Description

PROJECT: STATE OF WISCONSIN PROJECT-HAGEN FARM
SAMPLE ID.: 056-02-25-91-90

VOLATILE ORGANICS SW846-8240

Analyst: S. BUSSEY   Analysis Date: 28-FEB-91   Instrument: GC/MS VOA   Test: 0510.3. 0

Parameter	Result	Det. Limit	Units
ACETONE	BDL	20	ug/L
BENZENE	BDL	5	ug/L
CHLOROBENZENE	BDL	5	ug/L
DIBROMOCHLOROMETHANE	BDL	5	ug/L
ETHYLBENZENE	BDL	5	ug/L
METHYLENE CHLORIDE	BDL	5	ug/L
METHYL ETHYL KETONE	BDL	10	ug/L
TETRAHYDROFURAN	* 31000	25	ug/L
TOLUENE	BDL	5	ug/L
1,2-DICHLOROETHENE (TOTAL)	BDL	5	ug/L
VINYL CHLORIDE	BDL	10	ug/L
XYLENE (TOTAL)	12	5	ug/L
ETHYL ETHER	BDL	5	ug/L
SURROGATE RECOVERY			
DICHLOROETHANE-D4	91		% Rec
TOLUENE-D8	104		% Rec
BROMOFLUOROBENZENE	101		% Rec

**Compound quantitated from 1:500 dilution analyzed on 3/1/91.*

Sample Comments

* *See Note for Parameter*
BDL Below Detection Limit

Quality Assurance Officer: ______________________

Last Page 1

APPENDIX E

Soil Permeability Measurements

Date: March 15, 1991

To: Alan Li
Wendy Mouché

From: Paul Lear PLL

SUBJECT: **Permeability for Hagen Farm Sample**

Permeability measurements were obtained in triplicate for the Hagen Farm sample I received from Wendy Mouché. The methodology used for the permeability testing is contained in Section 2.8 of USEPA SW-846 Method 9100.

The permeability of the Hagen Farm material as determined by the method is in the range of 10^{-4}cm/s. Attached are data tables showing three permeability measurements for each of the three replicates.

Permeability Measurements for Sample

Hagen Farm - Sample #1

Sample Height (cm) 13.71

Sample Diameter (cm) 7.15

Sample Area (cm ^2) 40.15

Time (min)	Burette A Pressure (psi)	Burette A Reading (mL)	Burette A Change (mL/min)	Burette B Pressure (psi)	Burette B Reading (mL)	Burette B Change (mL/min)	Pressure Differential (psi)
0.00	20.1	6.0		19.0	12.5		1.1
0.50	20.1	6.8	1.6000	19.0	11.7	1.6000	1.1
1.00	20.1	7.6	1.6000	19.0	10.8	1.8000	1.1
1.50	20.1	8.4	1.6000	19.0	10.0	1.6000	1.1
2.00	20.1	9.2	1.6000	19.0	9.1	1.8000	1.1
2.50	20.1	10.0	1.6000	19.0	8.4	1.4000	1.1

Average Q (mL/min) 1.6200 Average h (psi) 1.10

Permeability (cm/s) 1.19E-04

Time (min)	Burette A Pressure (psi)	Burette A Reading (mL)	Burette A Change (mL/min)	Burette B Pressure (psi)	Burette B Reading (mL)	Burette B Change (mL/min)	Pressure Differential (psi)
0.00	20.1	6.2		19.5	15.8		0.6
1.00	20.1	7.0	0.8000	19.5	15.0	0.8000	0.6
2.00	20.1	7.9	0.9000	19.5	14.3	0.7000	0.6
3.00	20.1	8.7	0.8000	19.5	13.6	0.7000	0.6
4.00	20.1	9.4	0.7000	19.5	12.8	0.8000	0.5
5.00	20.1	10.1	0.7000	19.5	12.0	0.8000	0.6

Average Q (mL/min) 0.7700 Average h (psi) 0.60

Permeability (cm/s) 1.04E-04

Time (min)	Burette A Pressure (psi)	Burette A Reading (mL)	Burette A Change (mL/min)	Burette B Pressure (psi)	Burette B Reading (mL)	Burette B Change (mL/min)	Pressure Differential (psi)
0.00	20.1	7.6		18.5	15.0		1.6
0.50	20.0	8.5	1.8000	18.5	14.1	1.8000	1.5
1.00	20.1	9.4	1.8000	18.5	13.3	1.6000	1.6
1.50	20.1	10.3	1.8000	18.5	12.3	2.0000	1.6
2.00	20.1	11.2	1.8000	18.5	11.4	1.8000	1.6
2.50	20.1	12.1	1.8000	18.5	10.5	1.8000	1.6

Average Q (mL/min) 1.8000 Average h (psi) 1.58

Permeability (cm/s) 9.17E-05

Average Permeability (cm/s) 1.05E-04

Permeability Measurements for Sample — Hagen Farm - Sample #2

Sample Height (cm)	13.34
Sample Diameter (cm)	7.10
Sample Area (cm^2)	39.59

Time (min)	Burette A Pressure (psi)	Burette A Reading (mL)	Burette A Change (mL/min)	Burette B Pressure (psi)	Burette B Reading (mL)	Burette B Change (mL/min)	Pre Diffe (
0.00	20.1	9.0		19.5	14.1		[illegible]
1.50	20.1	10.2	0.8000	19.5	13.0	0.7333	[illegible]
3.00	20.1	11.2	0.6667	19.5	11.9	0.7333	[illegible]
4.50	20.1	12.3	0.7333	19.5	10.8	0.7333	[illegible]
6.00	20.1	13.4	0.7333	19.5	9.7	0.7333	[illegible]
7.50	20.1	14.5	0.7333	19.5	8.6	0.7333	[illegible]

Average Q (mL/min) 0.7333 — Average h (psi) 0.60

Permeability (cm/s) 9.73E-05

Time (min)	Burette A Pressure (psi)	Burette A Reading (mL)	Burette A Change (mL/min)	Burette B Pressure (psi)	Burette B Reading (mL)	Burette B Change (mL/min)	Pres Diffe (p
0.00	20.1	7.0		19.0	10.3		1
1.00	20.1	8.3	1.3000	19.0	9.0	1.3000	1
2.00	20.1	9.5	1.2000	19.0	7.8	1.2000	1
3.00	20.1	10.7	1.2000	19.0	6.5	1.3000	1.
4.00	20.1	12.0	1.3000	19.0	5.3	1.2000	1.
5.00	20.1	13.3	1.3000	19.0	4.1	1.2000	1.

Average Q (mL/min) 1.2500 — Average h (psi) 1.10

Permeability (cm/s) 9.04E-05

Time (min)	Burette A Pressure (psi)	Burette A Reading (mL)	Burette A Change (mL/min)	Burette B Pressure (psi)	Burette B Reading (mL)	Burette B Change (mL/min)	Press Differe (ps
0.00	20.1	4.9		18.5	10.8		1.6
0.50	20.1	6.1	2.4000	18.5	9.5	2.6000	1.6
1.00	20.1	7.3	2.4000	18.5	8.3	2.4000	1.6
1.50	20.1	8.5	2.4000	18.5	7.1	2.4000	1.6
2.00	20.1	9.7	2.4000	18.5	5.8	2.6000	1.6
2.50	20.1	10.8	2.2000	18.5	4.6	2.4000	1.6

Average Q (mL/min) 2.4200 — Average h (psi) 1.60

Permeability (cm/s) 1.20E-04

Average Permeability (cm/s) 1.03E-04

Permeability Measurements for Sample — Hagen Farm - Sample #3

Sample Height (cm) 13.82

Sample Diameter (cm) 7.13

Sample Area (cm^2) 39.93

Time (min)	Burette A Pressure (psi)	Burette A Reading (mL)	Burette A Change (mL/min)	Burette B Pressure (psi)	Burette B Reading (mL)	Burette B Change (mL/min)	Pressure Differential (psi)
0.00	20.0	7.4		19.5	15.9		0.5
2.00	20.0	8.4	0.5000	19.5	15.0	0.4500	0.5
4.00	20.0	9.5	0.5500	19.5	14.1	0.4500	0.5
6.00	20.0	10.6	0.5500	19.5	13.1	0.5000	0.5
8.00	20.0	11.5	0.4500	19.5	12.1	0.5000	0.5
10.00	20.0	12.4	0.4500	19.5	11.0	0.5500	0.5

Average Q (mL/min) 0.4950 Average h (psi) 0.50

Permeability (cm/s) 7.98E-05

Time (min)	Burette A Pressure (psi)	Burette A Reading (mL)	Burette A Change (mL/min)	Burette B Pressure (psi)	Burette B Reading (mL)	Burette B Change (mL/min)	Pressure Differential (psi)
0.00	20.0	8.6		19.0	12.7		1.0
1.00	20.0	9.5	0.9000	19.0	11.7	1.0000	1.0
2.00	20.0	10.5	1.0000	19.0	10.8	0.9000	1.0
3.00	20.0	11.4	0.9000	19.0	9.9	0.9000	1.0
4.00	20.0	12.3	0.9000	19.0	9.0	0.9000	1.0
5.00	20.0	13.2	0.9000	19.0	8.2	0.8000	1.0

Average Q (mL/min) 0.9100 Average h (psi) 1.00

Permeability (cm/s) 7.33E-05

Time (min)	Burette A Pressure (psi)	Burette A Reading (mL)	Burette A Change (mL/min)	Burette B Pressure (psi)	Burette B Reading (mL)	Burette B Change (mL/min)	Pressure Differential (psi)
0.00	20.0	5.7		18.5	13.1		1.5
0.50	20.0	6.4	1.4000	18.5	12.4	1.4000	1.5
1.00	20.0	7.1	1.4000	18.5	11.6	1.6000	1.5
1.50	20.0	7.8	1.4000	18.5	10.9	1.4000	1.5
2.00	20.0	8.6	1.6000	18.5	10.1	1.6000	1.5
2.50	20.0	9.5	1.8000	18.5	9.2	1.8000	1.5

Average Q (mL/min) 1.5400 Average h (psi) 1.50

Permeability (cm/s) 8.27E-05

Average Permeability (cm/s) 7.86E-05

APPENDIX F

Combined Sieve/Hydrometer Analysis

March 21, 1991

Ms. Wendy Mouche
Chemical Waste Management
1950 S. Batavia Avenue
Geneva, IL 60134

RE: Grain Size Distribution Analysis on Soil Sample -- STS Project No. 26804

Dear Ms. Mouche:

Please find attached three (3) copies of laboratory test data pertaining to the above referenced testing program. In accordance with your instructions, a combined sieve/hydrometer analysis was performed on a sample delivered to our Northbrook testing facility. The procedures followed ASTM D-422 for particle size analysis of soils. Incorporated into the test procedure were specific sieves assigned by you.

We are pleased to have had the opportunity to be of service to you.

If you have any questions pertaining to the test data or if we may be of assistance to you in any other matter, please do not hesitate to contact us.

Respectfully,

STS CONSULTANTS, LTD.

William P. Quinn (ngt)
William P. Quinn
Laboratory Manager

Andrew E. Haubert
Andrew E. Haubert, P.E.
Principal Engineer

WPQ/ngt/132.31

encl.

STS Consultants Ltd.
Consulting Engineers

111 Pfingsten Road
Northbrook, Illinois 60062
708.272.6520/Fax 708.498.2721

STS CONSULTANTS, LTD.

GRAIN SIZE DISTRIBUTION (ASTM D 422)

Project : CHEMICAL WASTE MANAGEMENT
Boring/Source: -
Sample Number: 1
Depth (feet): -
USCS Classification: (SM)
Soil Description : FINE TO COARSE SAND,LITTLE SILT,TRACE FINE GRAVEL---BROWN

STS Job No. : 26804
Date : 3-20-91
LL: - PL: - PI: -
WC: - SP.GR.: 2.65 Es

SIEVE ANALYSIS --

SAMPLE WEIGHT: 103.06 GRAMS

SIEVE SIZE	WEIGHT RETAINED	PER CENT RETAINED	PER CENT PASSING
3/8"	0.00	0.00	100.00
#4	3.76	3.65	96.35
#10	16.10	15.62	80.73
#18	10.54	10.23	70.50
#35	18.84	18.28	52.22
#60	24.76	24.02	28.20
#140	9.64	9.35	18.84
#270	1.32	1.28	17.56

HYDROMETER ANALYSIS --

HYDROMETER SAMPLE WEIGHT: 52.29 GRAMS

ELAPSED TIME	TEMPERATURE CENTIGRADE	ACTUAL READING	ADJUST READING	GRAIN SIZE	PER CENT FINER
0.25	22.5	16.00	11.50	0.0980	17.76
0.50	22.5	15.50	11.00	0.0695	16.99
1.00	22.5	13.50	9.00	0.0497	13.90
2.00	22.5	12.00	7.50	0.0355	11.59
5.00	22.5	11.00	6.50	0.0226	10.04
15.00	22.5	10.00	5.50	0.0131	8.50
30.00	22.5	8.50	4.00	0.0093	6.18
60.00	22.5	8.00	3.50	0.0066	5.41
120.00	22.5	7.50	3.00	0.0047	4.63
400.00	24.0	6.50	2.00	0.0025	3.09
4229.00	22.5	6.50	2.00	0.0008	3.09

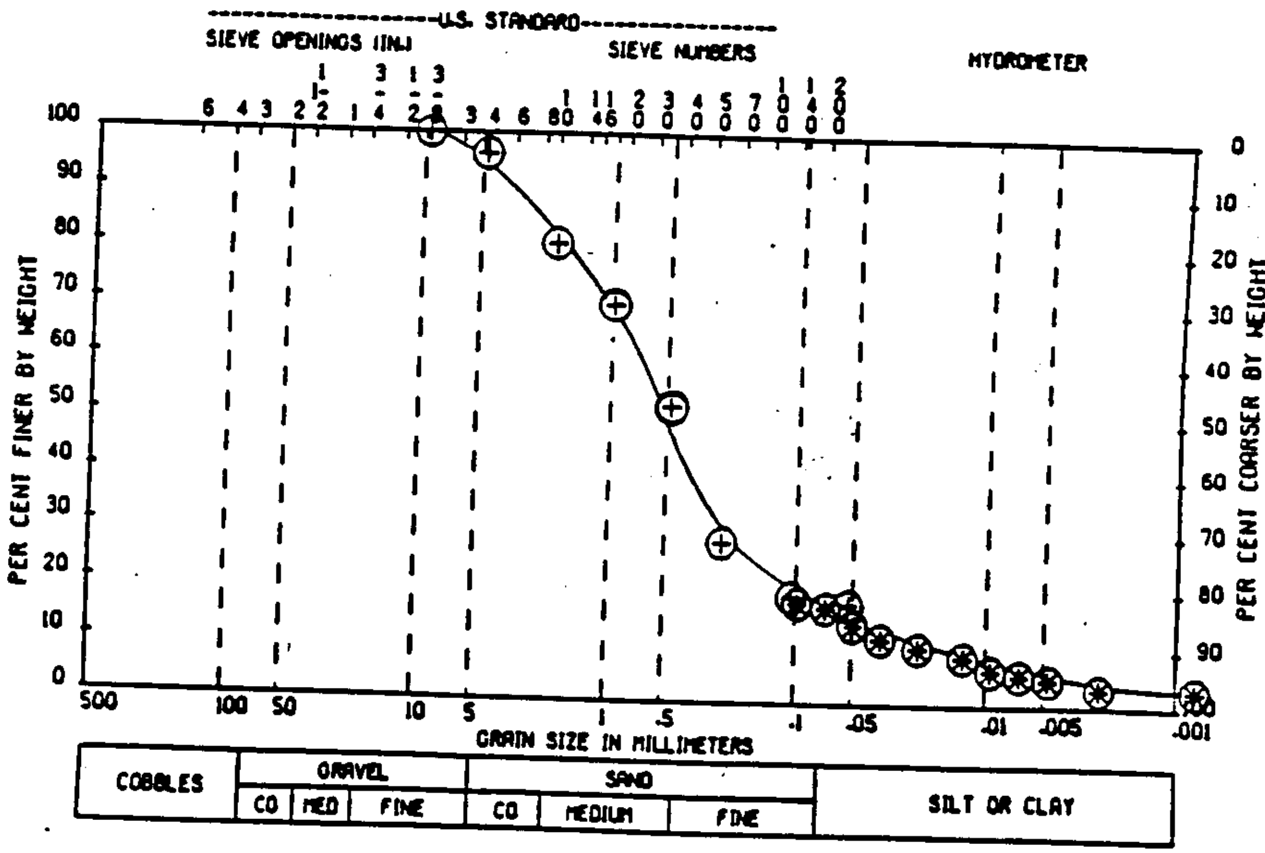
STS Consultants Ltd.

STS CONSULTANTS LTD.

GRAIN SIZE DISTRIBUTION (ASTM D 422)

PROJECT : CHEMICAL WASTE MANAGEMENT
BORING/SOURCE: -
SAMPLE NUMBER: 1
DEPTH (FEET) : -
USCS CLASSIFICATION: (SM)
SOIL DESCRIPTION : FINE TO COARSE SAND,LITTLE SILT,TRACE FINE GRAVEL---BROWN

STS JOB NO. : 26804
DATE : 3-20-91
LL: - PL: - PI: -
WC: - SP.GR. : 2.65 EST.



APPENDIX G

Analytical Results for Soil Fraction
Hagen Farm Soil Biodegradation Study

APPENDIX G

HAGEN FARM SOIL BIODEGRADATION STUDY, ANALYTICAL RESULTS FOR SOIL FRACTION

(all units in mg/kg wet weight except as noted)

	Original Soil	Initial Reactor Conditions	Day 12				Day 26			
			Reactor 1	Reactor 2	Reactor 3	Reactor 4	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Cyanide	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
PCBs and Pesticides										
Alpha-BHC	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Beta-BHC	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Delta-BHC	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Gamma-BHC (Lindane)	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Heptachlor	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Aldrin	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Heptachlor Epoxide	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Endosulfan I	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Dieldrin	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016
4,4'-DDE	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016
Endrin	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016
Endosulfan II	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016
4,4'-DDD	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016
Endosulfan Sulfate	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016
4,4'-DDT	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016
Methoxychlor	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Endrin Ketone	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016
Alpha-chlordane	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Gamma-chlordane	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Toxaphene	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
PCB Arochlor 1016	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
PCB Arochlor 1221	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
PCB Arochlor 1232	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
PCB Arochlor 1242	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
PCB Arochlor 1248	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
PCB Arochlor 1254	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
PCB Arochlor 1260	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16

APPENDIX G (continued)
HAGEN FARM SOIL BIODEGRADATION STUDY
ANALYTICAL RESULTS FOR SOIL FRACTION
(all units in mg/kg wet weight except as noted)

	Original Soil	Initial Reactor Conditions	Day 12				Day 26			
			Reactor 1	Reactor 2	Reactor 3	Reactor 4	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Alcohols										
Isobutyl Alcohol	NA	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Methanol	NA	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
N-butyl Alcohol	NA	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Cyclohexanone	NA	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

NA Not Analyzed

APPENDIX G (continued) HAGEN FARM SOIL BIODEGRADATION STUDY, ANALYTICAL RESULTS FOR SOIL FRACTION
(all units in mg/kg wet weight except as noted)

	Original Soil	Initial Reactor Conditions	Day 12				Day 26			
			Reactor 1	Reactor 2	Reactor 3	Reactor 4	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Volatile Organics (μg/kg)										
Acetone	70	23*	<20	<20	<20	<20	<20	<20	<20	<20
Benzene	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromodichloromethane	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromoform	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromomethane	<11	<10	<10	<10	<10	<10	<10	<10	<10	<10
Carbon Disulfide	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
Carbon Tetrachloride	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chlorobenzene	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chloroethane	<6	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chloroform	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chloromethane	<11	<10	<10	<10	<10	<10	<10	<10	<10	<10
Dibromochloromethane	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cis-1,3-Dichloropropene	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1-Dichloroethane	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,2-Dichloroethane	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1-Dichloroethene	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,2-Dichloropropane	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
Ethylbenzene	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
2-Hexanone	<11	<10	<10	<10	<10	<10	<10	<10	<10	<10
Methylene Chloride	<6	6	<5	<5	<5	<5	<5	<5	8	<5
Methyl Ethyl Ketone	<11	15*	<10	<10	<10	<10	<10	<10	<10	<10
4-Methyl-2-Pentanone	<11	<10	<10	<10	<10	<10	<10	<10	<10	<10
Styrene	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1,2,2-Tetrachloroethane	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
Tetrachloroethene	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
Tetrahydrofuran	<28	78	<25	<25	<25	<25	<10	<10	<10	<10
Toluene	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,2-Dichloroethene (Total)	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
Trans-1,3-Dichloropropene	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1,1-Trichloroethane	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1,2-Trichloroethane	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
Trichloroethene	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
Vinyl Acetate	<11	<10	<10	<10	<10	<10	<10	<10	<10	<10
Vinyl Chloride	<11	<10	<10	<10	<10	<10	<10	<10	<10	<10
Xylene (Total)	<6	<5	<5	<5	<5	<5	<5	<5	<5	<5
Ethyl Ether	<5	<5	<10	<10	<10	<10	<5	<5	<5	<5

* Also detected in blank

APPENDIX G (continued)
HAGEN FARM SOIL BIODEGRADATION STUDY, ANALYTICAL RESULTS FOR SOIL FRACTION
(all units in mg/kg wet weight except as noted)

	Original Soil	Initial Reactor Conditions	Day 12				Day 26			
			Reactor 1	Reactor 2	Reactor 3	Reactor 4	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Semi-Volatile Organics (μg/kg)										
Acenaphthene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Acenaphthylene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Anthracene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Benz(A)Anthracene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Benzo(A)Pyrene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Benzo(B)Fluoranthene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Benzo(G,H,I)Perylene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Benzo(K)Fluoranthene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Benzyl Alcohol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Benzylbutylphthalate	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Bis(2-Chloroethoxy)Methane	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Bis(2-Chloroethyl)Ether	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Bis(2-Chloroisopropyl)Ether	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Bis(2-Ethylhexyl)Phthalate	360	<330	<330	<330	<330	<330	<330	<330	<330	<330
4-Bromophenylphenylether	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
4-Chloroaniline	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
2-Chloronaphthalene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
4-Chlorophenylphenylether	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Chrysene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Dibenz(A,H)Anthracene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Dibenzofuran	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
1,2-Dichlorobenzene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
1,3-Dichlorobenzene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
1,4-Dichlorobenzene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
3,3'-Dichlorobenzidine	<660	<660	<660	<660	<660	<660	<660	<660	<660	<660
Diethylphthalate	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Dimethylphthalate	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Di-n-butylphthalate	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
2,4-Dinitrotoluene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
2,6-Dinitrotoluene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Di-n-octylphthalate	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Fluoranthene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Fluorene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330

APPENDIX G (continued)
HAGEN FARM SOIL BIODEGRADATION STUDY, ANALYTICAL RESULTS FOR SOIL FRACTION
(all units in mg/kg wet weight except as noted)

	Original Soil	Initial Reactor Conditions	Day 12				Day 26			
			Reactor 1	Reactor 2	Reactor 3	Reactor 4	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Semi-Volatile Organics (μg/kg) (CONTINUED)										
Hexachlorobenzene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Hexachlorobutadiene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Hexachlorocyclopentadiene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Hexachloroethane	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Indeno(1,2,3-CD)Pyrene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Isophorone	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
2-Methylnaphthalene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Naphthalene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
2-Nitroaniline	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600
3-Nitroaniline	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600
4-Nitroaniline	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600
Nitrobenzene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
N-nitroso-diphenylamine	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
N-nitroso-di-n-propylamine	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Phenanthrene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Pyrene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Pyridine	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600
1,2,4-Trichlorobenzene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Benzoic Acid	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600
4-Chloro-3-methylphenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
2-Chlorophenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
2,4-Dichlorophenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
2,4-Dimethylphenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
4,6-Dinitro-2-methylphenol	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600
2,4-Dinitrophenol	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600
2-Methylphenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
4-Methylphenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
2-Nitrophenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
4-Nitrophenol	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600
Pentachlorophenol	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600
Phenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
2,4,5-Trichlorophenol	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600	<1600
2,4,6-Trichlorophenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330
Total Solids (%)	92	83	87	89	88	89	85	83	84	85

APPENDIX G (continued)
HAGEN FARM SOIL BIODEGRADATION STUDY, ANALYTICAL RESULTS FOR SOIL FRACTION
(all units in mg/kg wet weight except as noted)

	Original Soil	Initial Reactor Conditions	Day 12				Day 26			
			Reactor 1	Reactor 2	Reactor 3	Reactor 4	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Metals										
Aluminum	3000	1300	870	510	510	860	1,900	1,500	1,600	3,700
Antimony	<2.0	<1.0	<10	<10	<10	<10	<10	<1.0	<1.0	1.1
Arsenic	<2.0	1.1	1.9	<2.0	<2.0	1.2	<1.0	<1.0	1.2	2.0
Barium	20	6.8	0.31	0.59	0.68	0.59	11	9.6	7.8	16
Beryllium	0.25	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.21	0.24
Cadmium	0.88	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
Calcium	58,000	7,500	7,600	7,700	6,400	7,000	8,500	6,800	5,100	11,000
Chromium	5.0	4.6	4.5	3.6	3.5	4.3	4.2	5.5	4.9	8.7
Cobalt	2.2	2.7	<2.0	<2.0	<2.0	<2.0	<2.0	4.0	2.4	3.6
Copper	7.3	4.8	3.7	5.2	4.3	4.4	4.7	5.6	6.3	12
Iron	6,500	590	4,100	3,700	3,900	4,200	540	940	650	920
Lead	3.4	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	14	<4.0	<4.0
Magnesium	35,000	29,000	57,000	40,000	39,000	48,000	38,000	40,000	22,000	60,000
Manganese	180	170	160	130	140	160	160	160	120	310
Mercury	<0.10	<0.1	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.1	<0.1
Nickel	5.7	6.8	3.1	2.4	2.9	3.2	7.3	12	6.8	13
Potassium	<10	250	300	<10	<10	<10	350	250	240	510
Selenium	<1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Silver	<0.20	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sodium	240	140	150	160	120	130	200	150	140	250
Thallium	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
Vanadium	14	<20	<20	<20	<20	<20	<20	24	<20	<20
Zinc	15	8.9	9.6	9.4	9.1	12	9.2	23	10	17
Phosphorus	99	110	79	92	96	96	96	73	100	110
Kjeldahl Nitrogen	NA	<110	<67	<6	<34	<6	<110	<110	<110	<110
TOC (dry weight basis)	15,300	31,900	13,000	21,751	18,550	3,800	5,000	19,000	46,000	43,200
pH (units)	8.3	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonia Nitrogen	6.9	13	NA	NA	NA	NA	2.7	3.2	19	16
CEC (meq/100g dry weight)	2.7	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA Not Analyzed

APPENDIX H

Analytical Results for Liquid Fraction
Hagen Farm Soil Biodegradation Study

APPENDIX H
HAGEN FARM SOIL BIODEGRADATION STUDY, ANALYTICAL RESULTS FOR LIQUID FRACTION
(all units in mg/L except as noted)

	Initial Reactor Conditions	Day 12				Day 26			
		Reactor 1	Reactor 2	Reactor 3	Reactor 4	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Cyanide	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCBs and Pesticides									
Alpha-BHC	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Beta-BHC	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Delta-BHC	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Gamma-BHC (Lindane)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Heptachlor	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Aldrin	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Heptachlor Epoxide	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Endosulfan I	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Dieldrin	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
4,4'-DDE	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Endrin	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Endosulfan II	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
4,4'-DDD	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Endosulfan Sulfate	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
4,4'-DDT	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Methoxychlor	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Endrin Ketone	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Alpha-chlordane	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Gamma-chlordane	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Toxaphene	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
PCB Arochlor 1016	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
PCB Arochlor 1221	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
PCB Arochlor 1232	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
PCB Arochlor 1242	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
PCB Arochlor 1248	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
PCB Arochlor 1254	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
PCB Arochlor 1260	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

APPENDIX H (continued)
HAGEN FARM SOIL BIODEGRADATION STUDY, ANALYTICAL RESULTS FOR LIQUID FRACTION
(all units in mg/L except as noted)

	Initial Reactor Conditions	Day 12				Day 26			
		Reactor 1	Reactor 2	Reactor 3	Reactor 4	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Alcohols									
Isobutyl Alcohol	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Methanol	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
N-butyl Alcohol	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Cyclohexanone	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

APPENDIX H (continued)
HAGEN FARM SOIL BIODEGRADATION STUDY, ANALYTICAL RESULTS FOR LIQUID FRACTION

	Initial Reactor Conditions	Day 12				Day 26			
		Reactor 1	Reactor 2	Reactor 3	Reactor 4	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Volatile Organics (µg/L)									
Acetone	<20	<20	55	<20	26*	<20	<20	<20	<20
Benzene	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromodichloromethane	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromoform	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromomethane	<10	<10	<10	<10	<10	<10	<10	<10	<10
Carbon Disulfide	<5	<5	<5	<5	<5	<5	<5	<5	<5
Carbon Tetrachloride	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chlorobenzene	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chloroethane	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chloroform	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chloromethane	<10	<10	<10	<10	<10	<10	<10	<10	<10
Dibromochloromethane	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cis-1,3-Dichloropropene	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1-Dichloroethane	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,2-Dichloroethane	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1-Dichloroethene	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,2-Dichloropropane	<5	<5	<5	<5	<5	<5	<5	<5	<5
Ethylbenzene	<5	<5	<5	<5	<5	<5	<5	<5	<5
2-Hexanone	<10	<10	<10	<10	<10	<10	<10	<10	<10
Methylene Chloride	<5	<5	<5	<5	<5	<5	7	<5	<5
Methyl Ethyl Ketone	<10	<10	18	<10	<10	<10	<10	<10	<10
4-Methyl-2-Pentanone	<10	<10	<10	<10	<10	<10	<10	<10	<10
Styrene	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1,2,2-Tetrachloroethane	<5	<5	<5	<5	<5	<5	<5	<5	<5
Tetrachloroethene	<5	<5	<5	<5	<5	<5	<5	<5	<5
Tetrahydrofuran	<25	<10	<10	<25	38	<25	<25	<25	<25
Toluene	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,2-Dichloroethene (Total)	<5	<5	<5	<5	<5	<5	<5	<5	<5
Trans-1,3-Dichloropropene	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1,1-Trichloroethane	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1,2-Trichloroethane	<5	<5	<5	<5	<5	<5	<5	<5	<5
Trichloroethene	<5	<5	<5	<5	<5	<5	<5	<5	<5
Vinyl Acetate	<10	<10	<10	<10	<10	<10	<10	<10	<10
Vinyl Chloride	<10	<10	<10	<10	<10	<10	<10	<10	<10
Xylene (Total)	<5	<5	<5	<5	<5	<5	<5	<5	<5
Ethyl Ether	<5	<5	<5	<10	<10	<5	<5	<5	<5

APPENDIX H (continued)
HAGEN FARM SOIL BIODEGRADATION STUDY, ANALYTICAL RESULTS FOR LIQUID FRACTION

	Initial Reactor Conditions	Day 12				Day 26			
		Reactor 1	Reactor 2	Reactor 3	Reactor 4	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Semi-Volatile Organics (μg/L)									
Acenaphthene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Acenaphthylene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Anthracene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benz(A)Anthracene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzo(A)Pyrene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzo(B)Fluoranthene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzo(G,H,I)Perylene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzo(K)Fluoranthene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzyl Alcohol	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzylbutylphthalate	<10	<10	<10	<10	<10	<10	<10	<10	<10
Bis(2-Chloroethoxy)Methane	<10	<10	<10	<10	<10	<10	<10	<10	<10
Bis(2-Chloroethyl)Ether	<10	<10	<10	<10	<10	<10	<10	<10	<10
Bis(2-Chloroisopropyl)Ether	<10	<10	<10	<10	<10	<10	<10	<10	<10
Bis(2-Ethylhexyl)Phthalate	<10	<10	<10	<10	<10	<10	<10	<10	<10
4-Bromophenylphenylether	<10	<10	<10	<10	<10	<10	<10	<10	<10
4-Chloroaniline	<10	<10	<10	<10	<10	<10	<10	<10	<10
2-Chloronaphthalene	<10	<10	<10	<10	<10	<10	<10	<10	<10
4-Chlorophenylphenylether	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chrysene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Dibenz(A,H)Anthracene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Dibenzofuran	<10	<10	<10	<10	<10	<10	<10	<10	<10
1,2-Dichlorobenzene	<10	<10	<10	<10	<10	<10	<10	<10	<10
1,3-Dichlorobenzene	<10	<10	<10	<10	<10	<10	<10	<10	<10
1,4-Dichlorobenzene	<10	<10	<10	<10	<10	<10	<10	<10	<10
3,3'-Dichlorobenzidine	<20	<20	<20	<20	<20	<20	<20	<20	<20
Diethylphthalate	<10	<10	<10	<10	<10	<10	<10	<10	<10
Dimethylphthalate	<10	<10	<10	<10	<10	<10	<10	<10	<10
Di-n-butylphthalate	<10	<10	<10	<10	<10	<10	<10	<10	<10
2,4-Dinitrotoluene	<10	<10	<10	<10	<10	<10	<10	<10	<10
2,6-Dinitrotoluene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Di-n-octylphthalate	<10	<10	<10	<10	<10	<10	<10	<10	<10
Fluoranthene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Fluorene	<10	<10	<10	<10	<10	<10	<10	<10	<10

APPENDIX H (continued)
HAGEN FARM SOIL BIODEGRADATION STUDY, ANALYTICAL RESULTS FOR LIQUID FRACTION

	Initial Reactor Conditions	Day 12				Day 26			
		Reactor 1	Reactor 2	Reactor 3	Reactor 4	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Semi-Volatile Organics (μg/L) (continued)									
Hexachlorobenzene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Hexachlorobutadiene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Hexachlorocyclopentadiene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Hexachloroethane	<10	<10	<10	<10	<10	<10	<10	<10	<10
Indeno(1,2,3-CD)Pyrene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Isophorone	<10	<10	<10	<10	<10	<10	<10	<10	<10
2-Methylnaphthalene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Naphthalene	<10	<10	<10	<10	<10	<10	<10	<10	<10
2-Nitroaniline	<50	<50	<50	<50	<50	<50	<50	<50	<50
3-Nitroaniline	<50	<50	<50	<50	<50	<50	<50	<50	<50
4-Nitroaniline	<50	<50	<50	<50	<50	<50	<50	<50	<50
Nitrobenzene	<10	<10	<10	<10	<10	<10	<10	<10	<10
N-nitroso-diphenylamine	<10	<10	<10	<10	<10	<10	<10	<10	<10
N-nitroso-di-n-propylamine	<10	<10	<10	<10	<10	<10	<10	<10	<10
Phenanthrene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Pyrene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Pyridine	<50	<50	<50	<50	<50	<50	<50	<50	<50
1,2,4-Trichlorobenzene	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzoic Acid	<50	<50	<50	<50	<50	<50	<50	<50	<50
4-Chloro-3-methylphenol	<10	<10	<10	<10	<10	<10	<10	<10	<10
2-Chlorophenol	<10	<10	<10	<10	<10	<10	<10	<10	<10
2,4-Dichlorophenol	<10	<10	<10	<10	<10	<10	<10	<10	<10
2,4-Dimethylphenol	<10	<10	<10	<10	<10	<10	<10	<10	<10
4,6-Dinitro-2-methylphenol	<50	<50	<50	<50	<50	<50	<50	<50	<50
2,4-Dinitrophenol	<50	<50	<50	<50	<50	<50	<50	<50	<50
2-Methylphenol	<10	<10	<10	<10	<10	<10	<10	<10	<10
4-Methylphenol	<10	<10	<10	<10	<10	<10	<10	<10	<10
2-Nitrophenol	<10	<10	<10	<10	<10	<10	<10	<10	<10
4-Nitrophenol	<50	<50	<50	<50	<50	<50	<50	<50	<50
Pentachlorophenol	<50	<50	<50	<50	<50	<50	<50	<50	<50
Phenol	<10	<10	<10	<10	<10	<10	<10	<10	<10
2,4,5-Trichlorophenol	<50	<10	<10	<10	<10	<50	<50	<50	<50
2,4,6-Trichlorophenol	<10	<10	<10	<10	<10	<10	<10	<10	<10
Total Solids (%)	2	3.7	1.8	1.7	2.5	2	2	2	2

APPENDIX H (continued)
HAGEN FARM SOIL BIODEGRADATION STUDY, ANALYTICAL RESULTS FOR LIQUID FRACTION

	Initial Reactor Conditions	Day 12				Day 26			
		Reactor 1	Reactor 2	Reactor 3	Reactor 4	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Metals									
Aluminum	170	320	170	240	180	260	210	190	210
Antimony	<1.5	<0.60	<0.60	<0.60	<0.60	<1.5	<1.5	<1.5	<1.5
Arsenic	0.030	0.17	0.12	0.15	0.11	0.029	0.041	0.045	0.040
Barium	1.7	3.1	2.1	2.6	2.1	2.7	2.1	2.1	2.7
Beryllium	0.0059	0.024	0.014	0.024	0.024	0.0088	0.010	0.0088	0.01
Cadmium	<0.25	<0.10	<0.10	<0.10	<0.10	<0.25	<0.25	<0.25	<0.25
Calcium	1,800	2,900	2,100	2,400	1,600	1,900	1,600	1,500	1,600
Chromium	0.30	0.52	0.30	0.40	0.31	0.45	0.34	0.32	0.35
Cobalt	0.21	0.31	0.21	0.27	0.21	0.29	0.23	0.24	0.26
Copper	0.77	1.1	0.84	0.98	0.74	0.94	0.77	0.74	1.1
Iron	320	720	440	600	440	460	370	340	510
Lead	0.37	0.45	0.34	0.42	0.32	0.46	0.42	0.42	0.45
Magnesium	1,000	1,300	920	1,100	700	1,100	890	860	870
Manganese	11	15	11	13	10	14	11	12	16
Mercury	<0.0005	0.010	0.015	<0.001	<0.001	0.0022	0.0023	0.0013	0.0018
Nickel	0.43	0.67	0.44	0.58	0.44	0.62	0.48	0.50	0.57
Potassium	25	49	28	37	33	41	34	34	33
Selenium	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium	110	86	71	120	110	82	70	110	120
Thallium	<15	<6.0	<6.0	<6.0	<6.0	<15	<15	<15	<15
Vanadium	0.53	0.91	0.53	0.71	0.55	0.76	0.62	0.56	0.61
Zinc	1.4	2.1	1.4	1.8	1.4	2.0	1.6	1.6	1.8
Alkalinity	300	150	500	1,600	950	150	30	26	19
Kjeldahl Nitrogen	<6	10	13	8.9	30	<6	9.0	10	<6
TOC (dry weight basis)	5.0	--	--	3.0	6.0	6.1	6.1	6.6	8.4
Ammonia Nitrogen	<0.01	NA	NA	NA	NA	<0.01	0.13	<0.01	<0.01
Chloride	25	7.5	120	120	120	8.0	110	130	130
Sulfate	110	150	160	190	360	150	370	520	620
Chemical Oxygen Demand	210	260	260	310	360	260	210	310	410
Phosphorus	6.7	24	22	26	33	15	24	34	24

NA Not Analyzed

APPENDIX I

Hagen Farm Soil Bioreactors
Dissolved Oxygen vs. Time

FIGURE I-1
Hagen Farm Soil Bioreactors
Dissolved Oxygen vs Time - Day 16

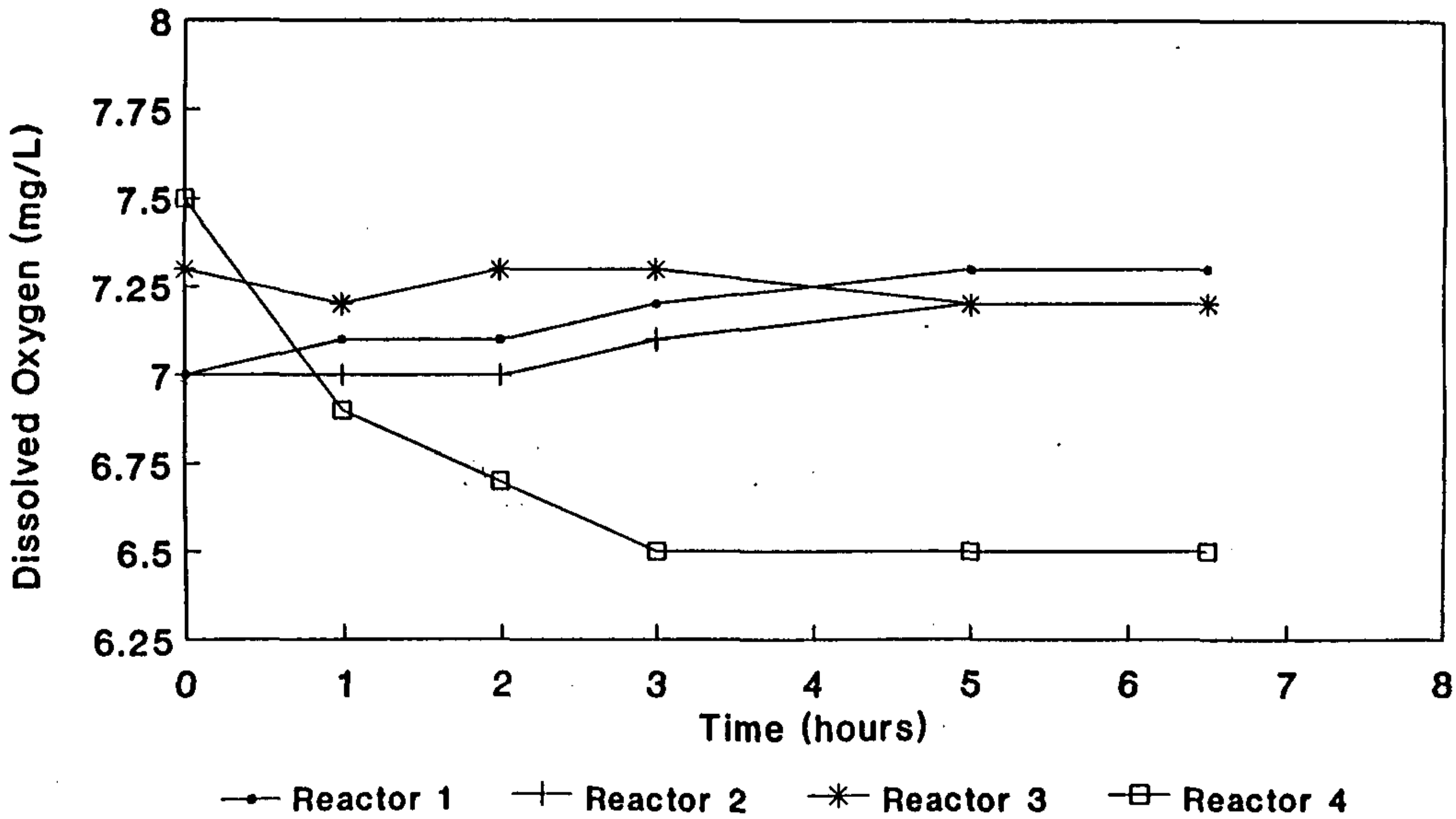


FIGURE I-2
Hagen Farm Soil Bioreactors
Dissolved Oxygen vs. Time - Day 25

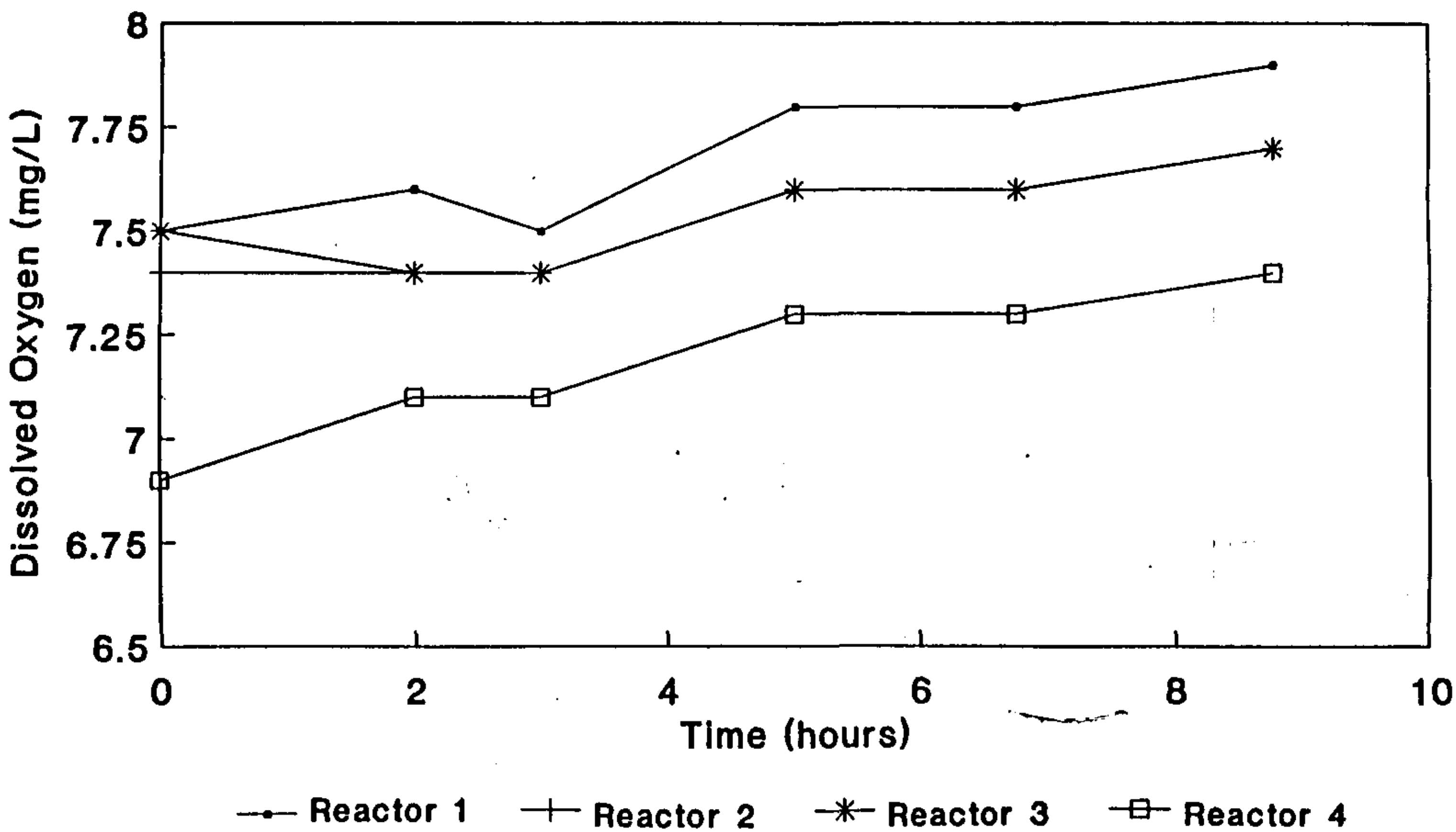
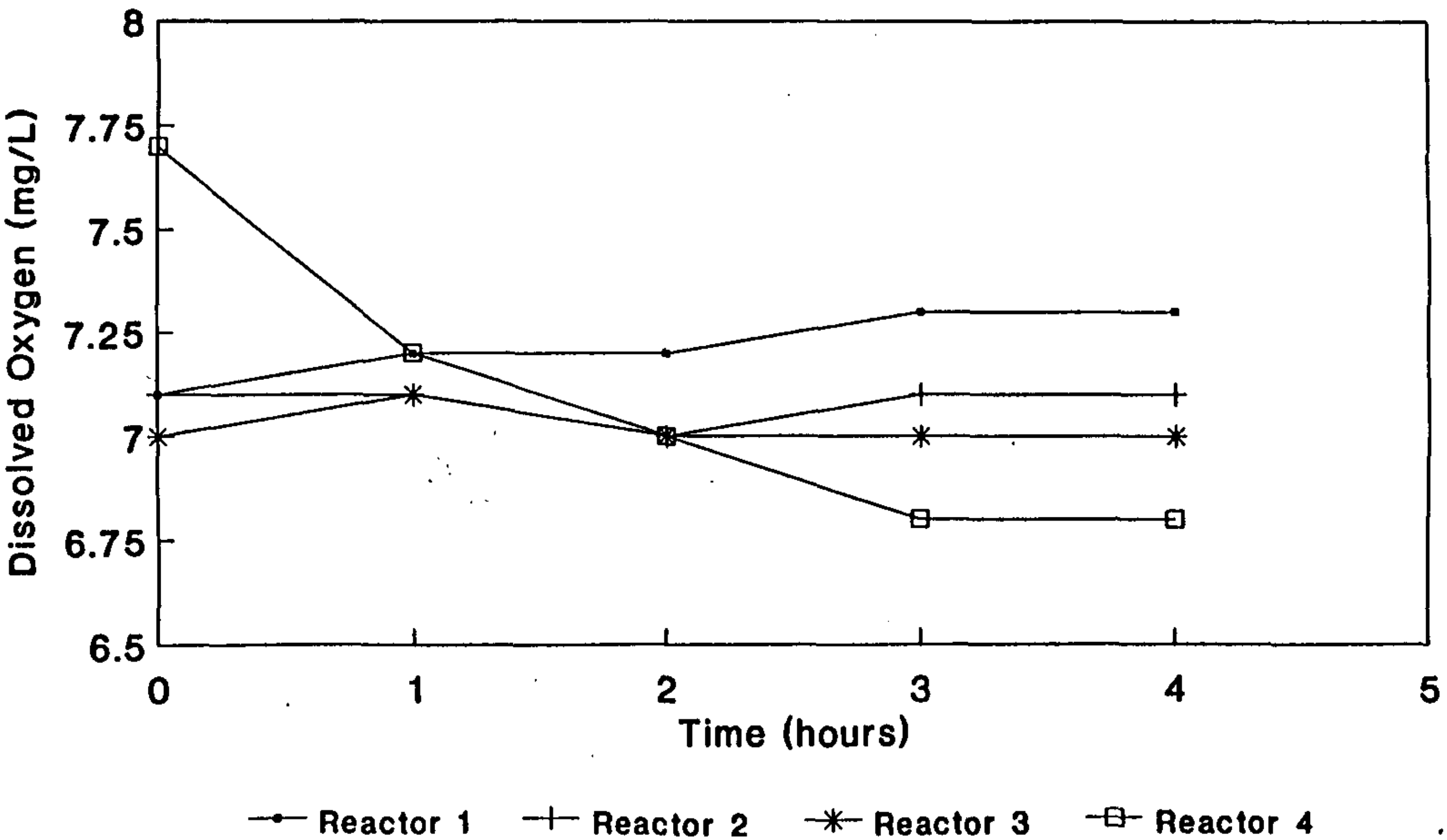


FIGURE I-3

Hagen Farm Soil Bioreactors

Dissolved Oxygen vs Time - Day 32



PELA

APPENDIX D

Alternative Costs - Source Control
(7 Pages)

Technology: Alternative I: No action, to include active extraction trenches and combustion of vented air.
Site Name: Dunn Landfill
Date: March 3, 1992

Technology: Alternative V: Same as Alternative II with the addition of vacuum extraction through wells and installation of membrane cutoff wall at cells 6 and 12.
Site Name: Dunn Landfill
Date: March 3, 1992

Technology: Cover A
Site Name: Dunn Landfill
Date: March 3, 1992

Technology: Alternative VI: Same as Alternative IV with the addition of vacuum extraction through wells and installation of membrane cutoff wall at cells 6 and 12.
Site Name: Dunn Landfill
Date: March 3, 1992

Technology: Cover B/C - no drainage/B
Site Name: Dunn Landfill
Date: March 3, 1992

Technology: *Alternative VII: Same as Alternative III except deep well vacuum extraction and* installation of membrane cutoff wall at cells 6 and 12.
Site Name: Dunn Landfill
Date: March 3, 1992

Technology: Cover B - no drainage layer
Site Name: Dunn Landfill
Date: March 3, 1992

Technology:	ALTERNATIVE I:	No action, to include active extraction trenches and combustion of vented air.
Site Name:	Dunn Landfill	
Date:	March 3, 1992	

Item Description	Units	Quantity	Unit Price	Total Cost
CAPITAL COSTS				
Vent/Trench-Sand	CY	800	$4.50	$3,600
4" Dia. Perforated Pipe	LF	4,200	14.00	58,800
Geotextile	SF	41,100	0.15	6,165
Header Pipe	LF	2,800	20.00	56,000
Drip Leg	LS	4	1,000.00	4,000
Blower	LS	1	5,000.00	5,000
Flare	LS	1	55,000.00	55,000
Flare Installation	LS	1	55,000.00	55,000
ANNUAL O & M COSTS				
Blower Maintenance(2 yr)	HR	104	100.00	10,400
Flare Maintenance(2 yr)	HR	104	100.00	10,400
Monitoring(offgas, 2 yr)	LS	1	6,100.00	6,100
Monitoring(gas &storm w)	LS	1	8,500.00	8,500
SUBTOTAL-Construction Cost				$243,565
LEGAL FEES, LICENSE & PERMIT COSTS AT 10% OF CONST. COST				24,357
ENGINEERING & ADMINISTRATIVE AT 15% OF CONST. COST				36,535
SUBTOTAL				$304,456
CONTINGENCY AT 20% OF CONSTRUCTION COST				60,891
TOTAL CAPITAL COST				$365,348
SUBTOTAL-Annual O & M Cost: FIRST 2 YEARS				$35,400
SUBTOTAL-Annual O & M Cost: AFTER 2 YEARS				$8,500
CONTINGENCY AT 20% OF O & M COST: FIRST 2 YEARS				7,080
CONTINGENCY AT 20% OF O & M COST: AFTER FIRST 2 YEARS				1,700
ANNUAL O & M COSTS: FIRST 2 YEARS				$42,480
ANNUAL O & M COSTS: AFTER FIRST 2 YEARS				$10,200
PRESENT NET VALUE 9.0% Discount Rate; 5.0% Inflation Rate				$587,739

Prepared by: JBH Date: 3/3/92

Checked by: RGJ Date: 3/3/92

Technology:	ALTERNATIVE V:	Same as Alternative II with the addition of vacuum extraction through wells and installation of membrane cutoff wall at cells 6 and 12.
Site Name:	Dunn Landfill	
Date:	March 3, 1992	

Item Description	Units	Quantity	Unit Price	Total Cost
ITEM				
Vent/Trench(V/T)-Sand	CY	800	$4.50	$3,600
V/T-4" Dia. Perfor. Pipe	LF	4,200	14.00	58,800
V/T-Geotextile	SF	41,100	0.15	6,165
V/T-Header Pipe	LF	2,100	20.00	42,000
V/T-Drip Leg	EA	4	1,000.00	4,000
Blower	LS	1	5,000.00	5,000
Flare	LS	1	55,000.00	55,000
Flare Installation	LS	1	55,000.00	55,000
Site Fencing	LF	6,500	10.00	65,000
Cover A	LS	1	1,821,788	1,821,788
Vent/Well(V/W)-cell 6&12	EA	4	3,000.00	12,000
V/W-Header Pipe	LF	2,700	20.00	54,000
V/W-Drip Leg	LS	2	1,000.00	2,000
Membrane Curtain/Wall	LS	1	55,000.00	55,000
ANNUAL O & M COSTS				
Site Inspections	EA	4	850.00	3,400
Turf and Erosion Repair	AC	24.2	100.00	2,420
Mowing	AC	24.2	50.00	1,210
Equipment & Facilities	LS	1	2,185.00	2,185
Blower Maintenance(5 yr)	HR	260	100.00	26,000
Flare Maintenance(5 yr)	HR	260	100.00	26,000
Monitoring (offgas,5 yr)	LS	1	6,100.00	6,100
Monitoring(gas &storm w)	LS	1	8,500.00	8,500

SUBTOTAL-Construction Cost	**$2,239,353**
LEGAL FEES, LICENSE & PERMIT COSTS AT 10% OF CONST. COST	223,935
ENGINEERING & ADMINISTRATIVE AT 15% OF CONST. COST	335,903
SUBTOTAL	**$2,799,191**
CONTINGENCY AT 20% OF CONSTRUCTION COST	559,838
TOTAL CAPITAL COST	**$3,359,030**
SUBTOTAL-Annual O & M Cost: FIRST 5 YEARS	**$75,815**
SUBTOTAL-Annual O & M Cost: AFTER 5 YEARS	**$17,715**
CONTINGENCY AT 20% OF O & M COST: FIRST 5 YEARS	15,163
CONTINGENCY AT 20% OF O & M COST: AFTER 5 YEARS	3,543
ANNUAL O & M COSTS: FIRST 5 YEARS	**$90,978**
ANNUAL O & M COSTS: AFTER 5 YEARS	**$21,258**
PRESENT NET VALUE	**$3,905,226**
9.0% Discount Rate; 5.0% Inflation Rate	

Prepared by: JBH Date: 3/3/92 Checked by: RG S Date: 3/3/92

Table No.
Technology: Cover A
Site Name: Dunn Landfill
Date: March 3, 1992

Item Description	Units	Quantity	Unit Price	Total Cost
Item				
Native Soil	CY	19,521	$4.00	$78,084
Cohesive Soil	CY	19,521	7.00	136,647
40 mil FML	SF	1,054,152	0.50	527,076
Drainage Layer	CY	39,043	8.00	312,344
Geotextile	SF	1,054,152	0.115	121,227
Root Zone	CY	58,564	7.00	409,948
Topsoil	CY	19,521	9.00	175,689
Seed, Fertilizer, Mulch	AC	24.2	1,100.00	26,620
Perimeter Shaping	LS	1	34,153.00	34,153
ANNUAL O & M COSTS				
Site Inspections	EA	4	850.00	3,400
Turf and Erosion Repair	AC	24.2	100.00	2,420
Mowing	AC	24.2	34.50	835
Equipment & facilities	LS	1	2,185.00	2,185
SUBTOTAL-Construction Cost				$1,821,788
LEGAL FEES, LICENSE & PERMIT COSTS AT 10% OF CONST. COST				182,179
ENGINEERING & ADMINISTRATIVE AT 15% OF CONST. COST				273,268
SUBTOTAL				$2,277,236
CONTINGENCY AT 20% OF CONSTRUCTION COST				455,447
TOTAL CAPITAL COST				$2,732,683

Prepared by: QBA1 Date: 3/3/92
Checked by: RGS Date: 3/3/92

Technology: ALTERNATIVE VI: Same as Alternative IV with the addition of vacuum extraction through wells and installation of membrane cut-off wall at cells 6 and 12.

Site Name: Dunn Landfill

Date: March 3, 1992

Item Description	Units	Quantity	Unit Price	Total Cost
ITEM				
Vent/Trench(V/T)-Sand	CY	800	$4.50	$3,600
V/T-4" Dia. Perfor. Pipe	LF	4,200	14.00	58,800
V/T-Geotextile	SF	41,100	0.15	6,165
V/T-Header Pipe	LF	2,100	20.00	42,000
V/T-Drip Leg	EA	4	1,000.00	4,000
Blower	LS	1	5,000.00	5,000
Flare	LS	1	55,000.00	55,000
Flare Installation	LS	1	55,000.00	55,000
Site Fencing	LF	6,500	10.00	65,000
Cover B/C	LS	1	1,835,479	1,835,479
Vent/Well(V/W)-cell 6&12	EA	4	3,000.00	12,000
V/W-Header Pipe	LF	2,700	20.00	54,000
V/W-Drip Leg	LS	2	1,000.00	2,000
Membrane Curtain/Wall	LS	1	55,000.00	55,000
ANNUAL O & M COSTS				
Site Inspections	EA	4	850.00	3,400
Turf and Erosion Repair	AC	24.2	100.00	2,420
Mowing	AC	24.2	50.00	1,210
Equipment & Facilities	LS	1	2,185.00	2,185
Blower Maintenance(5 yr)	HR	260	100.00	26,000
Flare Maintenance(5 yr)	HR	260	100.00	26,000
Monitoring (offgas,5 yr)	LS	1	6,100.00	6,100
Monitoring(gas &storm w)	LS	1	8,500.00	8,500
SUBTOTAL-Construction Cost				$2,253,044
LEGAL FEES, LICENSE & PERMIT COSTS AT 10% OF CONST. COST				225,304
ENGINEERING & ADMINISTRATIVE AT 15% OF CONST. COST				337,957
SUBTOTAL				$2,816,305
CONTINGENCY AT 20% OF CONSTRUCTION COST				563,261
TOTAL CAPITAL COST				$3,379,566
SUBTOTAL-Annual O & M Cost: FIRST 5 YEARS				$75,815
SUBTOTAL-Annual O & M Cost: AFTER 5 YEARS				$17,715
CONTINGENCY AT 20% OF O & M COST: FIRST 5 YEARS				15,163
CONTINGENCY AT 20% OF O & M COST: AFTER 5 YEARS				3,543
ANNUAL O & M COSTS: FIRST 5 YEARS				$90,978
ANNUAL O & M COSTS: AFTER 5 YEARS				$21,258
PRESENT NET WORTH 9.0% Discount Rate; 5.0% Inflation Rate				$3,925,008

Prepared by: JBH Date: 3/3/92 Checked by: RGS Date: 3/3/92

Table No.
Technology: Cover B/C- no Drainage/B
Site Name: Dunn Landfill
Date: March 3, 1992

Item Description	Units	Quantity	Unit Price	Total Cost
ITEM				
Clay	CY	78,085	$12.50	$976,063
40 mil FML	SF	191,664	0.70	134,165
Drainage Layer (sand)	CY	7,100	8.00	56,800
Geotextile	SF	191,664	0.115	22,041
Root Zone	CY	58,564	7.00	409,948
Topsoil	CY	19,521	9.00	175,689
Seed, Fertilizer, Mulch	AC	24.2	1,100.00	26,620
Perimeter Shaping	LS	1	34,153.00	34,153
ANNUAL O & M COSTS				
Site Inspections	EA	4	850.00	3,400
Turf and Erosion Repair	AC	24.2	100.00	2,420
Mowing	AC	24.2	34.50	835
Equipment & facilities	LS	1	2,185.00	2,185
SUBTOTAL-Construction Cost				$1,835,479
LEGAL FEES, LICENSE & PERMIT COSTS AT 10% OF CONST. COST				183,548
ENGINEERING & ADMINISTRATIVE AT 15% OF CONST. COST				275,322
SUBTOTAL				$2,294,348
CONTINGENCY AT 20% OF CONSTRUCTION COST				458,870
TOTAL CAPITAL COST				$2,753,218

Prepared by: GBH1 Date: 3/3/92

Checked by: RGS Date: 3/3/92

Technology: ALTERNATIVE VII: Same as Alternative III except deep well vacuum extraction and installation of membrane cutoff wall at cells 6 and 12.

Site Name: Dunn Landfill
Date: March 3, 1992

Item Description	Units	Quantity	Unit Price	Total Cost
ITEM				
Vent/Trench(V/T)-Sand	CY	800	4.50	3,600
V/T-4" Dia. Perfor. Pipe	LF	4,200	14.00	58,800
V/T Geotextile	SF	41,100	0.15	6,165
V/T Header Pipe	LF	2,100	20.00	42,000
V/T Drip Leg	EA	4	1,000.00	4,000
Blower	LS	1	5,000.00	5,000
Flare	LS	1	55,000.00	55,000
Flare Installation	LS	1	55,000.00	55,000
Site Fencing	LF	6,500	10.00	65,000
Cover B	LS	1	1,622,473	1,622,473
Vent/Well(V/W)-cell 6&12	EA	4	3,000.00	12,000
V/W-Header Pipe	LF	2,700	20.00	54,000
V/W-Drip Leg	LS	2	1,000.00	2,000
Membrane Curtain/Wall	LS	1	55,000.00	55,000
ANNUAL O & M COSTS				
Site Inspections	EA	4	850.00	3,400
Turf and Erosion Repair	AC	24.2	100.00	2,420
Mowing	AC	24.2	50.00	1,210
Equipment & Facilities	LS	1	2,185.00	2,185
Blower Maintenance(5 yr)	HR	260	100.00	26,000
Flare Maintenance(5 yr)	HR	260	100.00	26,000
Monitoring (offgas,5 yr)	LS	1	6,100.00	6,100
Monitoring(gas &storm w)	LS	1	8,500.00	8,500

SUBTOTAL-Construction Cost	$2,040,038
LEGAL FEES, LICENSE & PERMIT COSTS AT 10% OF CONST. COST	204,004
ENGINEERING & ADMINISTRATIVE AT 15% OF CONST. COST	306,006
SUBTOTAL	$2,550,048
CONTINGENCY AT 20% OF CONSTRUCTION COST	510,010
TOTAL CAPITAL COST	$3,060,057
SUBTOTAL-Annual O & M Cost: FIRST 5 YEARS	$75,815
SUBTOTAL-Annual O & M Cost: AFTER 5 YEARS	$17,715
CONTINGENCY AT 20% OF O & M COST: FIRST 5 YEARS	15,163
CONTINGENCY AT 20% OF O & M COST: AFTER 5 YEARS	3,543
ANNUAL O & M COSTS: FIRST 5 YEARS	$90,978
ANNUAL O & M COSTS: AFTER 5 YEARS	$21,258
PRESENT NET WORTH 9.0% Discount Rate; 5.0% Inflation Rate	$3,617,224

Prepared by: QBH Date: 3/3/92 Checked by: RGS Date: 3/3/92

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APPENDIX E

ARARs from U.S. EPA and WDNR - Source Control

ARAR Determinations
(2 Pages)

City Disposal Corporation Landfill
Potential Applicable or Relevant and Appropriate Requirements
Source Control
(2 Pages)

ARAR Determinations

Below are listed the ARAR's as determined by the Department based on the various remedial options presented. The Department may amend the list based on changes or additions to the list of possible remedial actions for the site.

Alternative	A or RA[1]	Code[2]	Preliminary Identification of Standards/Requirements
1) Institutional controls, access controls, monitoring cover A or B	RA	181.49	Groundwater monitoring to identify degree and extent of contamination, hazardous waste groundwater monitoring requirements
	A	181	Any waste generated during the remedial investigation must be handled consistent with hazardous waste requirements, general hazardous waste management requirements
	A	140	Groundwater standards and response requirements
	A	149	Laboratory certification for environmental testing
	A	504,506,445	Landfill gas collection, treatment and hazardous air emission controls
	A	508	Landfill monitoring requirements
	A	504,506,514,516	Landfill capping, closure and documentation requirements
2) Institutional controls, access controls, monitoring cover A or B/C	same requirements as alternative 1 above		
	RA	181.44(11)-(14)	Landfill capping, closure, monitoring and long term care requirements
3) Institutional controls, access controls, monitoring extraction, cover A or B	same requirements as alternative 1 above		
	A	181	Management requirements for hazardous wastes removed during construction of gas extraction systems
4) Institutional controls, access controls, monitoring, gas extraction, cover A or B/C	same as alternative 2		
	A	181	Management of hazardous wastes removed during construction of gas extraction systems
5) Institutional controls, access controls, monitoring trench/vent system, cover A or B	same as alternative 1		
6) Institutional controls, access controls, monitoring trench/vent system, cover A or B/C	same as alternative 2		

Alternative	A or RA[1]	Code[2]	Preliminary Identification of Standards/Requirements
7) Institutional controls, access restrictions, monitoring, gas extraction, trench/vent system, cover A or B	same as alternative 3		
8) Institutional controls, access restrictions, monitoring gas extraction, trench/vent system, cover A or B/C	same as alternative 4		

[1] A or RA = Applicable (A) or potentially Relevant and Appropriate (RA)
[2] Code = Wisconsin Administrative Code, Chapter NR series

City Disposal Corporation Landfill
Potential Applicable or Relevant and Appropriate Requirements
Source Control Operable Unit

All Alternatives. Each of the eight alternatives includes access restrictions, institutional controls, landfill cap and ground water monitoring.

ARARs:

Wis. Adm. Code NR. 600 series (formally NR. 181), including requirements for ground water monitoring, management of hazardous waste resulting from remedial activities, landfill capping, closure, monitoring, post closure maintenance and use, and documentation;

Wis. Adm. Code NR. 500 series, including 504, 506, 508, 514 and 516. These solid waste regulations include requirements for landfill gas collection and treatment, landfill capping, landfill closure, monitoring, post closure maintenance and use and documentation;

Wis. Adm. Code NR 445, hazardous air emissions control;

Wis. Adm. Code NR. 140, ground water quality standards and response requirements;

Wis. Adm. Code NR. 149, laboratory certification for environmental testing; AND

Resource Conservation and Recovery Act (RCRA) Subtitles C and D.

To Be Considered:

Technical Guidance Document Final Covers on Hazardous Waste Landfills and Surface Impoundments EPA/530/SW-89/047

Alternatives 3, 4, 5, 6, 7, and 8. These alternatives all include vacuum extraction, gas injection/extraction systems, and/or landfill gas trench/vent system.

ARARs: Wis. Adm. Code NR 445, hazardous air emissions control;

Title 40 of the Federal Code of Regulations (40 CFR) Part 50, National Ambient Air Quality Standards (NAAQS);

40 CFR Part 61, National Emission Standards for Hazardous Air Pollutants (NESHAP); AND

40 CFR Part 60, National New Source Performance Standards (NSPS).

To Be Considered:

OSWER Directive 9355.0-28, U.S. EPA policy guidance entitled Control of Air Emissions from Superfund Air Strippers at Superfund Ground Water Sites.

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APPENDIX F

Alternative Costs - Ground-Water Control
(5 Pages)

Table No.	Alternative 0
Technology:	No Action
Site Name:	Dunn Landfill
Date:	March 6, 1992

Table No.	Alternative 7
Technology:	Air Stripping, Activated Carbon & Catalytic Oxidation
Site Name:	Dunn Landfill
Date:	March 5, 1992

Table No.	Alternative 8
Technology:	Air Stripping & Activated Carbon
Site Name:	Dunn Landfill
Date:	March 5, 1992

Table No.	Alternative 9
Technology:	Bioremediation
Site Name:	Dunn Landfill
Date:	March 3, 1992

Table No.	Alternative 10
Technology:	Chemical Oxidation
Site Name:	Dunn Landfill
Date:	March 3, 1992

Table No. Alternative 0
Technology: No Action
Site Name: Dunn Landfill
Date: March 6, 1992

Item Description	Units	Quantity	Unit Price	Total Cost
ITEM				
N/A	-	0	$0	$0
ANNUAL O & M COSTS				
Monitoring	LS	1	114,216	114,216
SUBTOTAL-Construction Cost				$0
LEGAL FEES, LICENSE & PERMIT COSTS AT 10% OF CONST. COST				0
ENGINEERING & ADMINISTRATIVE AT 15% OF CONST. COST				0
SUBTOTAL				$0
CONTINGENCY AT 20% OF CONSTRUCTION COST				0
TOTAL CAPITAL COST				$0
SUBTOTAL-Annual O & M Cost: FIRST 20 YEARS				$114,216
SUBTOTAL-Annual O & M Cost: SECOND 20 YEARS				$114,216
CONTINGENCY AT 20% OF O & M COST: FIRST 20 YEARS				22,843
CONTINGENCY AT 20% OF O & M COST: SECOND 20 YEARS				22,843
ANNUAL O & M COSTS: FIRST 20 YEARS				$137,059
ANNUAL O & M COSTS: SECOND 20 YEARS				$137,059
PRESENT NET WORTH 9.0% Discount Rate; 5.0% Inflation Rate				$2,350,832

Prepared by: QBA1 Date: 3/6/92
Checked by: RGS Date: 3/6/92

Table No. Alternative 7
Technology: Air Strip, Act Carb & Cat Oxid
Site Name: Dunn Landfill
Date: March 5, 1992

Item Description	Units	Quantity	Unit Price	Total Cost
ITEM				
Groundwater Recovery Sys.	LS	1	$170,000	$170,000
Process Equipment-Instal.	LS	1	1,395,000	1,395,000
Site Piping	LS	1	45,000	45,000
Site Work and Buildings	LS	1	195,000	195,000
ANNUAL O & M COSTS				
Labor	LS	1	71,000	71,000
Analytical	LS	1	114,216	114,216
Chemicals	LS	1	130,000	130,000
Carbon Replace./Regener.	LS	1	395,000	395,000
Power & Natural Gas	LS	1	420,000	420,000
Residual Disposal	LS	1	40,000	40,000
Maintenance	LS	1	50,000	50,000
Administration	LS	1	42,000	42,000
SUBTOTAL-Construction Cost				$1,805,000
LEGAL FEES, LICENSE & PERMIT COSTS AT 10% OF CONST. COST				180,500
ENGINEERING & ADMINISTRATIVE AT 15% OF CONST. COST				270,750
SUBTOTAL				$2,256,250
CONTINGENCY AT 20% OF CONSTRUCTION COST				451,250
TOTAL CAPITAL COST				$2,707,500
SUBTOTAL-Annual O & M Cost: FIRST 20 YEARS				$1,262,216
SUBTOTAL-Annual O & M Cost: SECOND 20 YEARS				$95,406
CONTINGENCY AT 20% OF O & M COST: FIRST 20 YEARS				252,443
CONTINGENCY AT 20% OF O & M COST: SECOND 20 YEARS				19,081
ANNUAL O & M COSTS: FIRST 20 YEARS				$1,514,659
ANNUAL O & M COSTS: SECOND 20 YEARS				$114,487
PRESENT NET WORTH 9.0% Discount Rate; 5.0% Inflation Rate				$19,992,307

Prepared by: QBH Date: 3/5/92

Checked by: RGS Date: 3/5/92

Table No.
Technology: Air Stripping & Activated Carbon
Site Name: Dunn Landfill
Date: March 5, 1992

Alternative 8

Item Description	Units	Quantity	Unit Price	Total Cost
ITEM				
Groundwater Recovery Sys.	LS	1	$170,000	$170,000
Process Equipment-Instal.	LS	1	975,000	975,000
Site Piping	LS	1	45,000	45,000
Site Work and Buildings	LS	1	185,000	185,000
ANNUAL O & M COSTS				
Labor	LS	1	62,000	62,000
Monitoring	LS	1	114,216	114,216
Chemicals	LS	1	130,000	130,000
Carbon Replace./Regener.	LS	1	420,000	420,000
Power	LS	1	35,000	35,000
Residual Disposal	LS	1	40,000	40,000
Maintenance	LS	1	50,000	50,000
Administration	LS	1	42,000	42,000
SUBTOTAL-Construction Cost				$1,375,000
LEGAL FEES, LICENSE & PERMIT COSTS AT 10% OF CONST. COST				137,500
ENGINEERING & ADMINISTRATIVE AT 15% OF CONST. COST				206,250
SUBTOTAL				$1,718,750
CONTINGENCY AT 20% OF CONSTRUCTION COST				343,750
TOTAL CAPITAL COST				$2,062,500
SUBTOTAL-Annual O & M Cost: FIRST 20 YEARS				$893,216
SUBTOTAL-Annual O & M Cost: SECOND 20 YEARS				$95,406
CONTINGENCY AT 20% OF O & M COST: FIRST 20 YEARS				178,643
CONTINGENCY AT 20% OF O & M COST: SECOND 20 YEARS				19,081
ANNUAL O & M COSTS: FIRST 20 YEARS				$1,071,859
ANNUAL O & M COSTS: SECOND 20 YEARS				$114,487
PRESENT NET WORTH 9.0% Discount Rate; 5% Inflation Rate				$16,842,038

Prepared by: QBH Date: 3/5/92

Checked by: RGS Date: 3/5/92

Table No. Alternative 9
Technology: Bioremediation
Site Name: Dunn Landfill
Date: March 3, 1992

Item Description	Units	Quantity	Unit Price	Total Cost
ITEM				
Groundwater Recovery Sys.	LS	1	$170,000	$170,000
Process Equipment-Instal.	LS	1	1,105,000	1,105,000
Site Piping	LS	1	65,000	65,000
Site Work and Buildings	LS	1	210,000	210,000
ANNUAL O & M COSTS				
Labor	LS	1	83,000	83,000
Monitoring	LS	1	132,216	132,216
Chemicals	LS	1	48,000	48,000
Power	LS	1	40,000	40,000
Residual Disposal	LS	1	53,000	53,000
Maintenance	LS	1	70,000	70,000
Administration	LS	1	42,000	42,000
SUBTOTAL-Construction Cost				$1,550,000
LEGAL FEES, LICENSE & PERMIT COSTS AT 10% OF CONST. COST				155,000
ENGINEERING & ADMINISTRATIVE AT 15% OF CONST. COST				232,500
SUBTOTAL				$1,937,500
CONTINGENCY AT 20% OF CONSTRUCTION COST				387,500
TOTAL CAPITAL COST				$2,325,000
SUBTOTAL-Annual O & M Cost: FIRST 20 YEARS				$468,216
SUBTOTAL-Annual O & M Cost: SECOND 20 YEARS				$95,406
CONTINGENCY AT 20% OF O & M COST: FIRST 20 YEARS				93,643
CONTINGENCY AT 20% OF O & M COST: SECOND 20 YEARS				19,081
ANNUAL O & M COSTS: FIRST 20 YEARS				$561,859
ANNUAL O & M COSTS: SECOND 20 YEARS				$114,487
PRESENT NET WORTH 9.0% Discount Rate; 5.0% Inflation Rate				$10,301,833

Prepared by: QBH Date: 3/3/92
Checked by: RGS Date: 3/3/92

Table No.	Alternative 10
Technology:	**Chemical Oxidation**
Site Name:	Dunn Landfill
Date:	March 3, 1992

Item Description	Units	Quantity	Unit Price	Total Cost
ITEM				
Groundwater Recovery Sys.	LS	1	$170,000	$170,000
Process Equipment-Instal.	LS	1	805,000	805,000
Site Piping	LS	1	45,000	45,000
Site Work and Buildings	LS	1	185,000	185,000
ANNUAL O & M COSTS				
Labor	LS	1	62,000	62,000
Monitoring	LS	1	114,216	114,216
Chemicals	LS	1	65,000	65,000
Power	LS	1	130,000	130,000
Residual Disposal	LS	1	40,000	40,000
Maintenance	LS	1	85,000	85,000
Administration	LS	1	42,000	42,000
SUBTOTAL-Construction Cost				$1,205,000
LEGAL FEES, LICENSE & PERMIT COSTS AT 10% OF CONST. COST				120,500
ENGINEERING & ADMINISTRATIVE AT 15% OF CONST. COST				180,750
SUBTOTAL				$1,506,250
CONTINGENCY AT 20% OF CONSTRUCTION COST				301,250
TOTAL CAPITAL COST				$1,807,500
SUBTOTAL-Annual O & M Cost: FIRST 20 YEARS				$538,216
SUBTOTAL-Annual O & M Cost: SECOND 20 YEARS				$95,406
CONTINGENCY AT 20% OF O & M COST: FIRST 20 YEARS				107,643
CONTINGENCY AT 20% OF O & M COST: SECOND 20 YEARS				19,081
ANNUAL O & M COSTS: FIRST 20 YEARS				$645,859
ANNUAL O & M COSTS: SECOND 20 YEARS				$114,487
PRESENT NET WORTH 9.0% Discount Rate; 5.0% Inflation Rate				$10,926,379

Prepared by: QBAl Date: 3/3/92

Checked by: RCS Date: 3/3/92

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APPENDIX G

ARARs from U.S. EPA and WDNR - Ground-Water Control

TYPE OF DOCUMENT	DATE ISSUED	ADDRESSED TO	ADDRESSEE	NO. OF PAGES
Letter	May 20, 1991	Ms. Dee Brncich	Charles Wilk	5

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
230 SOUTH DEARBORN ST.
CHICAGO, ILLINOIS 60604

MAY 20 1991

REPLY TO ATTENTION OF:

Ms. Dee Brncich
Waste Management of North America, Incorporated
Midwest Region
Two Westbrook Corporate Center, Suite 1000
Westchester, Illinois 60154

Re: City Disposal Corporation Landfill
Applicable or Relevant and Appropriate Requirements

Dear Ms. Brncich:

The United States Environmental Protection Agency (U.S. EPA) and the Wisconsin Department of Natural Resources have completed their review of Technical Memorandum 6B, Alternatives Array Document for the Ground-water Control Operable Unit for the City Disposal Corporation Landfill. The principal purpose of the reviews were to identify potential Applicable or Relevant and Appropriate Requirements for alternatives described in the Alternatives Array Document.

Enclosed in this letter are lists of potential ARARs specific to described alternatives from the U.S. EPA and WDNR.

The ARARs listed in the enclosures were based on the alternatives presented. These lists may be amended due to additional information or changes to the alternatives presented. Final ARARs are identified at the time of signature of a Record of Decision. Once a Record of Decision is signed for the remedial action, U.S. EPA will not reopen that decision unless a new or modified requirement calls into question the protectiveness of the selected remedy.

If you have any questions concerning this letter please telephone me at (312) 353-1331.

Sincerely,

Charles Wilk
Remedial Project Manager

DATE RECEIVED/SENT 5/22/91
BY: DEE BRNCICH
SITE City Disposal
CC/ROUTE:
PK, DP, WS, HK, JD, GM, DO, AK, RO, AS
FILE SYSTEM: PROJECT/SITE
FILE CODE: 6495 W/ATTACH
W/O ATTACH

cc: Mike Schmoller, WDNR; Eileen Furey, ~~ORC; Doug~~ Ballotti, RERB

MAY 22 1991

U.S. EPA List

Nine alternatives have been proposed for potential application to the GCOU. Each alternative includes zoning/deed restrictions and groundwater monitoring. Alternatives 1-3, 5 and 7-9 include an extraction well system. Alternatives 1-2 and 7-8 include air stripping. Alternatives 1-3 and 7-9 include discharging treated groundwater to a local stream. Alternative 5 proposes discharge of untreated or pretreated groundwater to a local publically-owned treatment works ("POTW"). Alternatives 1 and 7 call for catalytic oxidation of treatment emissions. Alternatives 2 and 8 call for activated carbon adsorption of treatment emissions. Centralized carbon adsorption of contaminated groundwater is proposed in Alternative 3: activated carbon adsorption at individual wells is proposed in Alternative 4. (Activated carbon adsorption of treated groundwater is proposed as "effluent polishing" in Alternatives 7 and 8.) In-situ bioremediation is proposed in Alternative 6. Above-ground biotreatment is proposed in Alternative 9.

A. <u>ZONING, FENCING/DEED RESTRICTIONS</u>

Each of the proposed GCOU alternatives includes proposals to restrict access to the site by means of zoning regulations, fencing requirements and deed restrictions. The

ARARs pertinent to such proposals were listed in my memorandum of 12/26/90, but are restated here for convenience:

Section (40 CFR §)	A/RA/TBC	Standard/Requirement
264.117(c)	RA	post-closure use of property on or in which hazardous wastes remain
264.310(b)(5)	RA	protect and maintain curvoyed benchmarks

B. GROUNDWATER EXTRACTION AND DISCHARGE

The following ARARs pertain to the GCOU's proposals regarding an extraction well system, discharge of untreated water to a POTW, and direct discharge of treated groundwater to surface water:

Section	A/RA/TBC	Standard/Requirement
(40 CFR §) § 122	A	NPDES requirements of CWA
§ 403.5	TBC	POTW limitations
(Wis. Adm. Code) NR 102, 104, 200, 217 & 219	A	regulating discharge to surface water, effluent limits, discharge permit applications, sampling/testing procedures
NR 112	A (?)	regulates wells which singly or collectively with other wells on the property extract >70 gpm
WPDES permit requirements	A	
CWA § 304	RA	water quality criteria for specific pollutants

CWA Ambient Water Quality Criteria for Protection of Aquatic Life	RA	ambient water quality criteria
RCRA Part 264	RA	RCRA groundwater monitoring requirements

C. GROUNDWATER TREATMENT

1. Activated carbon adsorption.

Alternatives 3 and 4 propose activated carbon adsorption of contaminated groundwater. Alternatives 7 and 8 propose activated carbon adsorption as "effluent polishing." The following ARAR may pertain to this alternative if the resulting spent carbon material is a TCLP hazardous waste or a characteristic waste:

Section	A/RA/TBC	Standard/Requirement
(40 CFR §) 268	RA	RCRA land disposal restrictions

2. Air Stripping.

Alternatives 1,2,7 and 8 include proposals for air stripping. Alternatives 1 and 7 propose catalytic oxidation of treatment emissions from the air stripper: alternatives 2 and 8 propose activated carbon adsorption of treatment emissions from the air stripper. The following ARARs would pertain to these proposed actions:

Section	A/RA/TBC	Standard/Requirement
(Wis. Adm. Code) NR 140	A	Wis. groundwater standards
NR 160	A	Wis. protective action limits
NR 400-499	A	regulates air emissions from air stripping
CAA Part 61	RA	NESHAPs for, inter alia, vinyl chloride, benzene, radon(?)

OSWER Directive 9355.0-28	RA	EPA policy guidance entitled <u>Control of Air Emission from Superfund Air Strippers at Superfund Groundwater Sites</u>
(40 CFR §) 141.11-141.16	RA/TBC	SDWA MCLs
141.50	RA/TBC	MCL Goals for, <u>inter alia</u>, vinyl chloride
264.94	RA	RCRA MCLs
264.97	RA	general ground-water monitoring requirements for any ground-water monitoring program developed to satisfy, <u>inter alia</u>, § 264.100

APPENDIX H

Vehicular Traffic Estimation
Source Control Alternatives
Table 6A, March 3, 1992
and
Table 6B, March 4, 1992
(4 Pages)

Foth & Van Dyke	Client: WMWi Scope I.D.: 90L24 Project: City Disposal Landfill Page: 1 of 2 Prepared by: JBH1 Date: 3-3-92 Checked by: Date:

Vehicular Traffic ESTIMATION (TABLE 6A)
Source Control Alternatives

Calculate truck trips required to deliver the soil types necessary to construct the landfill cover.
Assumptions for TABLE 6A:

- 10 cubic yards capacity per truck
- All materials from offsite

Alternative I: No ACTION

Need to construct vent trenches

Item	Quantity (cu yd)
Vent trench Sand	800
TOTAL	800

I truck trips = $\frac{800 \text{ cu yd}}{10 \text{ cu yd/truck trip}}$ = 80

Alternative V: Cover "A", trench & well vapor extraction

Need to construct vent trenches and cover "A".

Item	Quantity (cu yd)
Vent Trench Sand	800
Grading Soil	5,000
Clay (Cohesive) Cover	19,500
Drainage Layer	39,050
Root ZONE	58,550
Topsoil	19,500
TOTAL	142,400

V truck trips = $\frac{142{,}400 \text{ cu yd}}{10 \text{ cuyd/truck trip}}$ = 14,240

Foth & Van Dyke	Client: WMWi — Scope I.D.: 90L24 Project: City Disposal Landfill — Page: 2 of 2 Prepared by: JBH1 — Date: 3-3-92 Checked by: — Date:

Vehicular Traffic Estimates (Table 6A)
(continued)

Alternative VI: Cover B/C, trench & well vapor extraction

Need to construct vent trenches and cover B/C

Item	Quantity (cu yd)
Vent Trench Sand	800
Grading Soil	5,000
Clay cover	78,100
Drainage Layer	7,100
Root Zone	58,550
Topsoil	19,500
TOTAL	169,050

$$\text{VI truck trips} = \frac{169{,}050 \text{ cu yd}}{10 \text{ cu yd/truck trip}} = \underline{16{,}905}$$

Alternative VII: Cover B, trench & well vapor extraction

Need to construct vent trenches and Cover B

Item	Quantity (cu yd)
Vent trench Sand	800
Grading soil	5000
Clay cover	78100
Drainage layer	0
ROOT ZONE	58,550
Topsoil	19,500
TOTAL	161,950

$$\text{VII truck Trips} = \frac{161{,}950}{10 \text{ cu yd/truck trip}} = \underline{16{,}195}$$

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Vehicular Traffic Estimation (TABLE 6B)
Source Control Alternatives

Calculate truck trips required to deliver the soil types necessary to construct the landfill cover.
Assumptions for TABLE 6B:

- 10 cubic yards capacity per truck
- Some materials obtained onsite*
  - ≈ 5000 cu yd grading soil
  - ≈ 19,500+ cu yd Topsoil
  - ≈ 17,630 cu yd ROOT ZONE

* Quantities are estimated. Field verif

Alternative I: No Action

Need to construct vent trenches.

Item	Quantity (cu yd)
Vent trench Sand	800
TOTAL	800

I truck trips = $\frac{800 \text{ cu yds}}{10 \text{ cu yd/trip}}$ = **80**

Alternative V: Cover "A", trench & well vapor extraction
Need to construct vent trenches and Cover A

Item	Quantity (cu yd)
Vent Trench Sand	800 - 0 800
Grading soil	5000 - 5000 = 0
Cohesive Soil	19500 - 0 19,500
Drainage layer	39,050 - 0 = 39,050
Root Zone	58,550 - 17,630 = 40,920
Topsoil	19500 - 19,500 = 0
TOTAL	100,270

V Truck Trips = $\frac{100,270 \text{ cu yd}}{10 \text{ cu yd/truck trip}}$ = **10,027**

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	Checked by:	Date:

Vehicular Traffic Estimate (TABLE 6B)
(continued ....)

Alternative VI: Cover B/C, trench & well vapor extraction
Need to construct vent trenches and Cover B/C

ITEM	Quantity (cu yd)
Vent Trench Sand	800 - 0 = 800
Grading Soil	5000 - 5000 = 0
Clay Cover	78,100 - 0 78,100
Drainage Layer	7,100 - 0 = 7,100
Root Zone	58,550 - 17,630 = 40,920
Topsoil	19,500 - 19,500 = 0
TOTAL	126,920

$$\text{VI TRUCK TRIPS} = \frac{126{,}920 \text{ cu yd}}{10 \text{ cu yd/truck trip}} = \underline{12{,}692}$$

Alternative VII: Cover B, trench & Well vapor extraction
Need to construct vent trenches and Cover B

ITEM	Quantity (cu Yd)
Vent trench sand	800 - 0 = 800
Grading Soil	5000 - 5000 = 0
Clay Cover	78,100 - 0 = 78100
Drainage layer	0 0
Root Zone	58,550 - 17,630 = 40,920
Topsoil	19,500 - 19,500 = 0
TOTAL	119,820

$$\text{VII truck trips} = \frac{119{,}820 \text{ cu yds}}{10 \text{ cu yd/truck trip}} = 11{,}982$$

TABLE 3.1

Hagen Farm Groundwater Quality Summary
Surface Quality Limits and NR 140 Groundwater Standards

CONSTITUENTS	Concentration[1] (µg/L)	NR 140 PAL (µg/L)
VOCs		
2-Butanone (MEK)	2,620 (3)[2]	--
Toluene	20 (1)	68.6
Ethylbenzene	99 (3)	272
Xylenes	1,066 (5)	124
Tetrahydrofuran	5,695 (5)	10
Semi-Volatiles		
Benzoic Acid	780 (2)	--
2,4-Dimethylphenol	153 (2)	--
4-Methylphenol	243 (2)	--
Phenol	3,816 (1)	--
1,4-Dichlorobenzene	10 (1)	15
Benzyl Alcohol	26 (1)	--
Bis(2-Chloroisopropyl) Ether	19 (1)	--
Naphthalene	8 (1)	--
4-Chloro-3-Methylphenol	7 (1)	--
Diethylphthalate	4.5 (1)	--
Bis(2-Ethylhexyl)Phthalate	18 (3)	--
Di-n-octyl Phthalate	5 (1)	--
Metals		
Mercury	0.8 (3)	0.2
Lead	6 (1)	5
Arsenic	10 (5)	5
Barium	850 (5)	200

[1]Geometric averages of results from source characterization wells with a detection.
[2]Number of wells (out of 5) with a detection.

TABLE 3.2

Average and Maximum Concentrations of Selected Metals Detected in Groundwater at Hagen Farm Site[1]

Metal	Geometric Average (μg/L)	Maximum (μg/L)
Arsenic	10 (5)[2]	25
Barium	850 (5)	1570
Copper	13 (5)	32
Iron	549 (5)	17,000
Lead	6 (1)	6
Manganese	1450 (5)	3,330
Mercury	0.8 (5)	6.5
Nickel	58 (5)	162
Zinc	103 (5)	185

[1]Values taken from individual well results at Hagen Farm Site with a detection.
[2]Number of wells (out of 5) with a detection.

TABLE 4.1

Constituents to be Analyzed for Hagen Farm Treatability Study

Group	Compound
Volatile Organics	2-Butone (MEK) Toluene Ethylbenzene Xylenes Tetrahydrofuran Acetone Benzene Chlorobenzene 1,2-dichloroethene Dibromochloromethane Methylene Chloride Vinyl Chloride
Semi-volatiles Organics	Benzoic Acid 2,4-Dimethylphenol 4-Methylphenol Phenol 1,4-Dichlorobenzene Benzyl Alcohol Bis(2-Chloroisopropyl)Ether Naphthalene 4-Chloro-3-Methylphenol Diethylphthalate Bis(2-Ethylhexyl)Phthalate Di-n-octyl Phthalate
Metals	Arsenic Barium Cadmium Chromium Iron Lead Mercury Nickel
Inorganics other than Metal	Alkalinity Chloride Sulfate

TABLE 4.2

Target Compounds Spiked for Hagen Farm Groundwater
(all units in $\mu g/L$)

Constituent	Final Concentration After Spiking
Volatile Organic Compounds	
2-Butanone (MEK)	2620
Xylene, Total	1066
Tetrahydrofuran (THF)	5698
1,2-Dichloroethylene	10
Dibromochloromethane	43
Methylene Chloride	15
Semi-Volatile Organic Compounds	
Benzoic Acid	780
2,4-Dimethylphenol	153
4-Methylphenol	243
Phenol	3816
1,4-Dichlorobenzene	15
Benzyl Alcohol	26
Bis (2-Chloroisopropyl) Ether	19
Naphthalene	8
4-Chloro-3-Methylphenol	7
Diethylphthalate	4.5
Bis(2-Ethylhexyl) Phthalate	18
Di-n-octyl Phthalate	5

TABLE 4.4

Soil Biodegradation Study
Operating Parameter Ranges

Parameter	Range	Reactors	Frequency
pH (units)	6.5 - 8.0	2, 3 and 4	Daily
D.O. (mg/L)	>5.0	2, 3 and 4	Daily
Temperature (°C)	room (20 - 25)	1, 2, 3 and 4	Daily

TABLE 5.1

Initial Characterization for Hagen Farm Groundwater - Compounds With Concentrations Above Detection Limits

Parameter	Concentration
1. Metal	
Arsenic	0.036 mg/L
Barium	0.49 mg/L
Calcium	200 mg/L
Iron	27 mg/L
Magnesium	80 mg/L
Nickel	0.033 mg/L
Potassium	21 mg/L
Sodium	38 mg/L
Zinc	0.036 mg/L
2. PCB, Pesticide	Not Found
3. VOC	
Ethylbenzene	3200 μg/L
THF	65000 μg/L
Xylene (total)	20000 μg/L
4. Semi-VOC	
Diethylphthalate	15 μg/L
5. Others	
Alkalinity	910 mg/L $CaCO_3$
Cl	41 mg/L
BOD	53 mg/L
COD	390 mg/L
Phosphorus	0.40 mg/L
NH_3	30 mg/L
TKN	23 mg/L

TABLE 5.2

Hagen Farm Bench-Scale Air Stripping Test Results
(all units in $\mu g/L$)

COMPOUND	Air/Water Ratio (ft^3 air/ft^3 water)				
	0	25	50	100	150
Acetone	<20	<20	<20	<20	<20
Benzene	57	<5	<5	<5	<5
Chlorobenzene	<5	<5	<5	<5	<5
Dibromochloromethane	<5	<5	<5	<5	<5
Ethylbenzene	<5	<5	<5	<5	<5
Methylene Chloride	<5	<5	<5	<5	<5
Methyl Ethyl Ketone	<10	<10	<10	<10	<10
Tetrahydrofuran	52000	46000	39000	36000	31000
Toluene	<5	<5	<5	<5	<5
1,2-Dichloroethane (total)	<5	<5	<5	<5	<5
Vinyl Chloride	11	<10	<10	<10	<10
Xylene (total)	11000	330	27	19	12
Ethyl Ether	10	<5	<5	<5	<5
Isobutyl Alcohol	<2.5	<2.5	<2.5	<2.5	<2.5
Methanol	<0.5	<0.5	<0.5	<0.5	<0.5
n-Butyl Alcohol	<2.5	<2.5	<2.5	<2.5	<2.5
Cyclohexanone	<0.25	<0.25	<0.25	<0.25	<0.25

TABLE 5.3

Steady-State Operational Results for Activated Sludge Reactor

Compound	1st Set			2nd Set		
1. VOCs (all units in μg/L)	Influent	Effluent	Eff (%)	Influent	Effluent	Eff (%)
Acetone	<10000	<20	—	<10000	<20	—
Benzene	<2500	<5	—	<2500	<5	—
Chlorobenzene	<2500	<5	—	<2500	<5	—
Dibromochloromethane	<2500	<5	—	<2500	<5	—
Ethylbenzene	<2500	<5	—	<2500	<5	—
Methylene Chloride	<2500	<5	—	<2500	<5	—
2-butanone (MEK)	<5000	<10	—	<5000	<10	—
Tetrahydrofuran (THF)	74000	<10	>99	80000	<10	>99
Toluene	<2500	<5	—	<2500	<5	—
1,2-Dichloroethene (total)	<2500	<5	—	<2500	<5	—
Vinyl Chloride	<5000	<10	—	<5000	<10	—
Xylene (total)	19000	<5	>99	1400	<5	>99
Ethyl Ether	<2500	<5	—	<2500	<5	—
2. Semi-VOCs (all units in μg/L)						
Benzyl Alcohol	<10	<10	—	<10	<10	—
Bis(2-Chloroisopropyl) Ether	<10	<10	—	<10	<10	—
Bis(2-Ethylhexyl)Phthalate	<10	<10	—	<10	<10	—
1,4-Dichlorobenzene	<10	<10	—	<10	<10	—
Diethylphthalate	13	<10	>23	13	<10	>23
Di-n-octylphthalate	<10	<10	—	<10	<10	—
Naphthalene	<10	<10	—	<10	<10	—
Benzoic Acid	<50	<10	—	<50	<50	—
4-Chloro-3-Methylphenol	<10	<10	—	<10	<10	—
2,4-Dimethylphenol	58	<10	>83	150	<10	>93
4-Methylphenol	<10	<10	—	<10	<10	—
Phenol	<10	<10	—	<10	<10	—

TABLE 5.3 (cont.)

Steady-State Operational Results for Activated Sludge Reactor

Compound	1st Set			2nd Set		
3. Metals (all units in mg/L)	Influent	Effluent	Eff (%)	Influent	Effluent	Eff (%)
Arsenic	0.034	0.0066	80.6	0.028	0.0091	67.5
Barium	0.47	0.43	8.5	0.055	0.042	23.6
Cadmium	<0.005	<0.005	—	<0.005	<0.005	—
Chromium	<0.01	<0.01	—	<0.01	<0.01	—
Iron	25	18	28	0.29	0.25	13.8
Lead	0.0087	<0.005	>67	<0.005	0.02	—
Mercury	<0.0005	<0.0005	—	<0.0005	<0.0005	—
Nickel	0.04	0.039	2.5	0.031	0.029	6.5
4. Others (all units in mg/L)						
Alkalinity (mg $CaCO_3$/l)	160	430	—	1000	600	—
Chloride	37	42	—	36	43	—
Sulfate	<10	<5	—	<10	<5	—
TSS	—	4	—	51	6	88.2
COD	350	76	78.3	300	76	74.7
BOD	49	4	91.8	44	3	93.2

TABLE 5.4

Bench-Scale UV/Peroxide Test Conditions for Hagen Farm Groundwater

Test	H_2O_2 Added	Initial pH	Catalyst, mg/l of Fe	UV Lamp Intesity, Wattage
1	500	7.8	0	64
2	500	5.0	3.6	64

TABLE 5.5

Bench-Scale UV/Peroxide Test Results on Hagen Farm Groundwater

	Test 1		Test 2	
	Initial Conc., µg/l	Effluent Conc., µg/l	Initial Conc., µg/l	Effluent Conc., µg/l
pH, unit	7.8	7.4	5.0	5.1
COD	560,000	<500,000	560,000	<500,000
Acetone	<10	80	<10	296
Bis(2-ethyl hexyl)phathalate	<10	232	<10	<10

TABLE 5.6

Bench-Scale UV/Peroxide Test Results on Hagen Farm Groundwater

Test 1	Contaminant	Initial Conc., μg/l	Final Conc., μg/l
Vendor 1	THF	57,950	ND
	MEK	<20	ND
	Xylenes	2080	ND
	2,4-dimethylphenol	270	ND
Vendor 2	THF	52,000	ND
	MEK	ND	ND
	Xylenes	13,500	ND

TABLE 5.7

Jar Test Results for Metal Precipitation With Sodium Hydroxide (all units in μg/l except pH)

Parameter, μg/L	Sodium Hydroxide Dosage, g/L							
	0	0.25	0.5	0.75	1.0	1.5	2.0	2.5
pH, unit	6.7	7.5	8.4	9.3	10.0	11.0	11.8	12.1
As	9.5	7.4	7.2	8.4	8.1	5.5	7.7	9.2
Ba	380	340	120	23	19	<10	<10	<10
Cd	<5	<5	<5	<5	<5	<5	<5	<5
Cr	<10	<10	<10	<10	<10	<10	<10	<10
Fe	7000	670	1400	360	140	21	58	60
Pb	<5	<5	<5	<5	<5	<5	<5	<5
Hg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ni	<10	<10	19	20	20	20	19	17
Mn	82	75	13	<10	<10	<10	<10	<10
Mg	68000	69000	64000	54000	59000	33000	1000	<200
Ca	170000	170000	56000	20000	57000	10000	24000	1700

TABLE 5.8

Jar Test Results for Metal Precipitation with Lime (all units in μg/l except pH)

	Lime Dosage, g/l				
Parameter, μg/l	**0**	**1.0**	**1.25**	**1.5**	**1.75**
pH, unit	6.7	9.2	9.9	11.1	11.9
As	9.5	5.2	5.7	<5	<5
Ba	380	400	<10	13	48
Cd	<5	<5	<5	<5	<5
Cr	<10	<10	<10	<10	<10
Fe	7000	2200	370	46	41
Pb	<5	<5	<5	<5	<5
Hg	<0.5	<0.5	<0.5	<0.5	<0.5
Ni	<10	24	26	26	22
Mn	82	86	<10	<10	<10
Mg	68000	67000	41000	4700	320
Ca	170000	580000	14000	38000	200000

TABLE 5.9
Characterization of Spiked Groundwater
(all units in μg/L)

Constituent	Target Concentration	Concentration After Spiking
Volatile Organic Compounds		
2-Butanone (Methyl Ethyl Ketone)	2620	2400
Xylene, Total	1066	380
Tetrahydrofuran	5698	55,000
1,2-Dichloroethylene	10	<5
Dibromochloromethane	43	<5
Methylene Chloride	15	140
Semi-Volatile Organic Compounds		
Benzoic Acid	780	<50
2,4-Dimethylphenol	153	99
4-Methylphenol	243	<10
Phenol	3816	<10
1,4-Dichlorobenzene	15	<10
Benzyl Alcohol	26	<10
Bis (2-Chloroisopropyl) Ether	19	<10
Naphthalene	8	<10
4-Chloro-3-Methylphenol	7	<10
Diethylphthalate	4.5	18
Bis(2-Ethylhexyl) Phthalate	18	9
Di-n-octyl Phthalate	5	<10

TABLE 5.10

Hagen Farm Bench-Scale
Air Stripping Test Results for Spiked Groundwater
(all units in μg/L)

COMPOUND	Air/Water Ratio (ft^3 air/ft^3 water)				
	0	25	50	100	150
Acetone	<10000	130	<10000	<20	<20
Benzene	<2500	<5	<2500	<5	<5
Chlorobenzene	<2500	<5	<2500	<5	<5
Dibromochloromethane	<2500	<5	<2500	<5	<5
Ethylbenzene	<2500	7	<2500	34	<5
Methylene Chloride	<2500	8	<2500	<5	<5
Methyl Ethyl Ketone	5000	7100*	<5000	3600	3000
Tetrahydrofuran	90000	46000	59000	59000	63000
Toluene	<2500	<5	<2500	77	<5
1,2-Dichloroethane (total)	<2500	<5	<2500	<5	<5
Vinyl Chloride	<5000	<10	<5000	<10	<10
Xylene (total)	<2500	110	<2500	110	<5
Ethyl Ether	<2500	<5	<2500	<5	<5

* Estimated value

TABLE 5.11
Compounds Detected in Bench-Scale GAC
Column Test for Spiked Hagen Farm Groundwater

Compound	Influent	Time of Test, Hours								
1. VOCs (all units in µg/L)		10	24	33	48	56	72	80	96	104
Acetone	110	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Ethylbenzene	96	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Methylene Chloride	140	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Methyl Ethyl Ketone	2400	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4-Methyl-2-pentanone	91	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Tetrahydrofuran	55000	< 25	< 25	< 25	< 25	< 25	< 25	150	7600	22000
Toluene	260	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Xylene (total)	380	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
2. Semi-VOCs (all units in µg/L)										
Bis(2-Ethylhexyl)Phthalate	9	30	10	29	27	35	38	33	8	< 10
Diethylphthalate	18	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dimethylphthalate	6	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	99	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE 5.12
Steady-State Operational Results for Activated Sludge Reactor - Spiked Groundwater

Compound	1st Set			2nd Set		
1. VOCs (all units in μg/L)	Influent	Effluent	Eff (%)	Influent	Effluent	Eff (%)
Acetone	<10000	<20	---	<20	<20	---
Benzene	<2500	<5	---	42	<5	>88
Chlorobenzene	<2500	<5	---	<5	<5	---
Dibromochloromethane	<2500	<5	---	<5	<5	---
Ethylbenzene	<2500	<5	---	32	<5	>84
Methylene Chloride	<2500	<5	---	130	<5	>96
2-butanone (MEK)	<5000	<10	---	4000	<10	>99
Tetrahydrofuran (THF)	110000	<10	>99	780000	<10	>99
Toluene	<2500	<5	---	14	<5	>64
1,2-Dichloroethene (total)	<2500	<5	---	<5	<5	---
Vinyl Chloride	<5000	<10	---	14	<10	>29
Xylene (total)	1700	<5	>99	10000	<5	>99
Ethyl Ether	<2500	<5	---	15	<5	>67
2. Semi-VOCs (all units in μg/L)						
Benzyl Alcohol	<10	<10	---	<10	<10	---
Bis(2-Chloroisopropyl) Ether	<10	<10	---	<10	<10	---
Bis(2-Ethylhexyl)Phthalate	15	44	---	<10	~10*	---
1,4-Dichlorobenzene	<10	<10	---	<10	<10	---
Diethylphthalate	22	<10	>55	25	<10	>60
Di-n-octylphthalate	<10	<10	---	<10	<10	---
Naphthalene	<10	<10	---	<10	<10	---
Benzoic Acid	<50	<10	---	220	<50	>77
4-Chloro-3-Methylphenol	<10	<10	---	<10	<10	---
2,4-Dimethylphenol	930	<10	>99	96	<10	>89
4-Methylphenol	<10	<10	---	<10	<10	---
Phenol	<10	<10	---	<10	<10	---

* Estimation

TABLE 5.12 (cont.)
Steady-State Operational Results for
Activated Sludge Reactor - Spiked Groundwater

Compound	1st Set			2nd Set		
3. Metals (all units in mg/L)	Influent	Effluent	Eff (%)	Influent	Effluent	Eff (%)
Arsenic	0.062	0.0094	>85	0.028	0.0096	>66
Barium	0.47	0.03	>94	0.059	0.02	>97
Cadmium	<0.005	<0.005	—	<0.005	<0.005	—
Chromium	<0.01	<0.01	—	<0.01	<0.01	—
Iron	31	0.14	>99	53	0.17	>99
Lead	<0.05	<0.015	—	<0.015	0.05	—
Mercury	<0.0005	<0.0005	—	<0.0005	<0.0005	—
Nickel	0.04	0.028	>30	0.072	0.031	>57
4. Others (all units in mg/L)						
Alkalinity (mg $CaCO_3$/l)	800	550	—	850	580	—
Chloride	34	40	—	34	38	—
Sulfate	<5	<5	—	<5	<5	—
TSS	—	8	—	22	10	>55
COD	—	65	—	280	65	>77
BOD	—	<5	—	29	3.2	>90

TABLE 5.13

Hagen Farm Soil Biodegradation
Soil Characteristics*

Parameter	Value
Hydraulic Conductivity	range of 10^{-4} cm/sec
Soil Texture (USDA)	Loamy Sand
Bulk Density	2.12 g/cm^3
pH	8.3
CEC	2.7 meq/100 g dry soil
Microbial enumeration	1.6 x 10^5 cfu/g dry soil

* See Table 5.14 for Analytical Results of Parameters in the Target Compound List.

TABLE 5.14

Hagen Farm Soil Biodegradation Study
Compounds Detected in Original Soil Sample

Parameter	Concentration
Volatile Organics (µg/kg)	
Acetone	70
Semi-Volatile Organics (µg/kg)	
Bis(2-ethylhexyl)phthalate	360
PCBs and Pesticides	BDL
Metals (mg/kg)	
Aluminum	3,000
Barium	20
Beryllium	0.25
Cadmium	0.88
Calcium	58,000
Chromium	5.0
Cobalt	2.2
Copper	7.3
Iron	6,500
Lead	3.4
Magnesium	35,000
Manganese	180
Nickel	5.7
Sodium	240
Vanadium	14
Zinc	15
Others (mg/kg)	
Ammonia Nitrogen	6.9
CEC (meq/100g dry)	2.7
pH (units)	8.3
Phosphorus	99
TOC (dry weight basis)	15,300
Total Solids (% by weight)	92

BDL Below Detection Limit

TABLE 5.15
Hagen Farm Soil Biodegradation Study, Compounds Detected in Soil Fraction[a]
(all units in mg/kg wet weight except as noted)

Parameter	Initial Reactor Conditions	Day 12				Day 26			
		Reactor 1	Reactor 2	Reactor 3	Reactor 4	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Volatile Organics (μg/kg)									
Acetone	23[b]	<20	<20	<20	<20	<20	<20	<20	<20
Methylene Chloride	6	<5	<5	<5	<5	<5	<5	8	<5
Methyl Ethyl Ketone	15[b]	<10	<10	<10	<10	<10	<10	<10	<10
Tetrahydrofuran	78	<25	<25	<25	<25	<25	<25	<25	<25
Metals									
Aluminum	1,300	870	510	510	660	1,900	1,500	1,600	3,700
Antimony	<1.0	<10	<10	<10	<10	<1.0	<1.0	<1.0	1.1
Arsenic	1.1	1.9	<2.0	<2.0	1.2	<1.0	<1.0	1.2	2.0
Barium	6.8	0.31	0.59	0.68	0.59	11	9.6	7.8	16
Beryllium	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.21	0.24
Calcium	7,500	4,600	7,700	6,400	7,000	8,500	6,800	5,100	1,100
Chromium	5.0	4.5	3.6	3.5	4.3	4.2	5.5	4.9	8.7
Cobalt	2.7	<2.0	<2.0	<2.0	<2.0	<2.0	4.0	2.4	3.6
Copper	4.8	3.7	5.2	4.3	4.4	4.7	5.6	6.3	12
Iron	590	4,100	3,700	3,900	4,200	540	940	650	920
Lead	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	14	<4.0	<4.0
Magnesium	29,000	57,000	40,000	39,000	48,000	38,000	40,000	22,000	60,000
Manganese	170	160	130	140	160	160	160	120	310
Nickel	6.8	3.1	2.4	2.9	3.2	7.3	12	6.8	13
Potassium	250	300	<10	<10	<10	350	250	240	510
Sodium	140	150	160	120	130	200	150	140	250
Vanadium	<20	<20	<20	<20	<20	<20	24	<20	<20
Zinc	8.9	9.6	9.4	9.1	12	9.2	23	10	17
Others									
Ammonia Nitrogen	13	NA	NA	NA	NA	2.7	3.2	19	16
Phosphorus	110	79	92	96	96	96	73	100	110
TOC (dry weight basis)	31,900	13,000	21,751	18,550	3,800	5,000	19,000	46,000	43,200
Total Solids in Soil Fraction (%)	83	87	89	88	89	85	83	84	85

a See Appendix G for detection limits for all compounds analyzed
b Also detected in blank
NA Not Analyzed

TABLE 5.16

Hagen Farm Soil Biodegradation Study, Compounds Detected in Liquid Fraction[a]
(all units in mg/L except as noted)

	Initial Reactor Conditions	Day 12				Day 26			
		Reactor 1	Reactor 2	Reactor 3	Reactor 4	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Volatile Organics (μg/L)									
Acetone	<20	<20	55	<20	26[b]	<20	<20	<20	<20
Methylene Chloride	<5	<5	<5	<5	<5	<5	7	<5	<5
Methyl Ethyl Ketone	<10	<10	18	<10	<10	<10	<10	<10	<10
Tetrahydrofuran	<25	<10	<10	<25	38	<25	<25	<25	<25
Metals									
Aluminum	170	320	170	240	180	260	210	190	210
Arsenic	0.030	0.17	0.12	0.15	0.11	0.029	0.041	0.045	0.040
Barium	1.7	3.1	2.1	2.6	2.1	2.7	2.1	2.1	2.7
Beryllium	0.0059	.024	0.014	0.024	0.024	0.0088	0.010	0.0088	0.01
Calcium	1,800	2,900	2,100	2,400	1,600	1,900	1,600	1,500	1,600
Chromium	0.30	0.52	0.30	0.40	0.31	0.45	0.34	0.32	0.35
Cobalt	0.21	0.31	0.21	0.27	0.21	0.29	0.23	0.24	0.26
Copper	0.77	1.1	0.84	0.98	0.74	0.94	0.77	0.74	1.1
Iron	320	720	440	600	440	460	370	340	510
Lead	0.37	0.45	0.34	0.42	0.32	0.46	0.42	0.42	0.45
Magnesium	1,000	1,300	920	1,100	700	1,100	890	860	870
Manganese	11	15	11	13	10	14	11	12	16
Mercury	<0.0005	0.010	0.015	<0.001	<0.001	0.0022	0.0023	0.0013	0.0018
Nickel	0.43	0.67	0.44	0.58	0.44	0.62	0.48	0.50	0.57
Potassium	25	49	28	37	33	41	34	34	33
Sodium	110	86	71	120	110	82	70	110	120
Vanadium	0.53	0.91	0.53	0.71	0.55	0.76	0.62	0.56	0.61
Zinc	1.4	2.1	1.4	1.8	1.4	2.0	1.6	1.6	1.8
Others									
Alkalinity	300	150	500	1600	950	150	30	26	19
Ammonia Nitrogen	<0.01	NA	NA	NA	NA	<0.01	0.13	<0.01	<0.01
Chemical Oxygen Demand	210	260	260	310	360	260	210	310	410
Chloride	25	7.5	120	120	120	8.0	110	130	130
Phosphorus	6.7	24	22	26	33	15	24	34	24
Sulfate	110	150	160	190	360	150	370	520	620
TOC	5.0	--	--	3.0	6.0	6.1	6.1	6.6	8.4
Total Kjeldahl Nitrogen	<6	10	13	8.9	30	<6	9.0	10	<6
Total Solids in Liquid Fraction (%)	2	3.7	1.8	1.7	2.5	2	2	2	2

a See Appendix H for detection limits for all compounds analyzed b Also detected in blank NA Not Analyzed

TABLE 6.1

Hagen Farms Groundwater Treatment Basis of Design

Item	Value
Flow	100 gpm
Number of Recovery Wells	3
Method of Effluent Discharge	Reinjection*
Number of Reinjection Wells	6
Facility Operating Frequency	7 days/week
Influent Conditions	
Chemical Oxygen Demand	250 mg/l
Total Suspended Solids	60 mg/l
Iron	10 mg/l
Manganese	4 mg/l
Barium	1 mg/l
Ethyl Benzene	99 μg/l
Xylenes	1066 μg/l
Tetrahydrofuran	5698 μg/l
Air Stripper Information	
Air/Water Ratio	100
Removal Efficiencies, Volatiles	>90
Removal Efficiencies, THF	30
Granular Activated Carbon Information	
Adsorption Capacity	10 mg THF/g GAC
Activated Sludge Information	
Loading, F/M	0.1 g COD/g VSS-day
Sludge Yield	0.15 g VSS/g COD
Mixed Liquor Concentration, MLVSS	2250 mg/l
MLVSS/MLTSS Ratio	0.7
Aeration Type	Fine Bubble

*Method chosen due to prohibitive cost of POTW discharge and amenability for inclusion of in-situ bioremediation.

TABLE 6.2
HAGEN FARM GROUNDWATER
TREATMENT FACILITY COST ESTIMATE

ITEM	OPTION 1 AIR STRIP+GAC	OPTION 2 GAC	OPTION 3 ASP	OPTION 4 CHEM-OX
GROUNDWATER RECOVERY WELLS(3,INSTALLED)	$60,000	$60,000	$60,000	$60,000
EFFLUENT REINJECTION WELLS(6,INSTALLED)	$120,000	$120,000	$120,000	$120,000
PROCESS EQUIPMENT	$985,800	$847,000	$986,400	$1,089,400
INSTALLATION(@30%OF PROCESS EQUIPMENT)	$295,740	$254,100	$295,920	$326,820
BUILDING/CIVIL WORK	$225,025	$212,700	$394,900	$225,025
FACILITY COST(FC)	$1,686,565	$1,493,800	$1,857,220	$1,821,245
ENGINEERING,PERMITTING(@12% FC)	$202,388	$179,256	$222,866	$218,549
CONTINGENCY,INSURANCE(@15% FC)	$252,985	$224,070	$278,583	$273,187
TOTAL INSTALLED FACILITY COSTS	$2,141,938	$1,897,126	$2,358,669	$2,312,981

TABLE 6.3
HAGEN FARM
GROUNDWATER TREATMENT
ANNUAL OPERATING COST ESTIMATE

ITEM	BASIS	AIRSTR.+GAC TREATMENT	GAC TREATMENT	ASP TREATMENT	CHEM-OX TREATMENT
LABOR	$16/HR WAGE,1.33 FRINGE MULT.	$66,400	$66,400	$88,500	$66,400
ANALYTICAL	RCRA,EFFLUENT,OPERATIONAL ANA	$40,400	$40,400	$44,400	$40,400
CHEMICAL					
POLYMER	$2.00/#,FOR METALS,BIOLOGICAL	$26,300	$26,300	$39,400	$26,300
GAC-LIQUID	$1.25/#,REGENERATION+SERVICE	$196,500	$312,000	$0	$0
GAC-VAPOR	$1.25/#,REGENERATION+SERVICE	$84,200	$0	$0	$0
LIME	$110/TON;1.25g/l DOSAGE	$30,100	$0	$0	$0
HYDROCHLORIC ACI	$76/TON;1.5g/l DOSAGE	$25,000	$0	$0	$0
SULFURIC ACID	$0.06/#; DOSAGE	$0	$0	$0	$8,000
PHOSPHORIC ACID	$0.18/#	$0	$0	$300	$0
PEROXIDE	VENDOR QUOTE	$0	$0	$0	$111,840
CAUSTIC	$0.15/#	$0	$0	$0	$16,500
ANTIFOAM	$2.00/#,FOR BIOLOGICAL	$0	$0	$13,100	$0
DISPOSAL	$350/TON	$23,800	$23,800	$35,500	$23,800
UTILITIES	$0.06/kW-HR	$69,900	$65,200	$52,000	$166,300
MAINTENANCE	@3% CAPITAL	$63,800	$56,900	$70,800	$69,400
MISCELLANEOUS	@1.5% OF CAPITAL	$31,900	$28,500	$35,400	$34,700
DEPRECIATION	30 YEAR, STRAIGHT LINE	$70,800	$63,200	$78,600	$77,100
INTEREST	10% ANNUAL BOOK VALUE	$109,900	$98,000	$121,900	$119,500
ADMINISTRATION	HISTORICAL DATABASE	$48,000	$48,000	$48,000	$48,000
TOTAL COSTS		$887,000	$828,700	$627,900	$808,240
PROCESSING COSTS,$/GALLON		$0.0169	$0.0158	$0.0119	$0.0154

TABLE 6.4

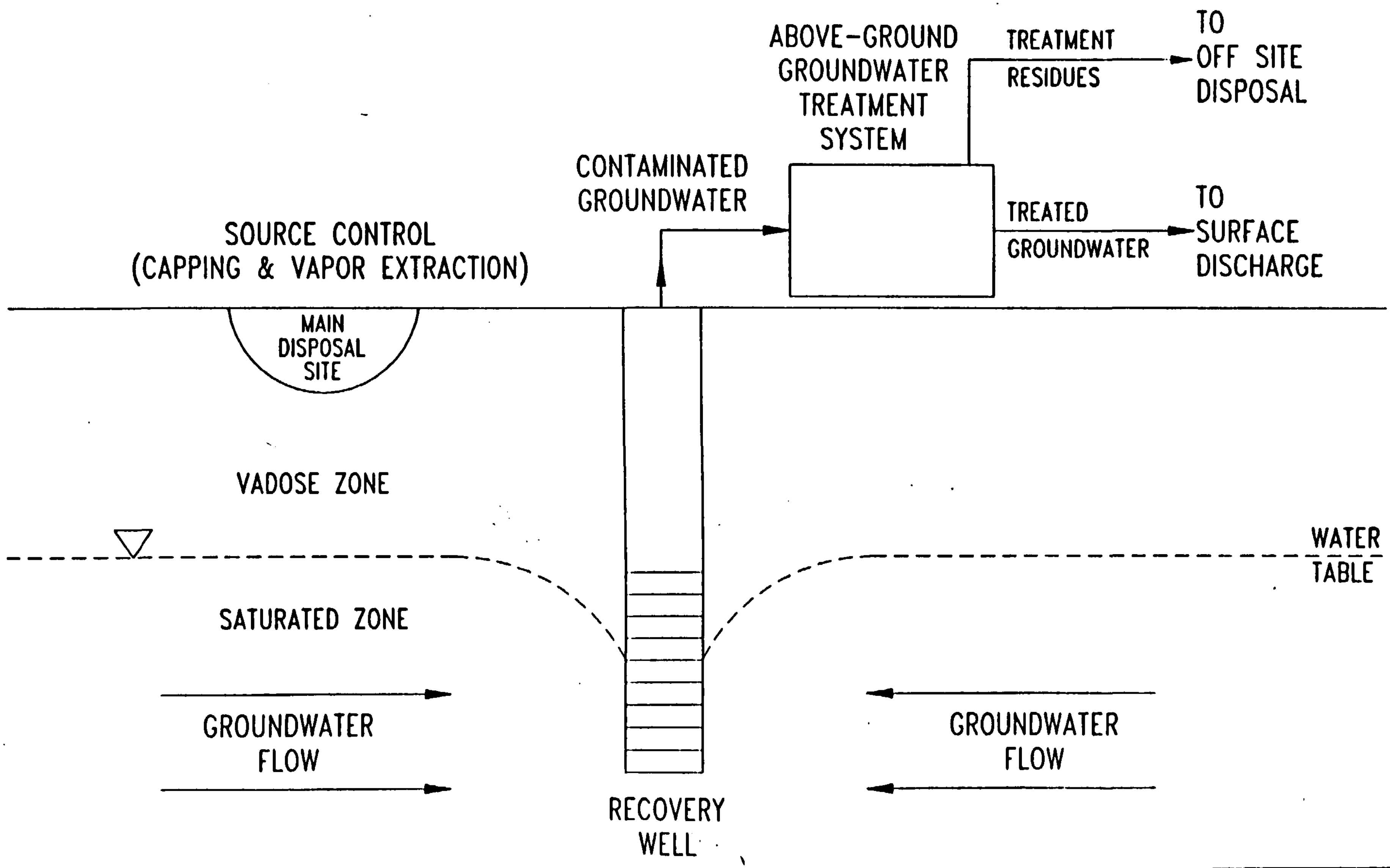
Summary of the Cost Estimate for Hagen Farm Groundwater Treatment

	Option 1	Option 2	Option 3	Option 4
Cost	Metal + Air Stripping + Carbon	Metal + Carbon	Metal + Biological Trmt	Metal + UV/Chem-Ox
Installed Capital, $	2,125,400	1,897,100	2,358,700	2,313,000
Operating, $/yr	706,300	667,500	427,400	611,640
Total Annual *, $/yr	887,000	828,700	627,900	808,240
Processing Unit Cost, ¢/gal	$0.0169	$0.0158	$0.0110	$0.0154

* includes straight-line depreciation for 30 years and at an average interest of 10% (book value).

LIST OF FIGURES

Figure 1.1
Hagen Farm Superfund Site
Process Schematic for Pump-and-Treat Alternative



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Geneva, IL 60134

Figure 1.2
Hagen Farm Superfund Site
Process Schematic for In-Situ Bioremediation Alternative

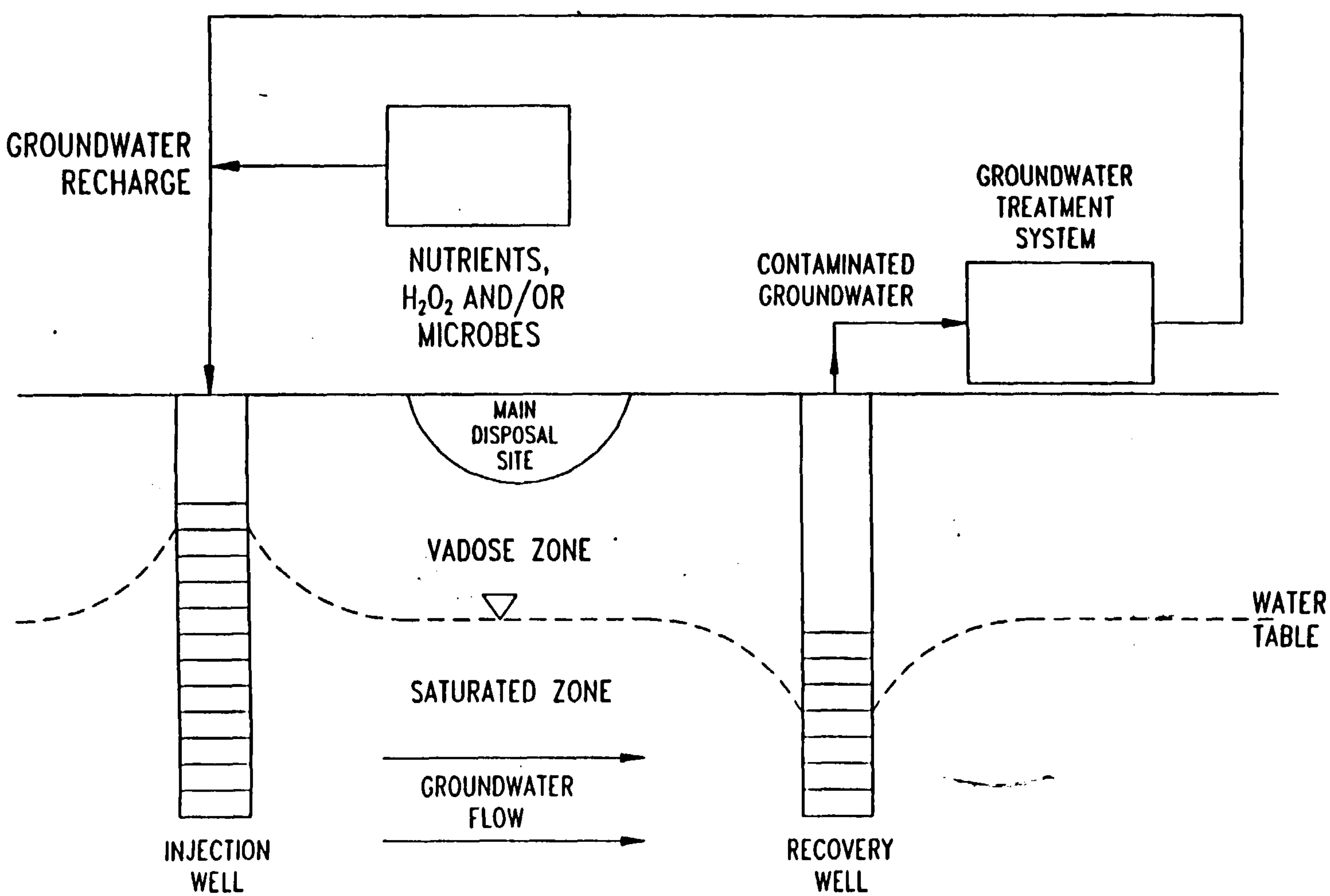

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Figure 4.1
Schematic Diagram: Bench Scale Packed Tower Air Stripper

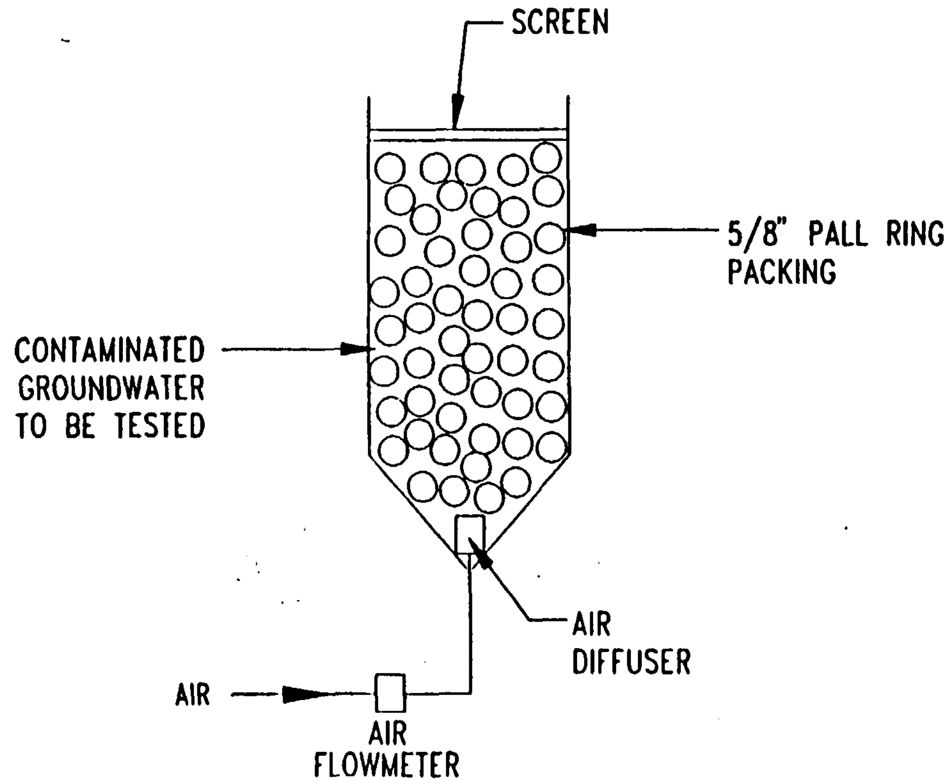

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Figure 4.2
Schematic Diagram: GAC Column Test Set UP

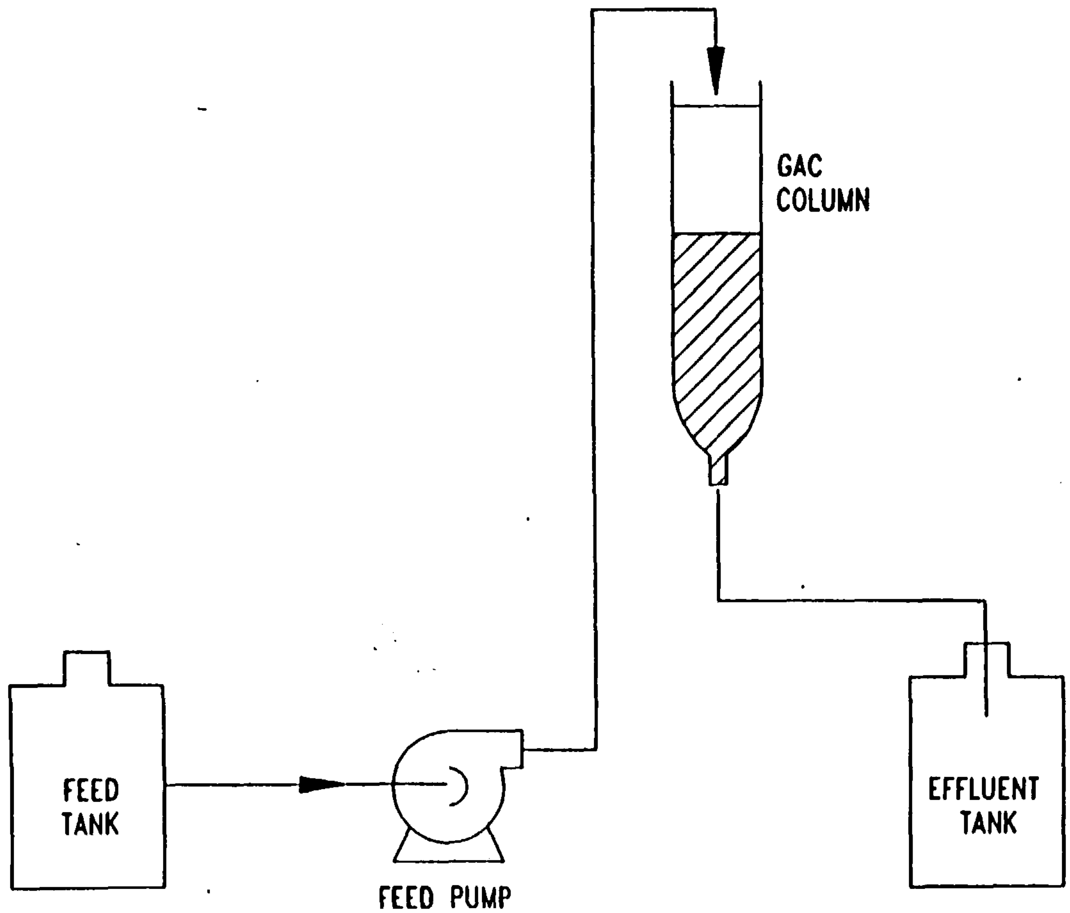

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Figure 4.3
Schematic Diagram: UV / Peroxide Test Apparatus

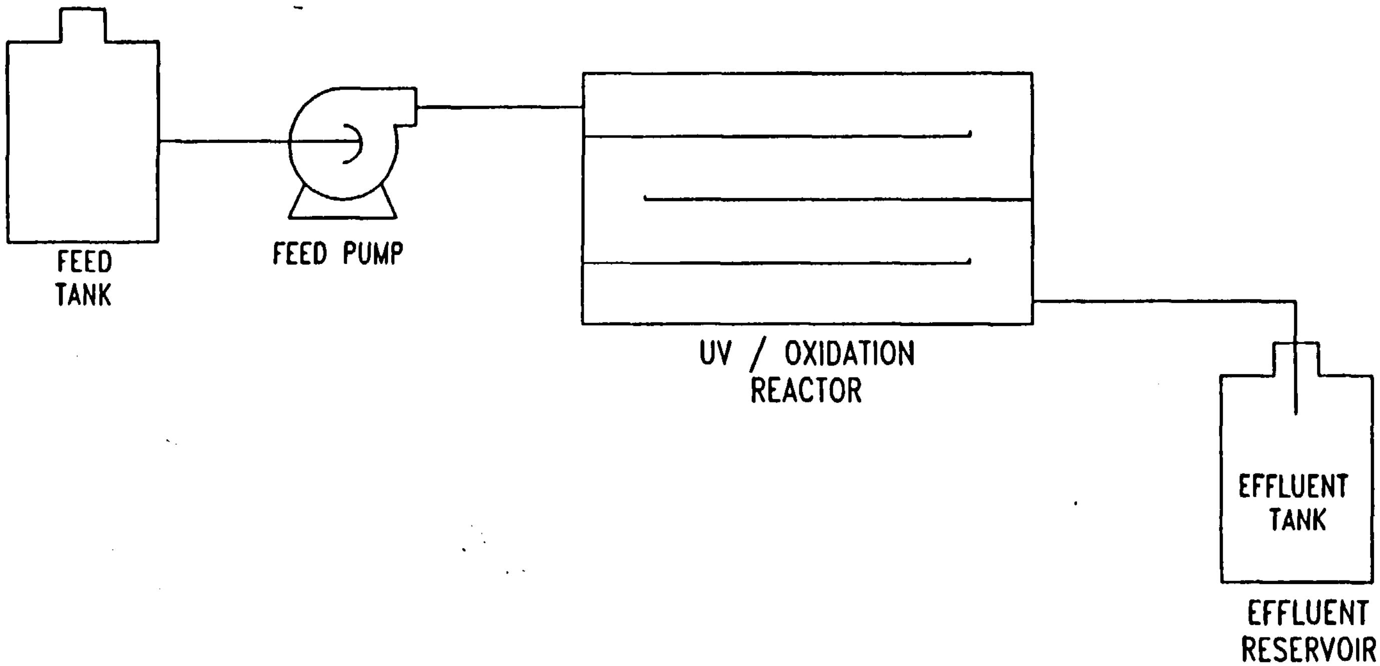

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Figure 4.4
Schematic Diagram: Bench Scale Activated Sludge Biological Reactor

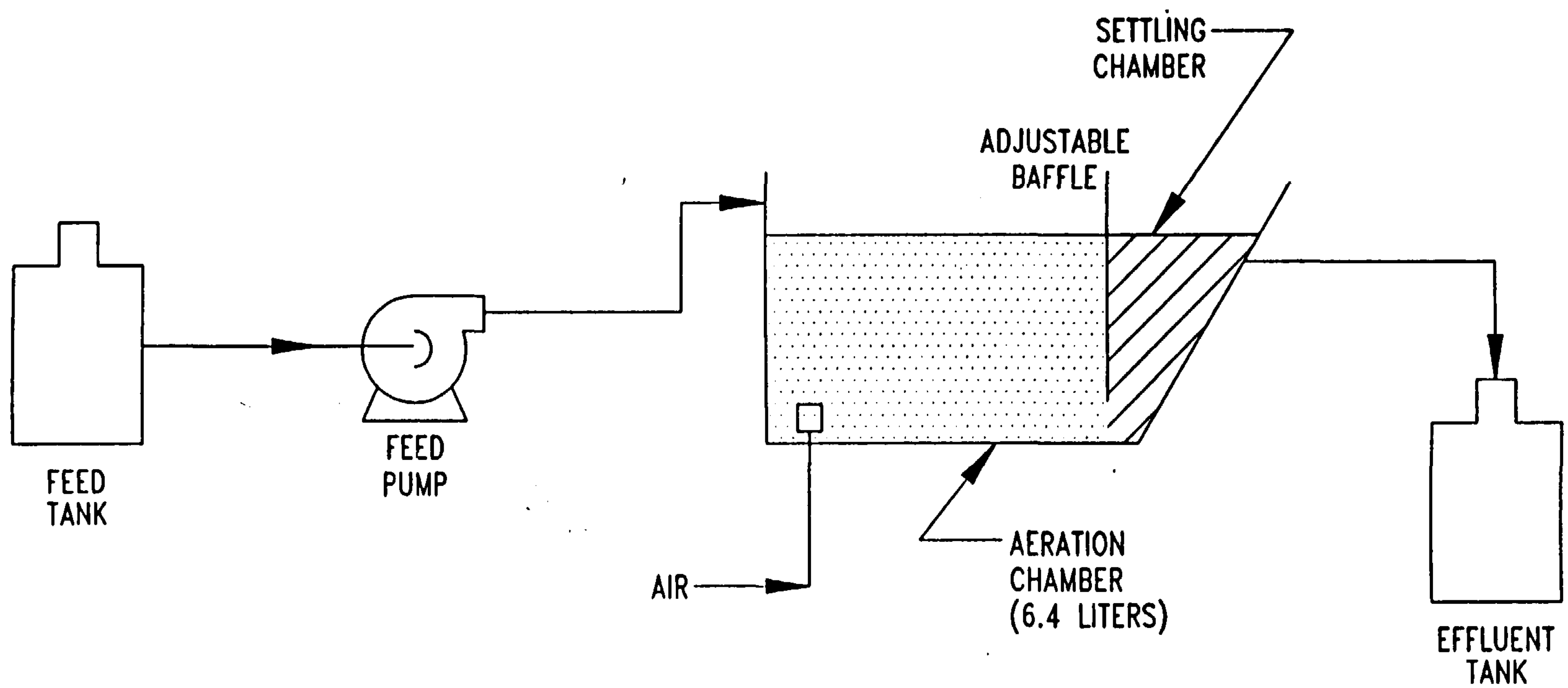

Figure 4.5
Schematic Diagram: Jar Test Apparatus for Metal Precipitation Testing

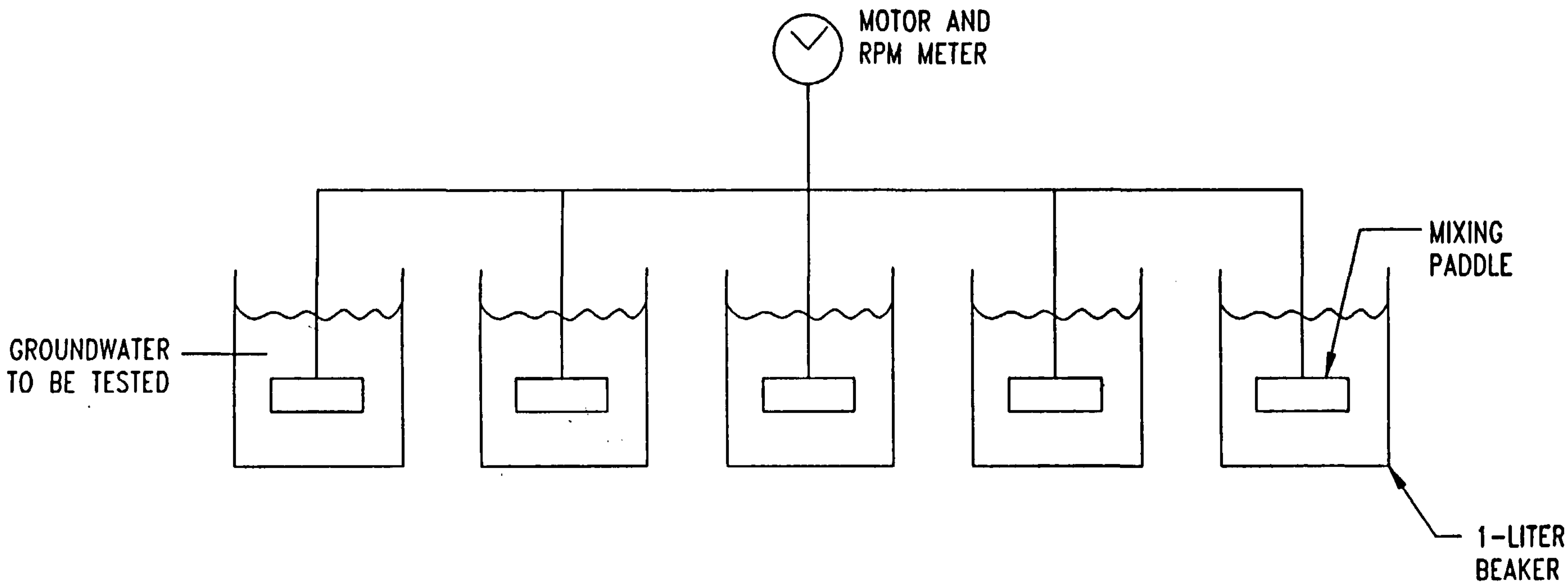

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Figure 4.6
Schematic Diagram: Bench Scale Soil Slurry Bioreactors for Hagen Farm Project

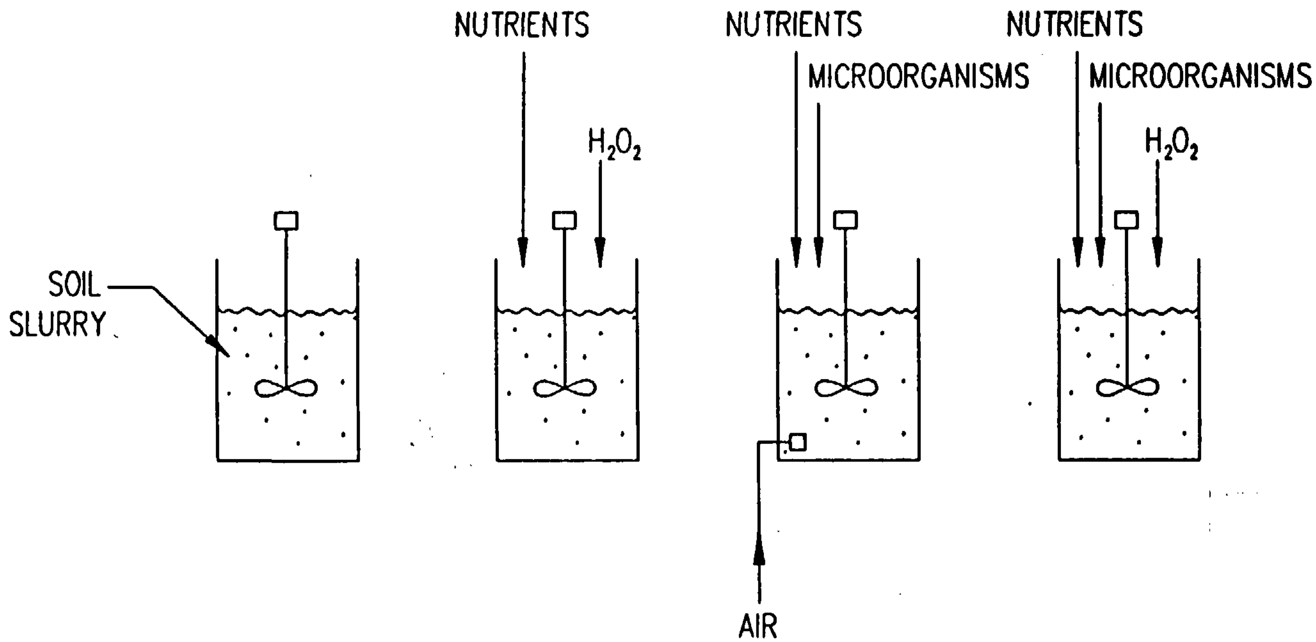

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Figure 4.7
Schematic Diagram: Bench Scale Soil Column Test for Hagen Farm Project

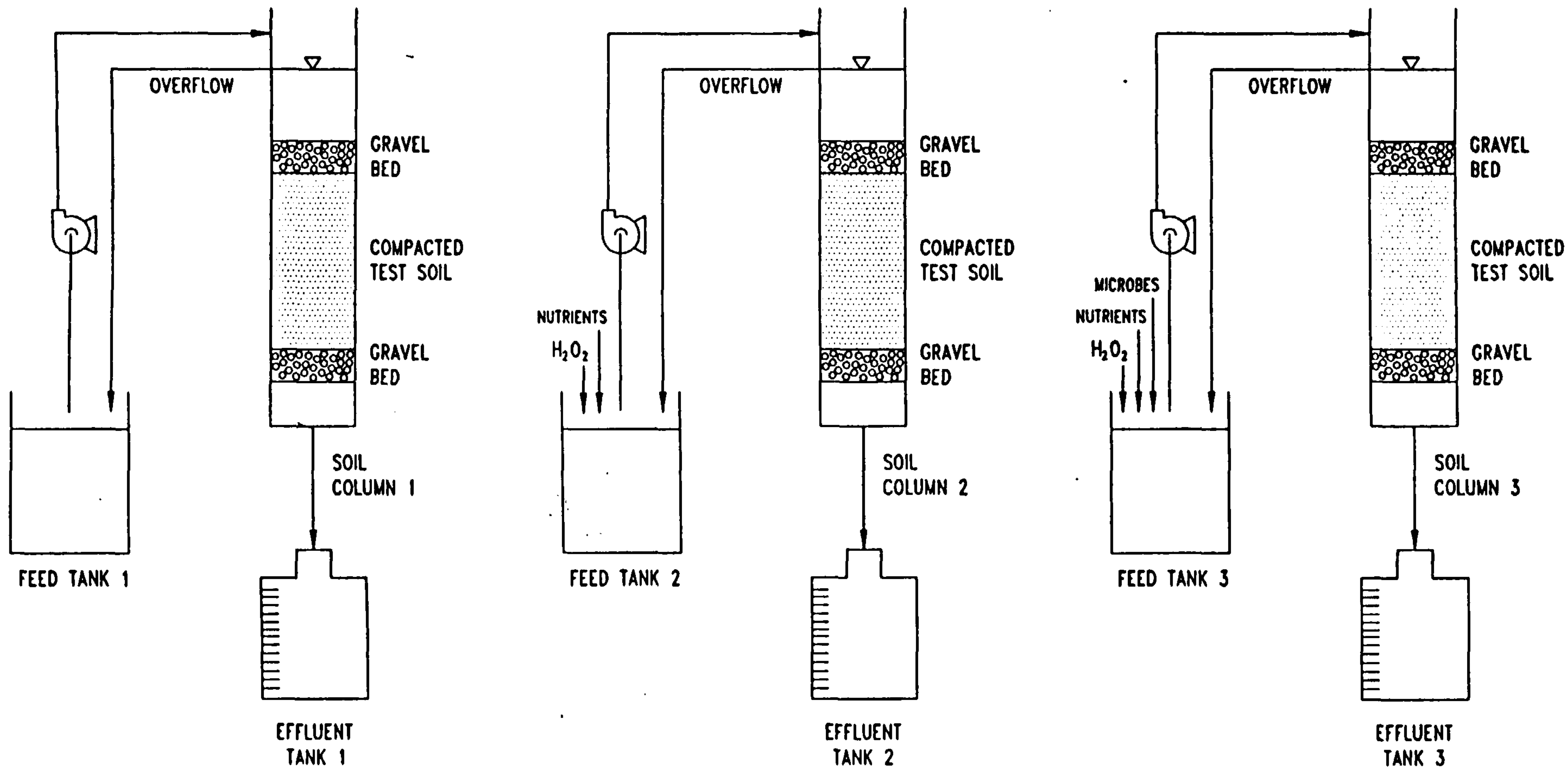

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FIGURE 5.1
Hagen Farm Groundwater
Air Stripping Test

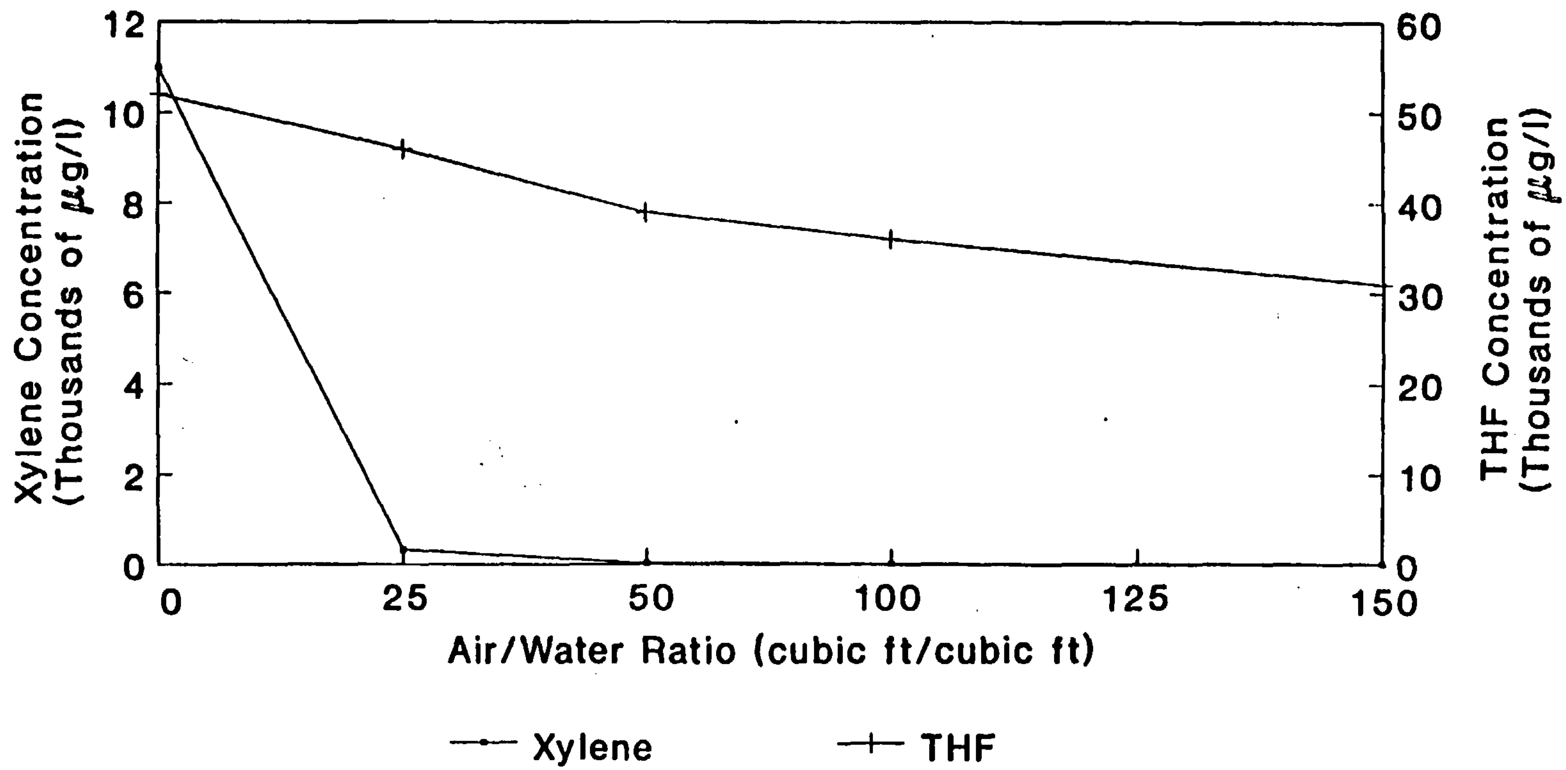


FIGURE 5.2
Activated Sludge Reactor
Solids Accumulation vs. Time

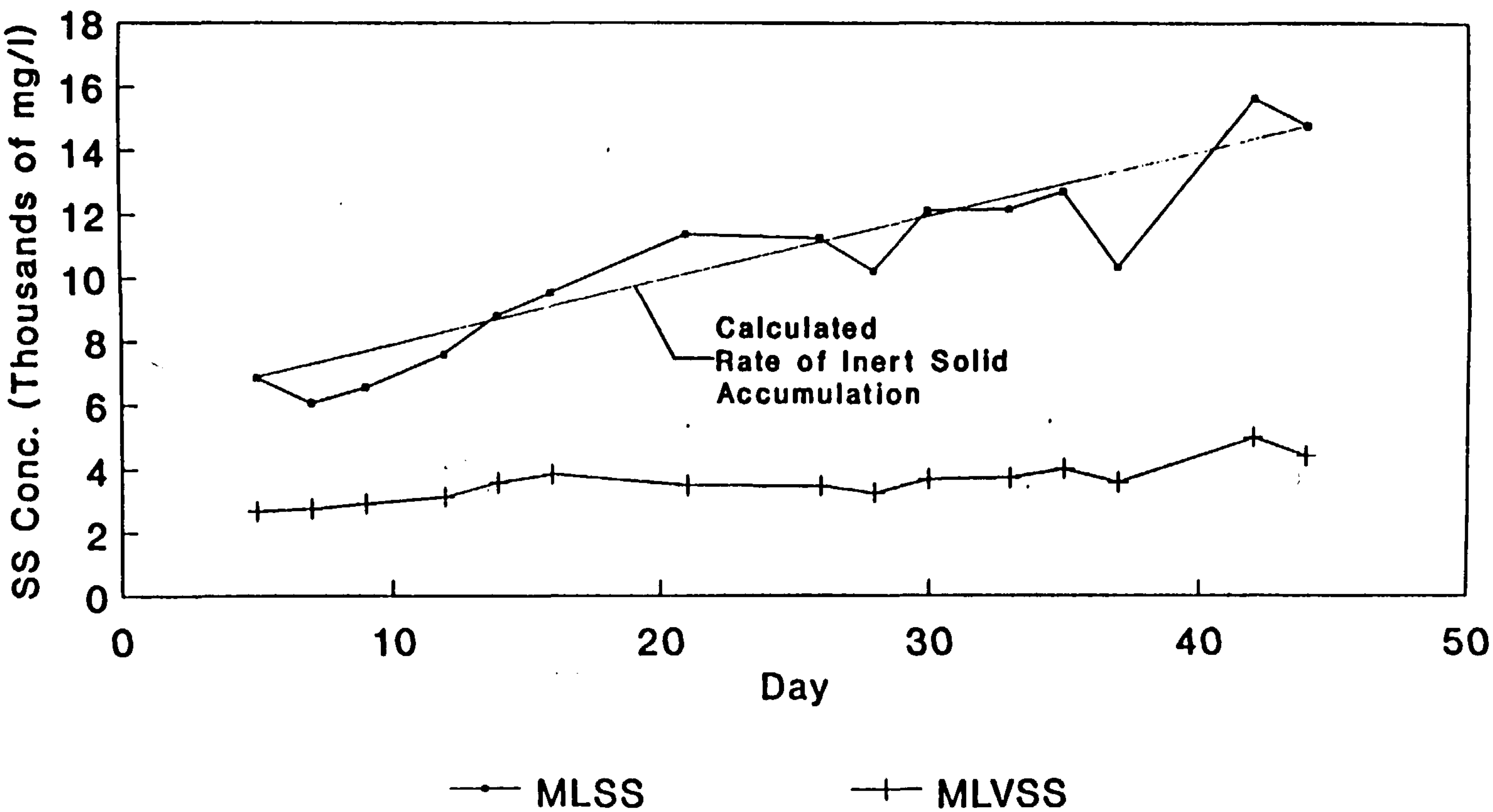


FIGURE 5.3
Hagen Farm Groundwater
Iron Removal Using Air Oxidation

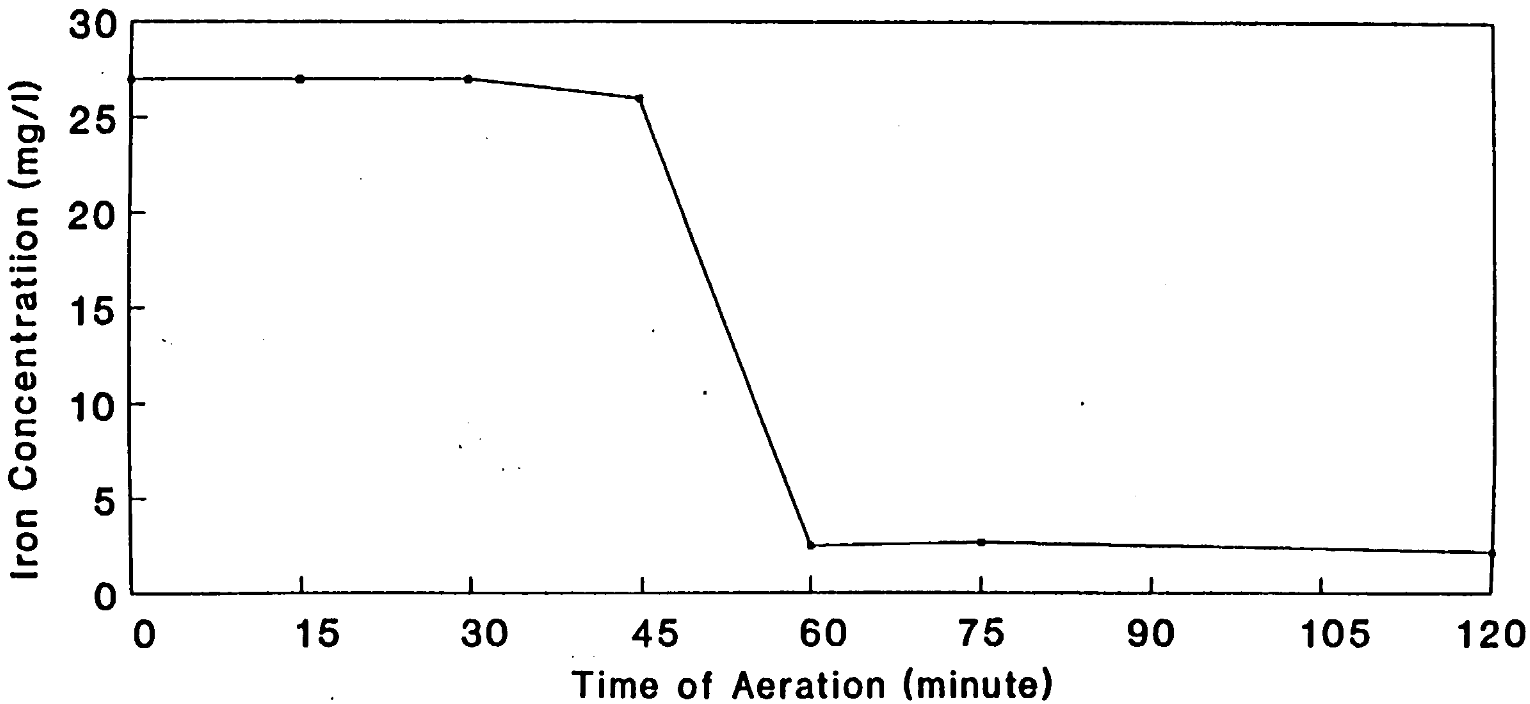


FIGURE 5.4
Hagen Farm Groundwater
Air Stripping Test-Spiked Groundwater

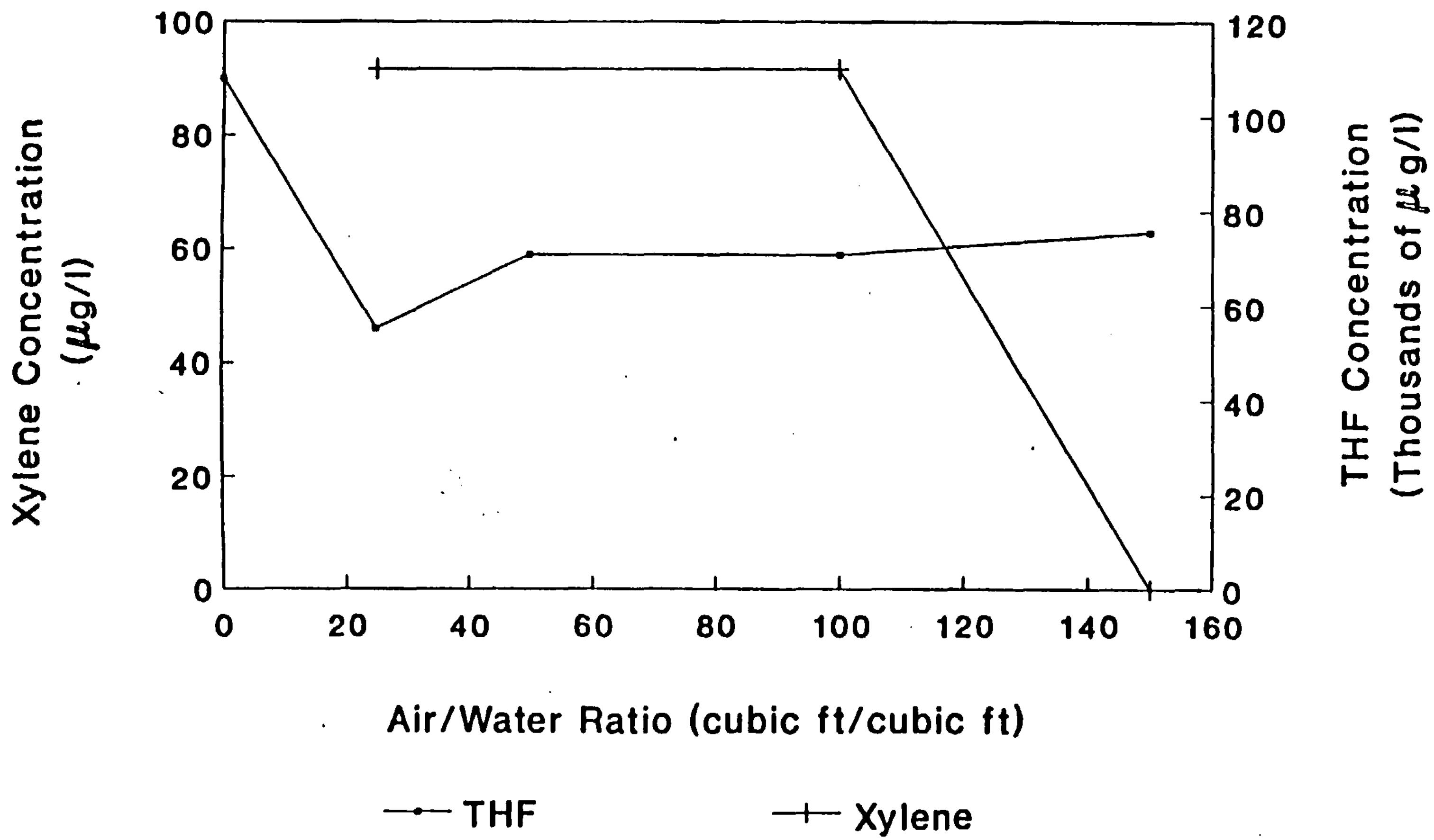


FIGURE 5.5
Hagen Farm Groundwater
Tetrahydrofuran Breakthrough Curve
GAC Column Test for Spiked Groundwater

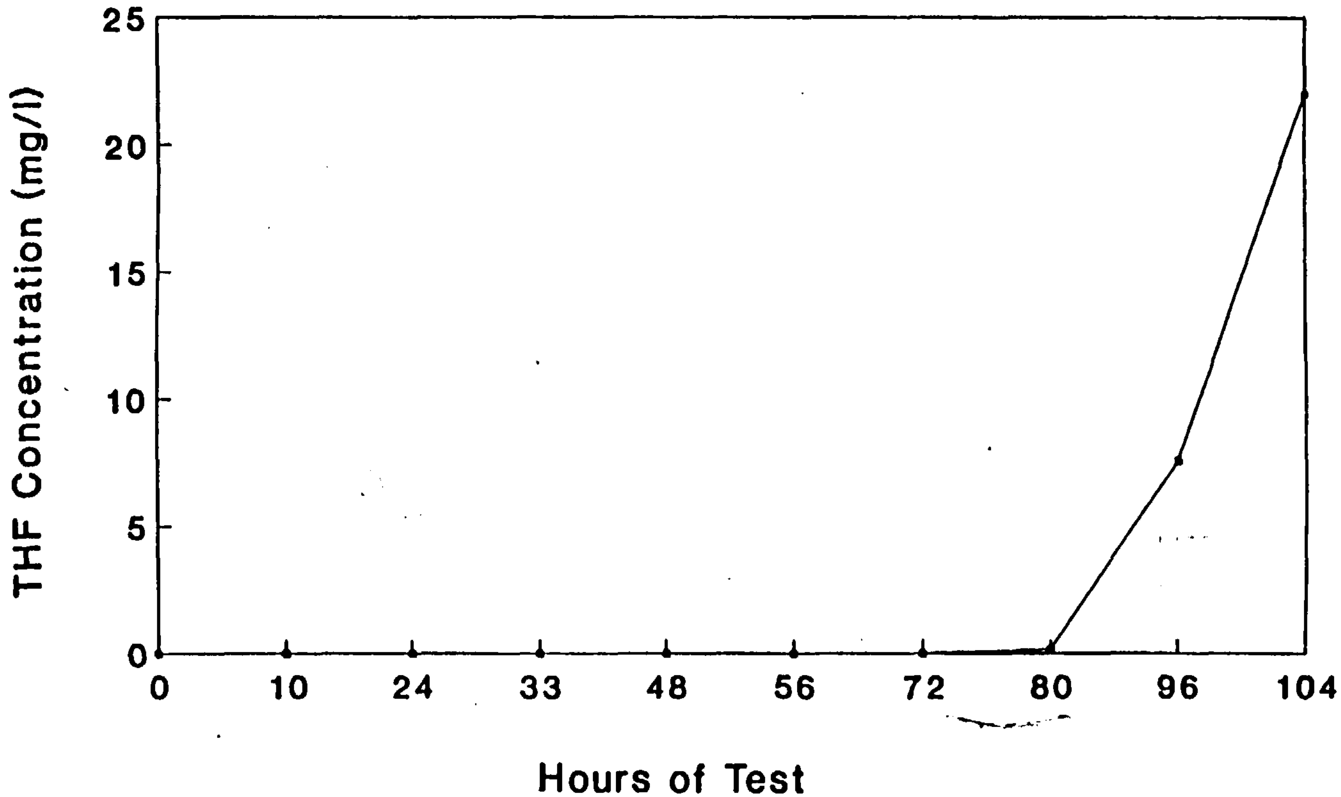


FIGURE 5.6
Hagen Farm Soil Bioreactors
TOC Biodegradation (Reactor 1)

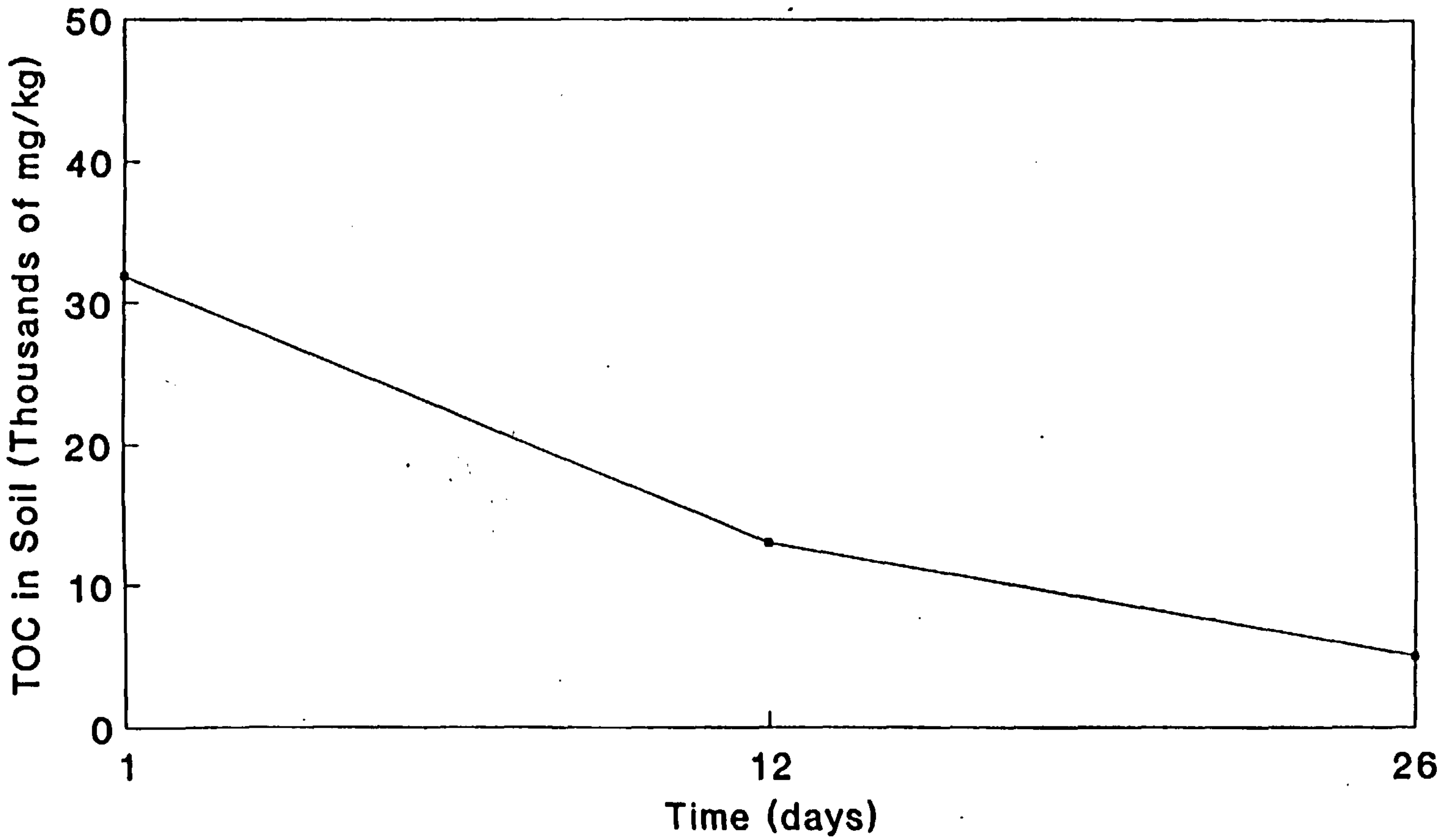


FIGURE 5.7
Hagen Farm Soil Bioreactors
TOC Biodegradation (Reactor 2)

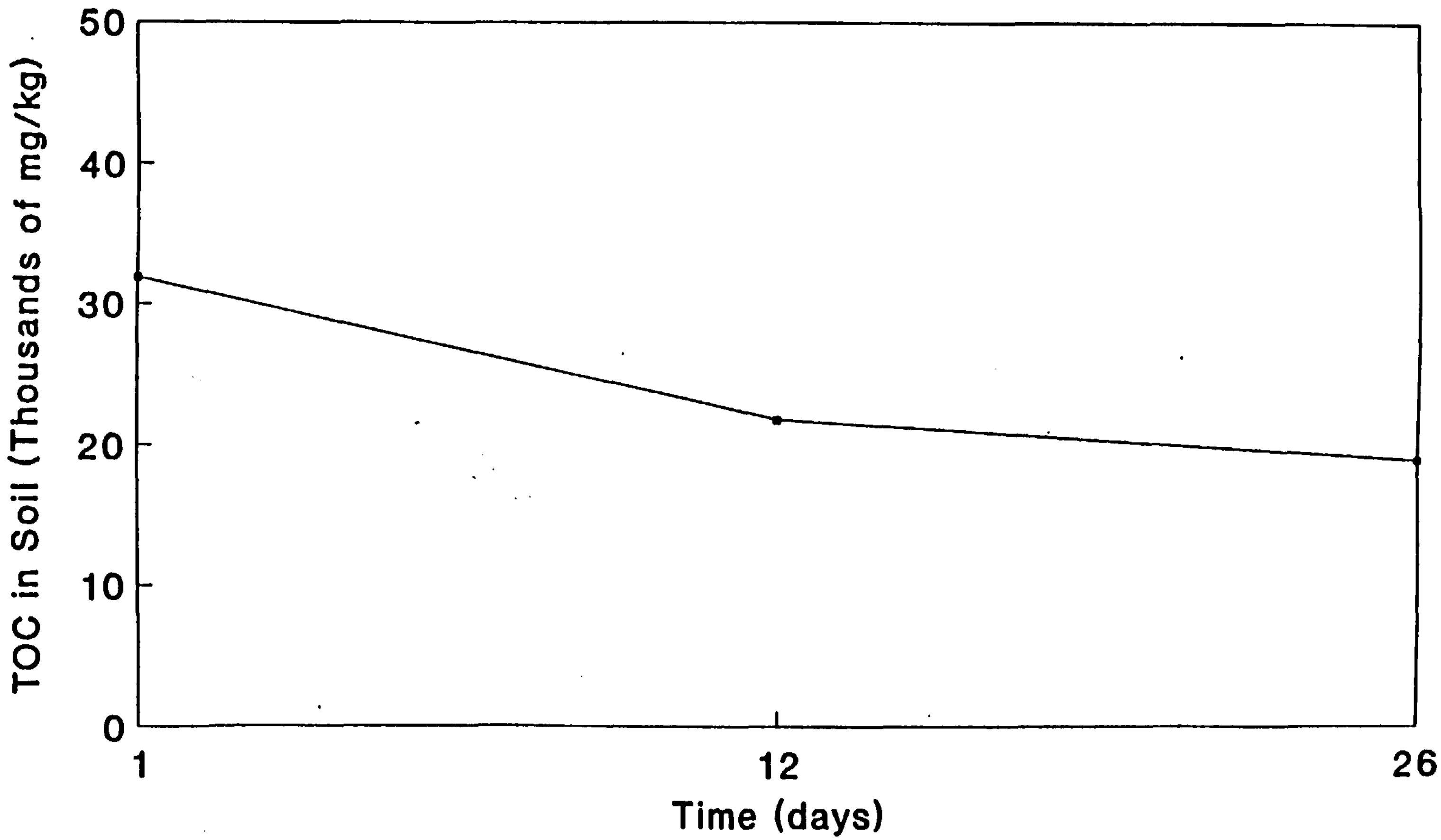


FIGURE 5.8
Hagen Farm Soil Bioreactors
TOC Biodegradation (Reactor 3)

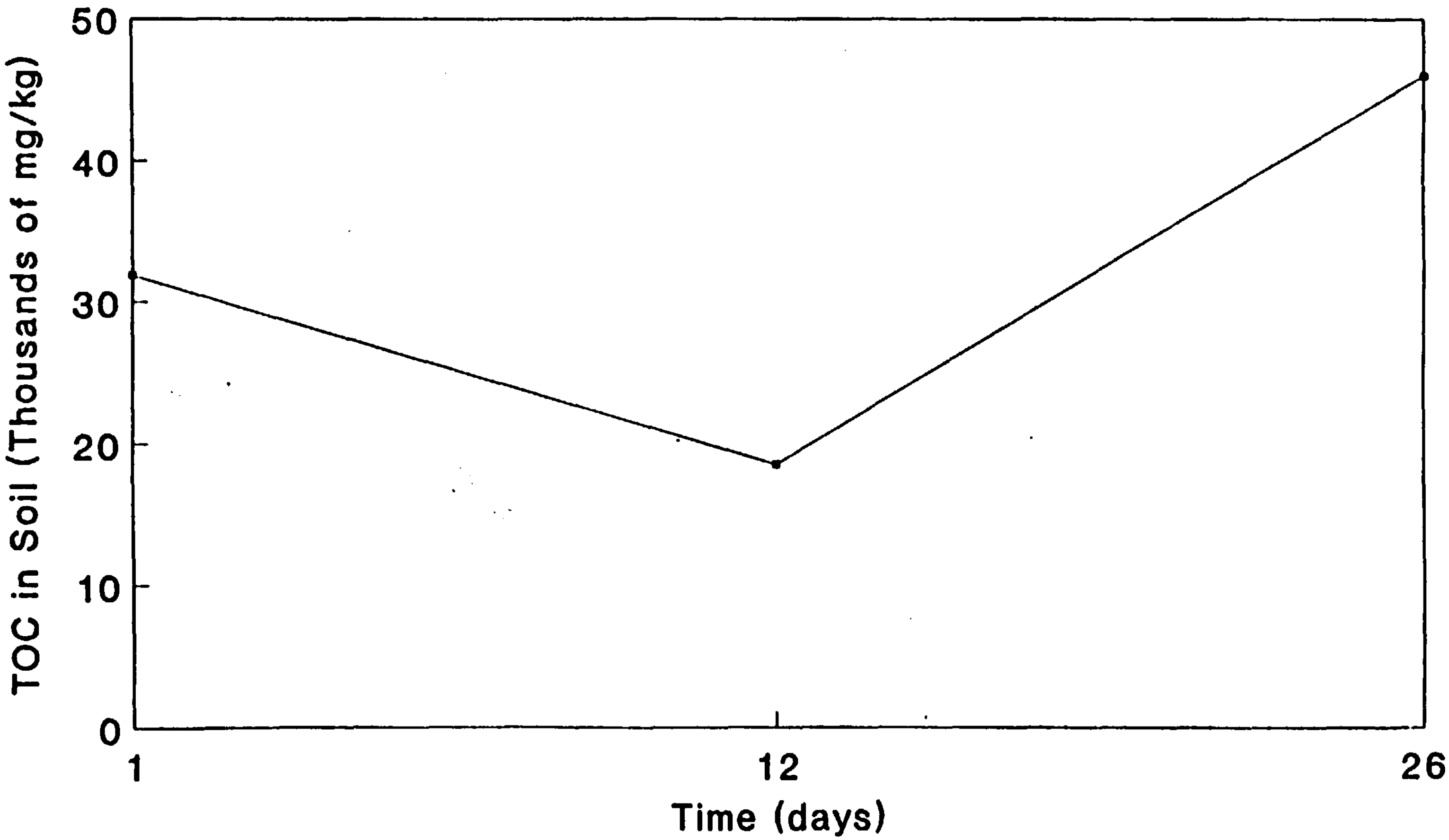


FIGURE 5.9
Hagen Farm Soil Bioreactors
TOC Biodegradation (Reactor 4)

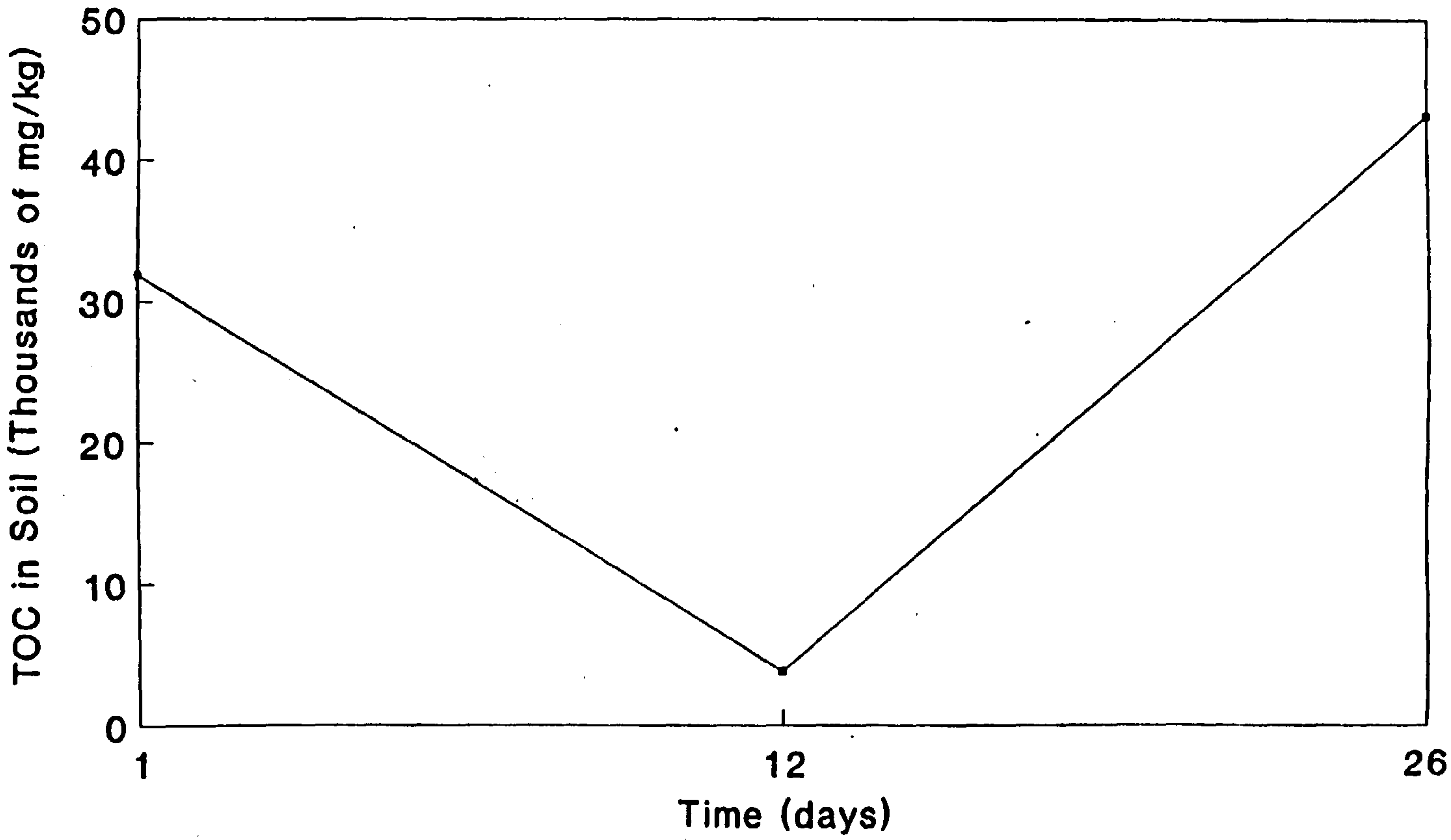


FIGURE 5.10
Hagen Farm Soil Bioreactors
Dissolved Oxygen vs Time - Day 8

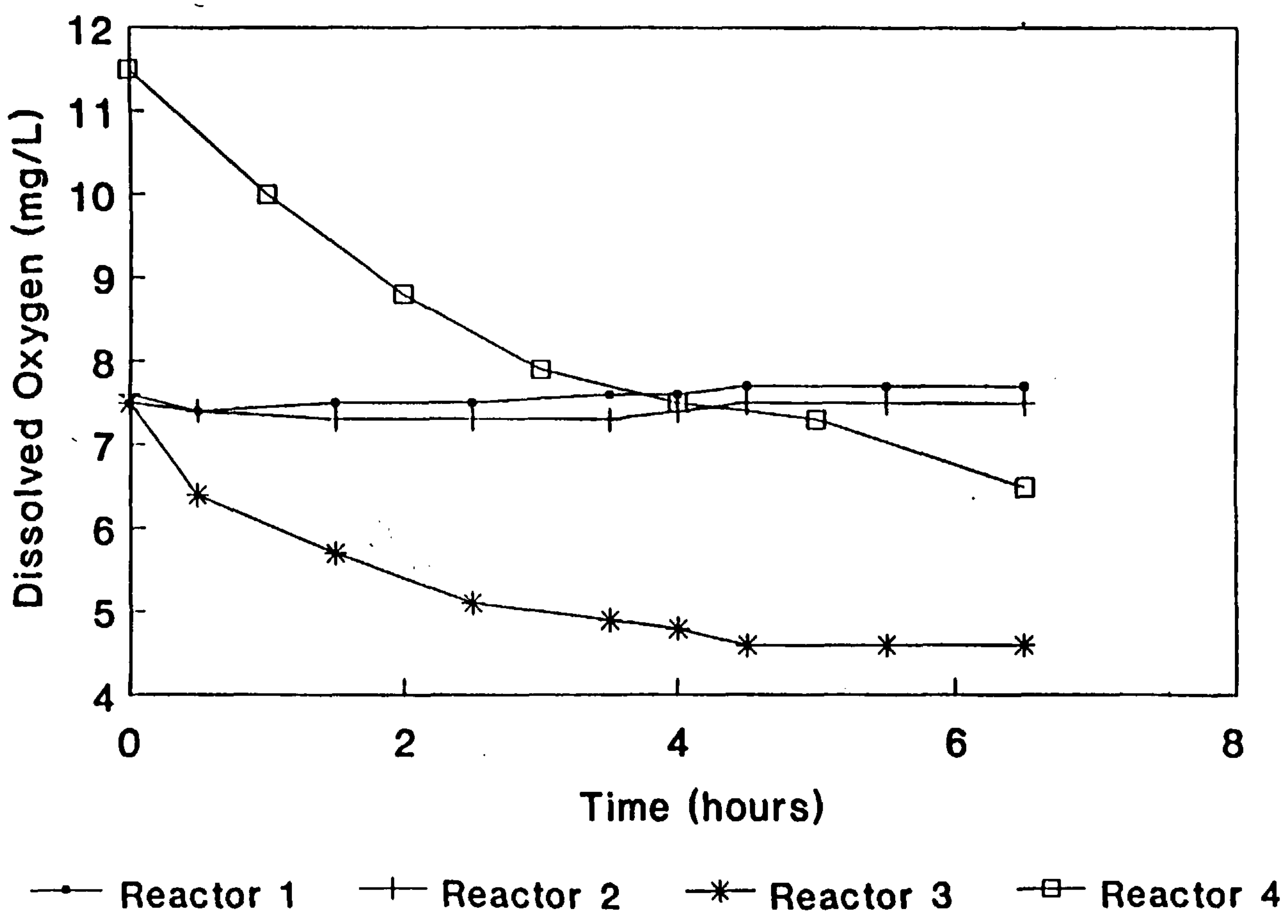


FIGURE 5.11
Hagen Farm Soil Bioreactors
Oxygen Uptake Rate vs Time

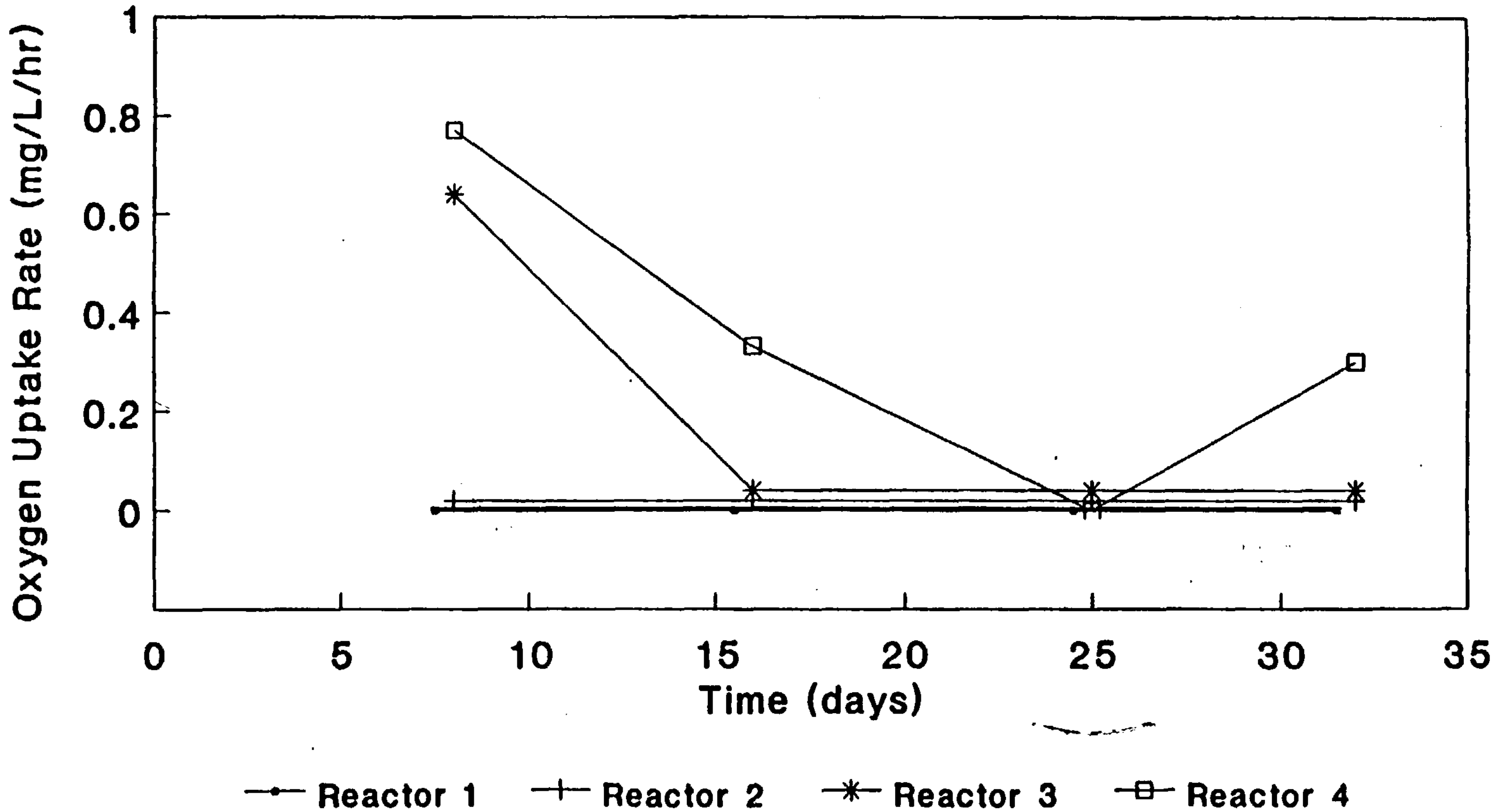


FIGURE 5.12
Hagen Farm Soil Bioreactors
Bacterial Growth (Reactor 1)

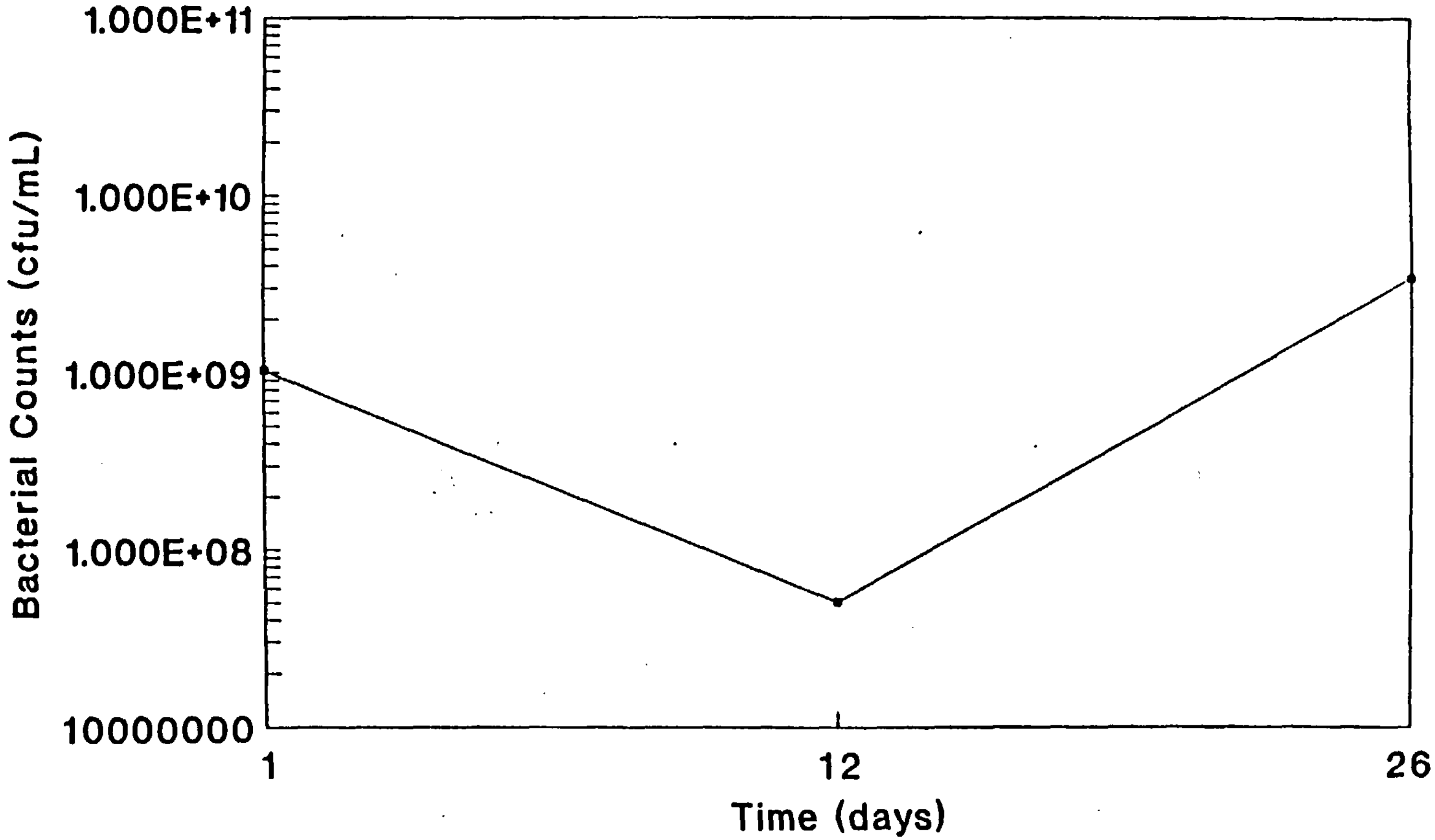


FIGURE 5.13
Hagen Farm Soil Bioreactors
Bacterial Growth (Reactor 2)

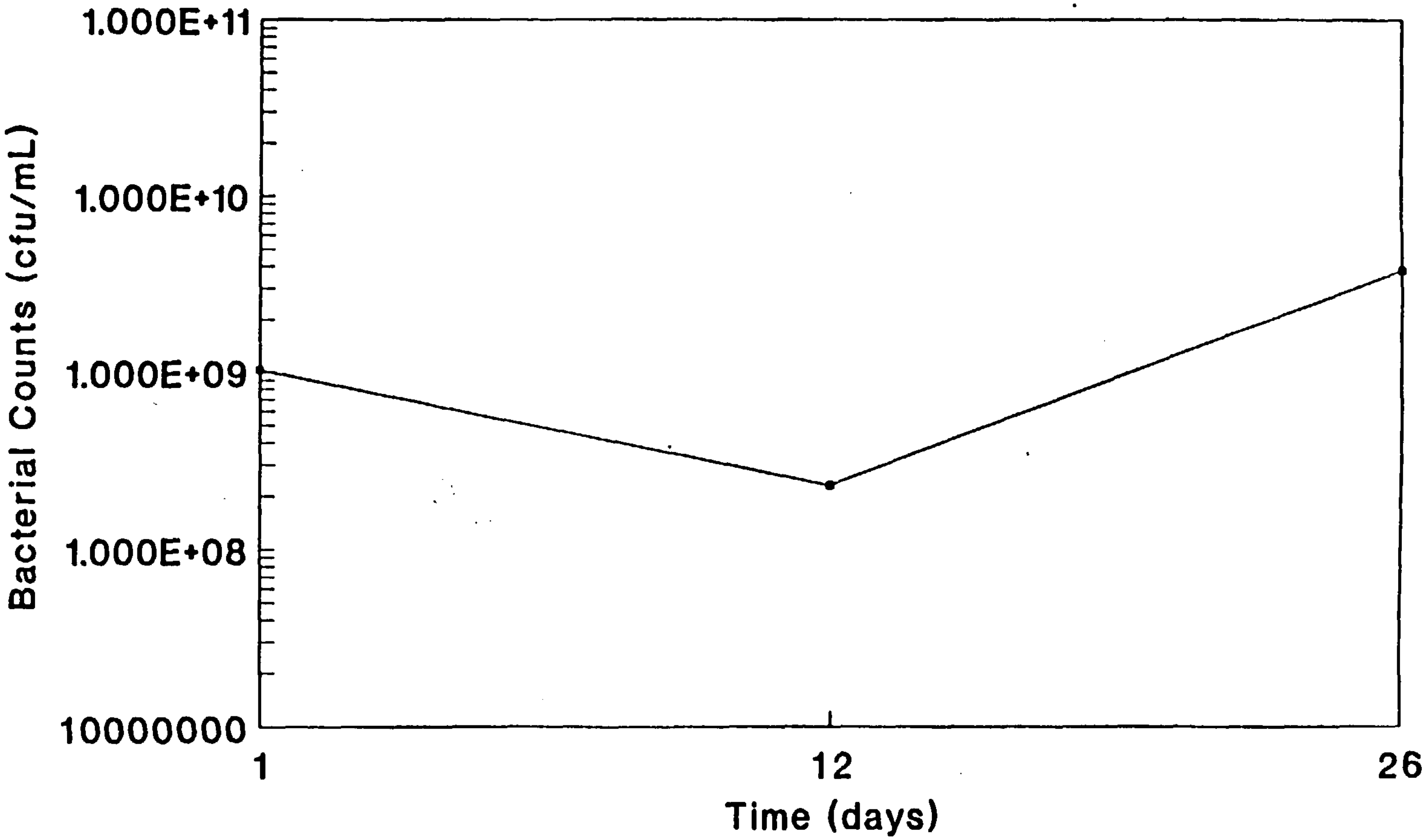


FIGURE 5.14
Hagen Farm Soil Bioreactors
Bacterial Growth (Reactor 3)

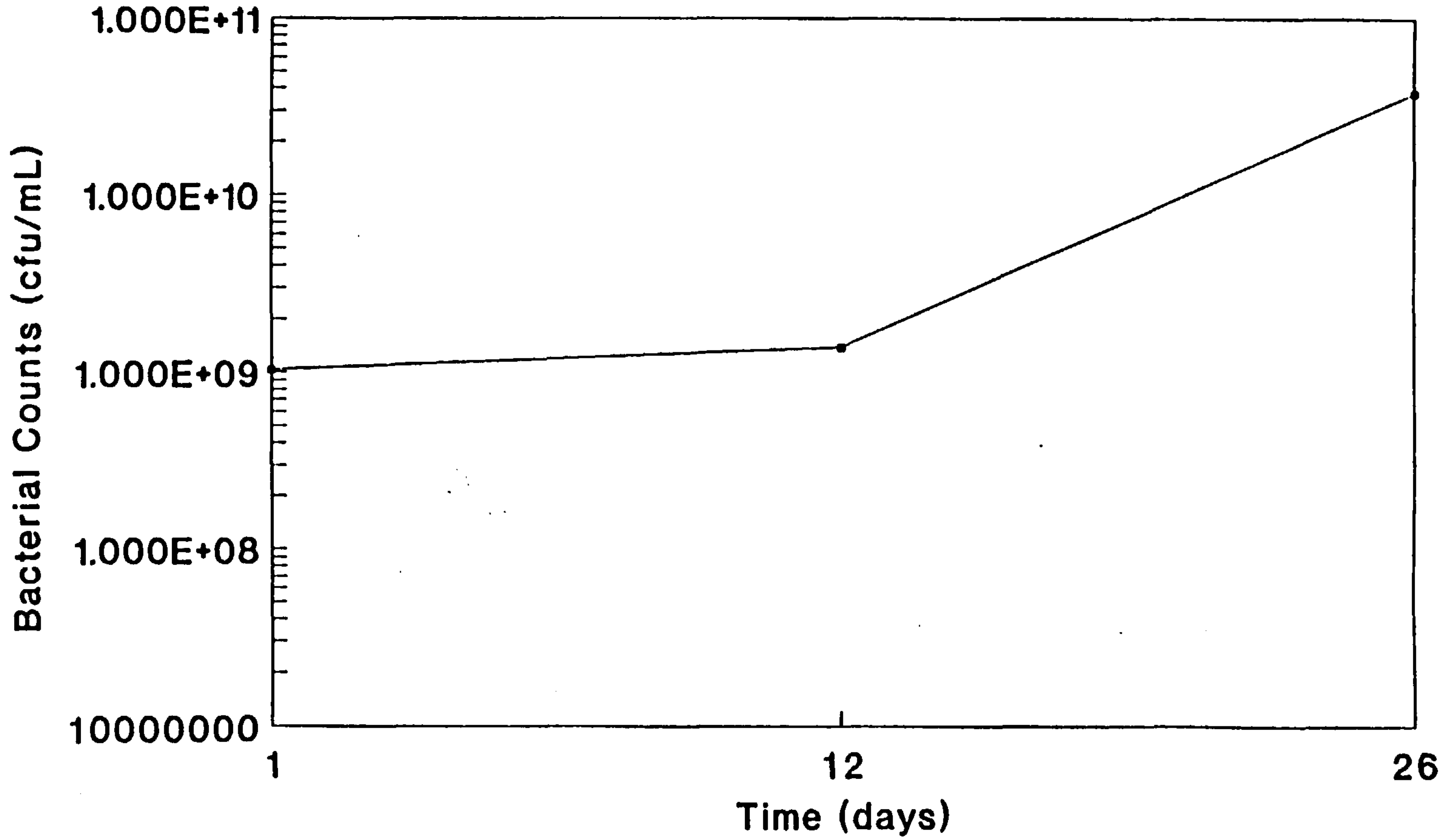


FIGURE 5.15
Hagen Farm Soil Bioreactors
Bacterial Growth (Reactor 4)

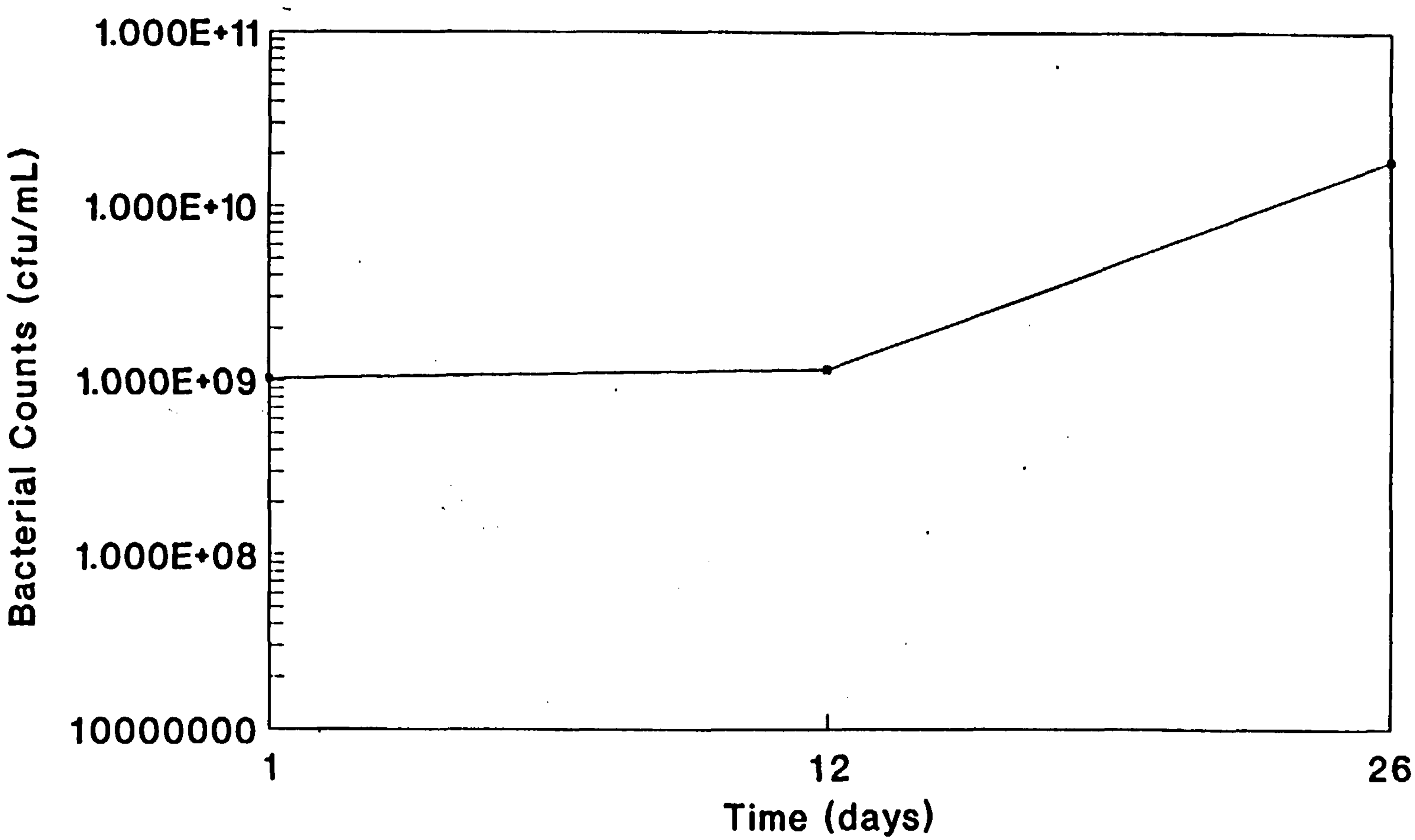
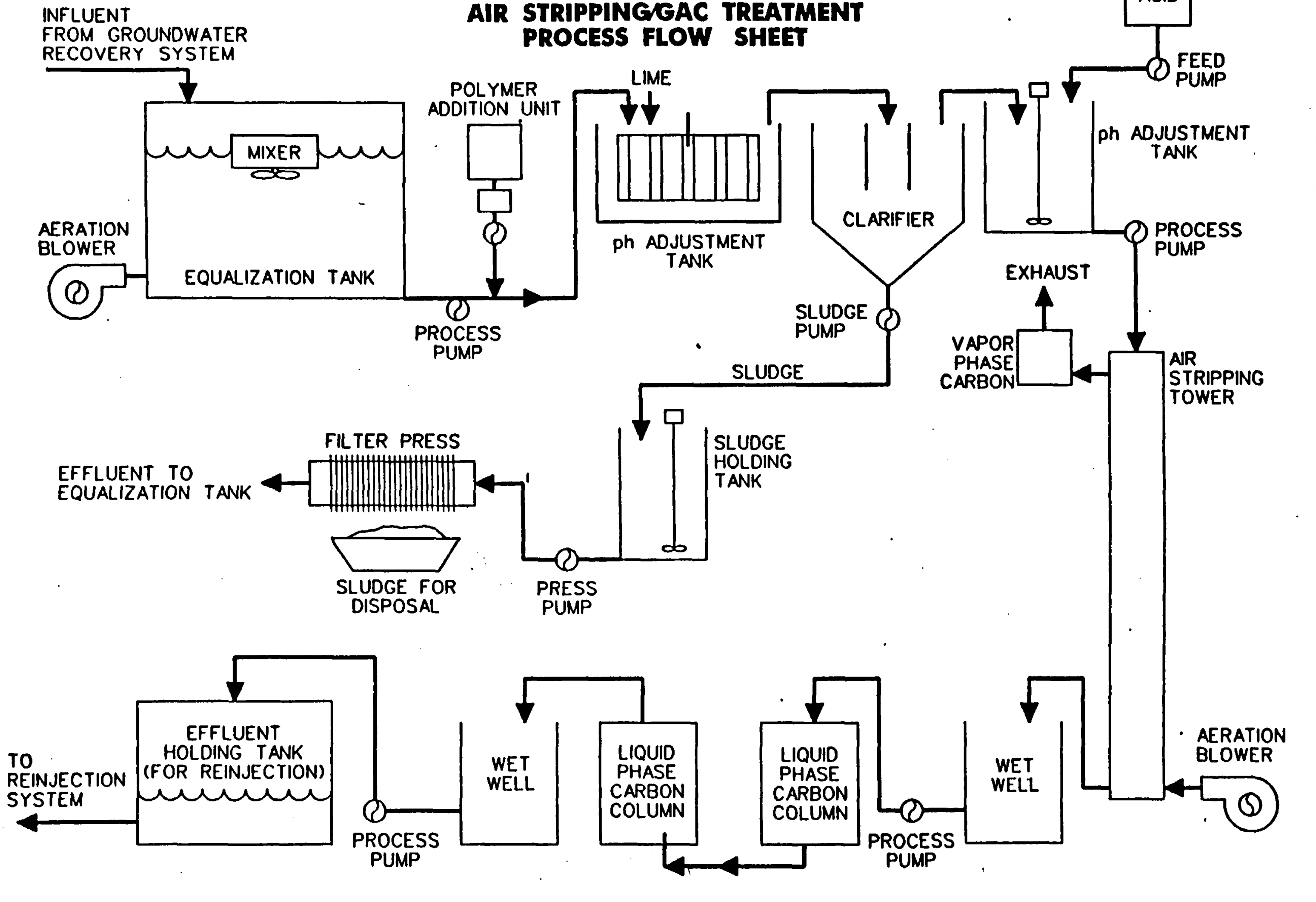


FIGURE 6.1
HAGEN FARM TREATABILITY STUDY
GROUNDWATER TREATMENT OPTION 1:
AIR STRIPPING/GAC TREATMENT
PROCESS FLOW SHEET



HAGEN FARM TREATABILITY STUDY
GROUNDWATER TREATMENT OPTION 2:
GAC TREATMENT
PROCESS FLOW SHEET

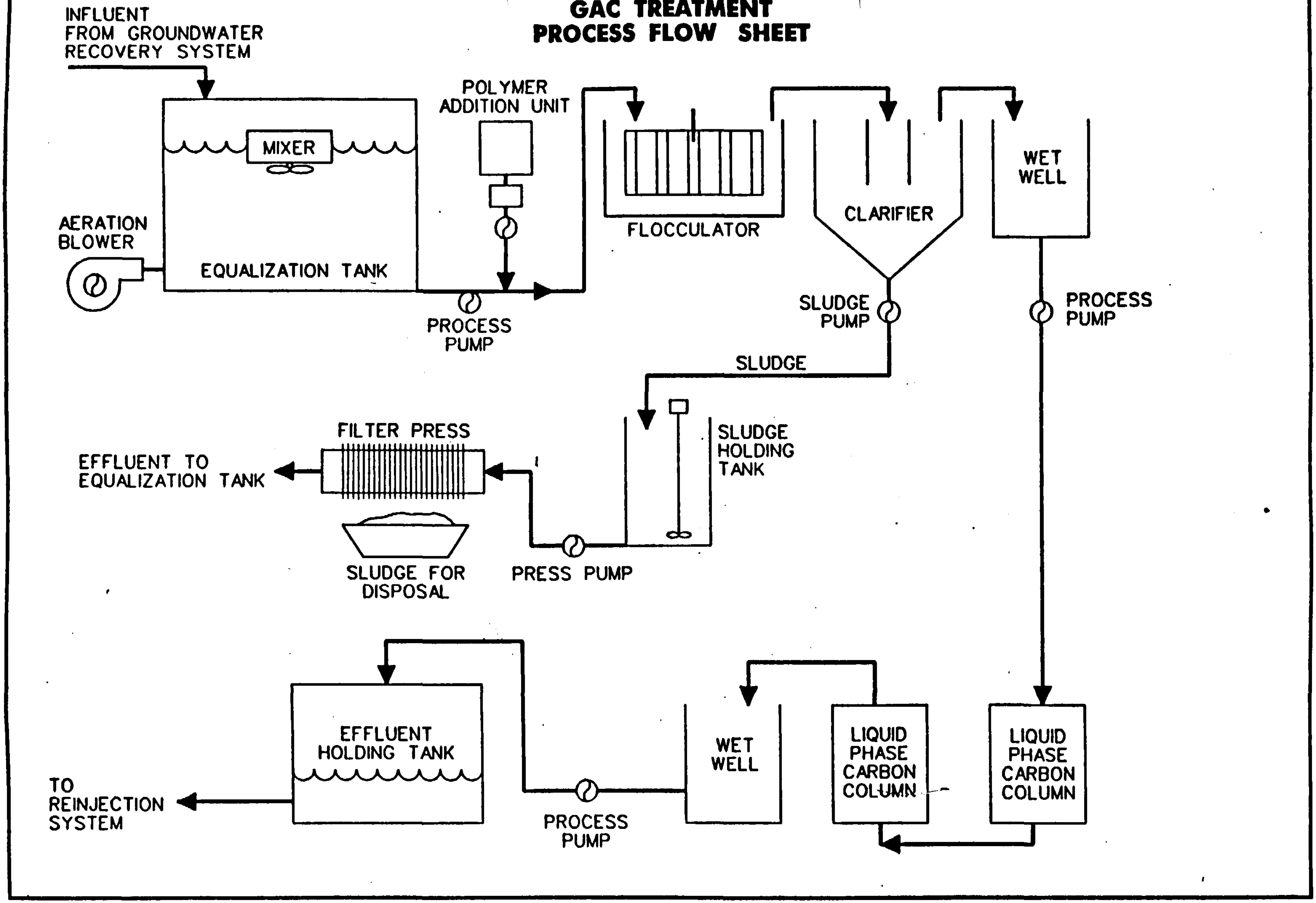


FIGURE 6.3

HAGE FARM TREATABILITY STUDY
GROUNDWATER TREATMENT OPTION 3:
ACTIVATED SLUDGE TREATMENT
PROCESS FLOW SHEET

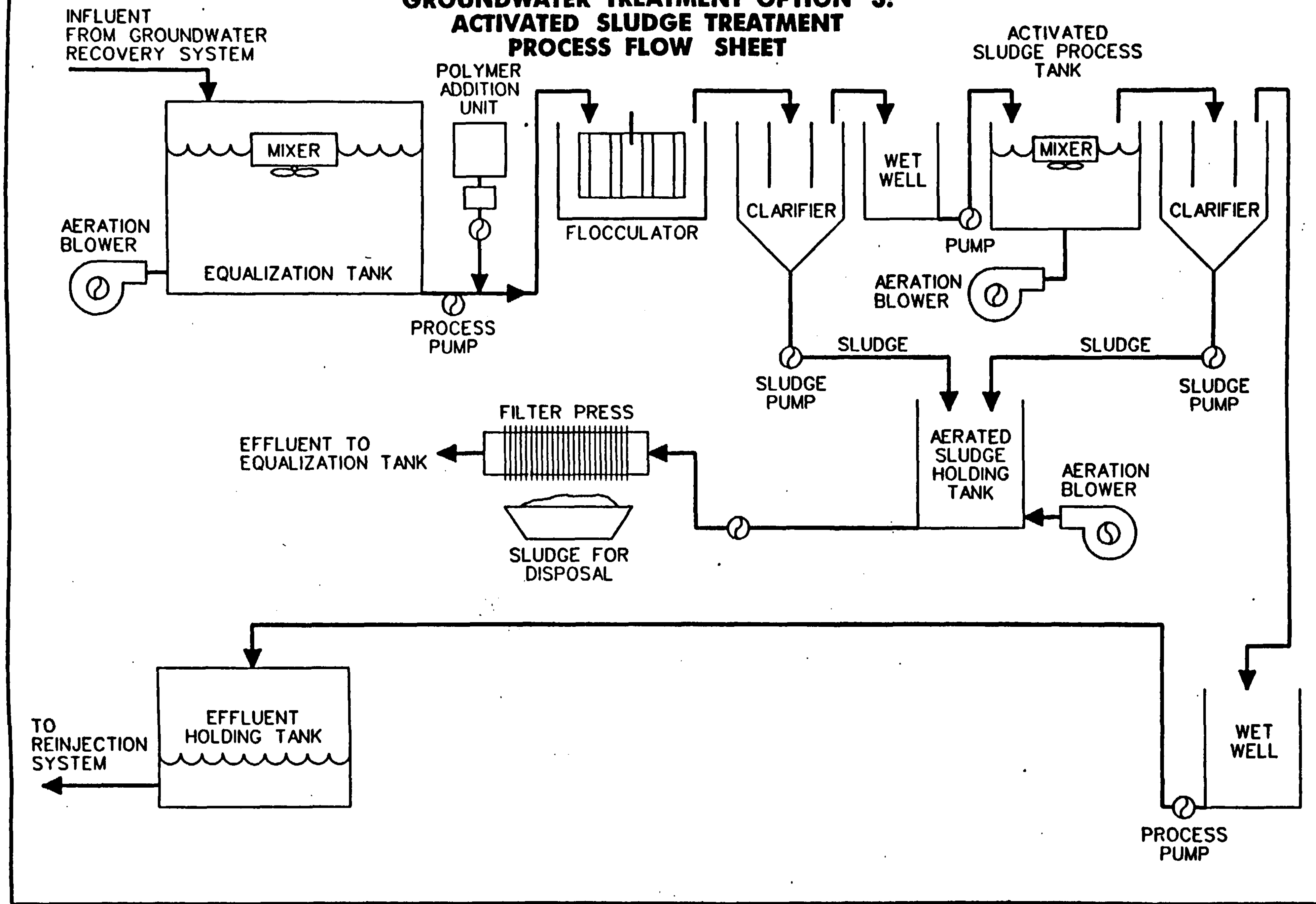
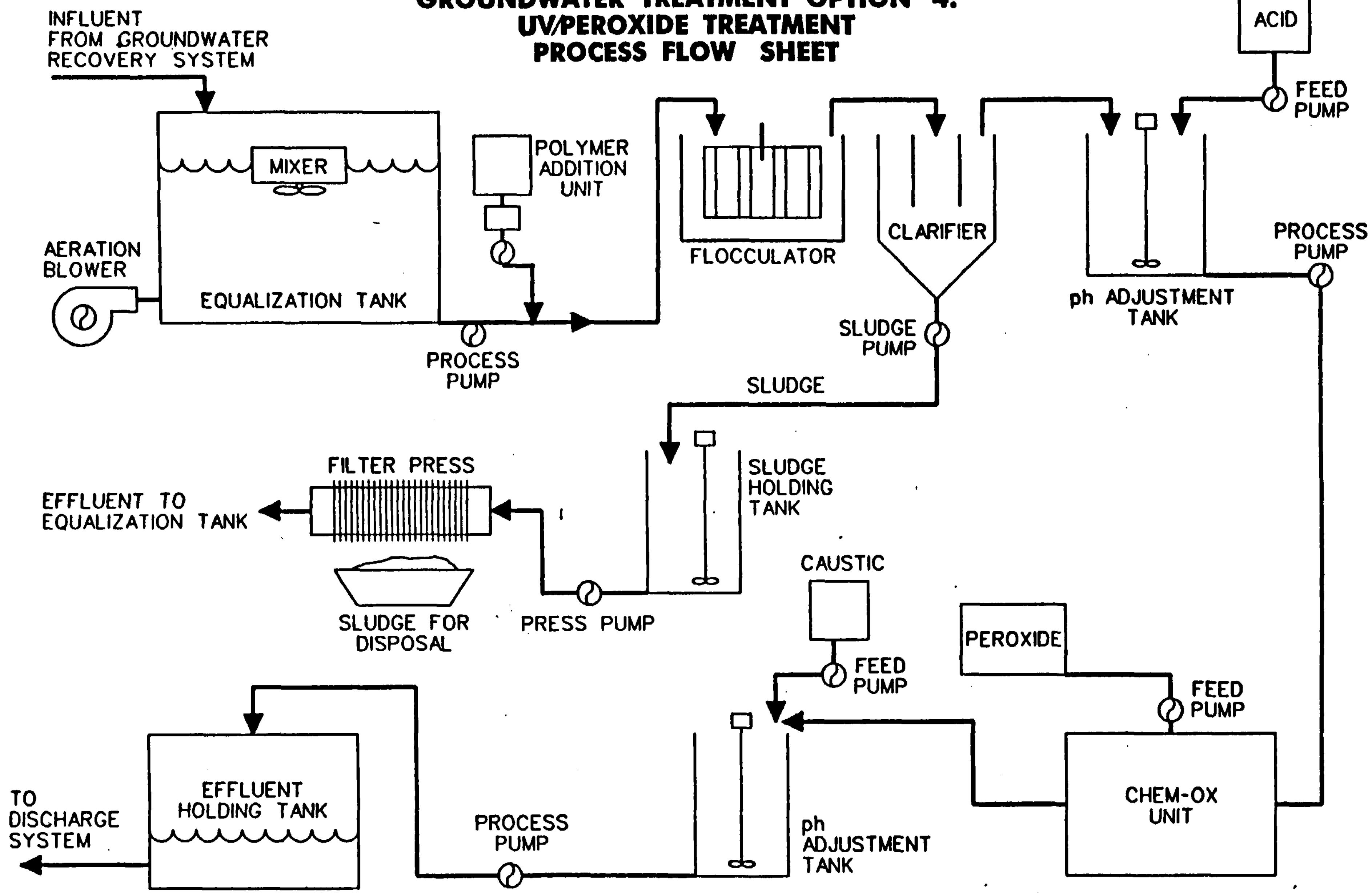


FIGURE 6.4
HAGEN FARM TREATABILITY STUDY
GROUNDWATER TREATMENT OPTION 4:
UV/PEROXIDE TREATMENT
PROCESS FLOW SHEET



LIST OF APPENDICES

APPENDIX A

EPA's Correspondence on F039 Determination

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
230 SOUTH DEARBORN ST.
CHICAGO, ILLINOIS 60604

MAR 0 5 1991

REPLY TO ATTENTION OF:

Dee Brncich
Waste Management of North America, Inc.
Two Westbrook Corporate Center, Suite 1000
P.O. Box 7070
Westchester, Illinois 60154

Dear Ms. Brncich:

The United States Environmental Protection Agency (U.S. EPA) and Wisconsin Department of Natural Resources (WDNR) have received the Treatability Study Work Plan, dated February 8, 1991 for the Hagen Farm Superfund site in Stoughton, Wisconsin. We have also received your response, dated March 21, 1991, for the review comments we provided to you on March 13, 1991. This letter is to formally notify you that the Work Plan, including the Quality Assurance Project Plan, has been approved.

For the issue concerning F039 waste you raised in the Work Plan, it is determined that only leachate from the landfill will carry the RCRA multisource leachate hazardous waste code of F039. The contaminated groundwater will not carry the same waste code of F039. However, if leachate is produced in the laboratory to conduct the treatability study, then the leachate shall be considered as F039 waste and shall be tested for the compounds specified in the F039 waste code.

For any soil, waste refuse, ashes, sludges, spent carbons, or residues produced during the treatability study, a test shall be conducted to determine whether any F003 and/or F005 constituents are present above detection limits required by the U.S. EPA. The soil, waste refuse, sludges, ashes, spent carbon, or residues shall be 1) considered as solid waste if F003/F005 constituents are detected below detection limits, 2) disposed of in a RCRA-compliance landfill if detected above detection limits but below LDR standard, and 3) treated to meet LDR standard and disposed of RCRA compliance landfill if detected above LDR standard. For the groundwater collected from the site to conduct the treatability study, the subsequent requirements and standards under NPDES are applicable if groundwater is to be discharged to the local ditch of the site. If groundwater is discharged to the local POTW, then pretreatment requirements of local POTW are applicable.

If you have questions, please feel free to contact me at (312) 886-4749.

APR 11 1991

Sincerely,

Jae B. Lee

Jae B. Lee
Remedial Project Manager

cc T. Evanson, WDNR
J. Smith, Versar

DATE RECEIVED/SENT 4/11/91
BY DEE BRNCICH
SITE Hagen Farm
CC/ROUTE:
PK. DP. WS. HK. JD. GM. DO. AK. RO. AS
FILE SYSTEM: PROJECT/SITE
FILE CODE: ______ W/ATTACH
2.1 2.3 W/O ATTACH
17.5

APPENDIX B

EPA Target Compound List (TCL)

Make Table

= (152)

Table

TARGET COMPOUND LIST (TCL) AND CONTRACT REQUIRED QUANTITATION LIMITS (CRQL)*

	Volatiles	CAS Number	Detection Limits (1) Low Water (2) ug/l	Detection Limits (1) Low Soil Sediment (3) ug/kg
1.	Chloromethane	74-87-3	10	10
2.	Bromomethane	74-83-9	10	10
3.	Vinyl Chloride	75-01-4	10	10
4.	Chloroethane	75-00-3	10	10
5.	Methylene Chloride	75-09-2	5	5
6.	Acetone	67-64-1	10	10
7.	Carbon Disulfide	75-15-0	5	5
8.	1,1-Dichloroethene	75-35-4	5	5
9.	1,1-Dichloroethane	75-35-3	5	5
10.	Total-1,2-Dichloroethene	156-60-5	5	5
11.	Chloroform	67-66-3	5	5
12.	1,2-Dichloroethane	107-06-2	5	5
13.	2-Butanone	78-93-3	10	10
14.	1,1,1-Trichloroethane	71-55-6	5	5
15.	Carbon Tetrachloride	56-23-5	5	5
16.	Vinyl Acetate	108-05-4	10	10
17.	Bromodichloromethane	75-27-4	5	5
18.	1,1,2,2-Tetrachloroethane	79-34-5	5	5
19.	1,2-Dichloropropane	78-87-5	5	5
20.	trans-1,3-Dichloropropene	10061-02-6	5	5
21.	Trichloroethene	79-01-6	5	5
22.	Dibromocloromethane	124-48-1	5	5
23.	1,1,2-Trichloroethane	79-00-5	5	5
24.	Benzene	71-43-2	5	5
25.	cis-1,3-Dichloropropene	10061-01-5	5	5
27.	Bromoform	75-25-2	5	5
28.	2-Hexanone	591-78-6	10	10
29.	4-Methyl-2-pentanone	108-10-1	10	10
30.	Tetrachloroethene	127-18-4	5	5
31.	Toluene	108-88-3	5	5
32.	Chlorobenzene	108-90-7	5	5
33.	Ethyl Benzene	100-41-4	5	5
34.	Styrene	100-41-4	5	5
35.	Total Xylenes	100-42-5	5	5

Tetrahydrofuran will also be analyzed with the volatile fraction.

	Volatiles	CAS Number	Detection Limits(1) Low Water(2) ug/l	Low Soil/Sediment(3) ug/kg
36.	Phenol	108-95-2	10	330
37.	bis(2-Chloroethyl)ether	111-44-4	10	330
38.	2-Chlorophenol	95-57-8	10	330
39.	1,3-Dichlorobenzene	541-73-1	10	330
40.	1,4-Dichlorobenzene	106-46-7	10	330
41.	Benzyl Alcohol	100-51-6	10	330
42.	1,2-Dichlorobenzene	95-50-1	10	330
43.	2-Methylphenol	95-48-7	10	330
44.	bis(2-Chloroisopropyl)ether	39638-32-9	10	330
45.	4-Methylphenol	106-44-5	10	330
46.	N-Nitroso-Dipropylamine	621-64-7	10	330
47.	Hexachloroethane	67-72-1	10	330
48.	Nitrobenzene	98-95-3	10	330
49.	Isophorone	78-59-1	10	330
50.	2-Nitrophenol	88-75-5	10	330
51.	2,4-Dimethylphenol	105-67-9	10	330
52.	Benzoic Acid	65-85-0	50	1600
53.	bis(2-Chloroethoxy)methane	111-91-1	10	330
54.	2,4-Dichlorophenol	120-83-2	10	330
55.	1,2,4-Trichlorobenzene	120-82-1	10	330
56.	Naphthalene	91-20-3	10	330
57.	4-Chloroaniline	106-47-8	10	330
58.	Hexachlorobutadiene	87-68-3	10	330
59.	4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7	10	330
60.	2-Methylnaphthalene	91-57-6	10	330
61.	Hexachlorocyclopentadiene	77-47-4	10	330
62.	2,4,6-Trichlorophenol	88-06-2	10	330
63.	2,4,5-Trichlorophenol	95-95-4	50	1600
64.	2-Chloronaphthalene	91-58-7	10	330
65.	2-Nitroaniline	88-74-4	50	1600
66.	Dimethyl Phthalate	131-11-3	10	330
67.	Acenaphthylene	208-96-8	10	330
68.	3-Nitroaniline	99-09-2	50	1600
69.	Acenaphthene	83-32-9	10	330
70.	2,4-Dinitrophenol	51-28-5	50	1600
71.	4-Nitrophenol	100-02-7	50	1600
72.	Dibenzofuran	132-64-9	10	330
73.	2,4-Dinitrotoluene	121-14-2	10	330
74.	2,6-Dinitrotoluene	606-20-2	10	330
75.	Diethylphthalate	84-66-2	10	330

Volatiles	CAS Number	Detection Limits(1) Low Water(2) ug/l	Low Soil Sediment(3) ug/kg
76. 4-Chlorophenyl Phenyl ether	7005-72-3	10	330
77. Fluorene	86-73-7	10	330
78. 4-Nitroaniline	100-01-6	50	1600
79. 4,6-Dinitro-2-methylphenol	534-52-1	50	1600
80. N-nitrosodiphenylamine	86-30-6	10	330
81. 4-Bromophenyl Phenyl ether	101-55-3	10	330
82. Hexachlorobenzene	118-74-1	10	330
83. Pentachlorophenol	87-86-5	50	1600
84. Phenanthrene	85-01-8	10	330
85. ANTHRACENE	120-12-7	10	330
86. Di-n-butylphthalate	84-74-2	10	330
87. Fluoranthene	206-44-0	10	330
88. Pyrene	129-00-0	10	330
89. Butyl Benzyl Phthalate	85-68-7	10	330
90. 3,3'-Dichlorobenzidine	91-94-1	20	660
91. Benzo(a)anthracene	56-55-3	10	330
92. bis(2-ethylhexyl)phthalate	117-81-7	10	330
93. Chrysene	218-01-9	10	330
94. Di-n-octyl Phthalate	117-84-0	10	330
95. Benzo(b)fluoranthene	205-99-2	10	330
96. Benzo(k)fluoranthene	207-08-9	10	330
97. Benzo(a)pyrene	50-32-8	10	330
98. Indeno(1,2,3-cd)pyrene	193-39-5	10	330
99. Dibenz(a,h)anthracene	53-70-3	19	330
100. Benzo(g,h,i)perylene	191-24-2	10	330
101. alpha-BHC	319-84-6	0.05	8.0
102. beta-BHC	319-85-7	0.05	8.0
103. delta-BHC	319-86-8	0.05	8.0
104. gamma-BHC (Lindane)	58-89-9	0.05	8.0
105. Heptachlor	76-44-8	0.05	8.0
106. Aldrin	309-00-2	0.05	8.0
107. Heptachlor Epoxide	1024-57-3	0.05	8.0
108. Endosulfan I	959-98-8	0.05	8.0
109. Dieldrin	60-57-1	0.10	16.0
110. 4,4'-DDE	75-55-9	0.10	16.0
111. Endrin	72-20-8	0.10	16.0
112. Endosulfan II	33213-65-9	0.10	16.0
113. 4,4-DDD	72-54-8	0.10	16.0
114. Endosulfan Sulfate	1031-07-8	0.10	16.0
115. 4,4'-DDT	50-29-3	0.10	16.0

Volatiles		CAS Number	Detection Limits(1) Low Water(2) ug/l	Low Soil/Sediment(3) ug/kg
116.	Endrin Ketone	53494-70-5	0.10	16.0
117.	Methoxychlor	72-43-5	0.5	80.0
118A.	Alpha Chlordane		0.5	80.0
118B.	Gamma Chlordane		0.5	80.0
119.	Toxaphene	8001-35-2	1.0	160.0
120.	AROCLOR-1016	12674-11-2	0.5	80.0
121.	AROCLOR-1221	11104-28-2	0.5	80.0
122.	AROCLOR-1232	11141-16-5	0.5	80.0
123.	AROCLOR-1242	53469-21-9	0.5	80.0
124.	AROCLOR-1248	12672-29-6	0.5	80.0
125.	AROCLOR-1254	11097-69-1	1.0	160.0
126.	AROCLOR-1260	11096-82-5	1.0	160.0

NOTES

(1) Detection limits listed for soil/sediment are based on net weight. The detection limits calculated by the laboratory for soil/sediments will be on dry weight basis and will be higher.

(2) Targert Compound List (TCL) Compounds are 100 times the individual Low Water DL.

(3) Medium Soil/Sediment CRQL for Volatile TCL Compounds are 125 times the individual Low soil sediment CRQL.

(4) Meidum Soil/Sediment CRQL for Semi-Volatile HSL Compunds are 60 times the individual Low Soil/Sediment CRQL.

(5) Medium Soil/Sediment CRQL for Pesticide and PCB's TCL Compunds are 15 times the individual Low Soil/Sediment CRQL.

* Specific detection limits are highly matrix dependent. The detection limit listed herein are provided for guidance and may not always be achievable.

ELEMENTS DETERMINED BY
INDUCTIVELY COUPLED PLASMA EMISSION
OR ATOMIC ABSORPTION SPECTROSCOPY

Metal	Required Detection Level(1) ug/l
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5000
Chromium	10
Cobalt	50
Copper	25
Iron	100
Lead	5
Magnesium	5000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5000
Selenium	5
Silver	10
Sodium	5000
Thallium	10
Vanadium	50
Zinc	20
Other	
Cyanide	10

NOTES

(1) Any analytical method specified in Exhibit D of IFB WA 84-J091/J092 may be utilized as long as the documented instrument or method detection limits meet the CRQL requirements. Higher detection levels may only be used in the following circumstances.

If the sample concentration exceeds two times the detection limit of the instrument or method in use, the value may be reported even though the instrument or method detection limit may not equal the CRQL.

[jpl-401-53]

APPENDIX C

Analytical Results for Initial Characterization

Feb 22.91 12:15 No.010 P.01

HERITAGE REMEDIATION/ENGINEERING, INC.

1319 Marquette Dr.
Romeoville, IL 60441
Phone: 708 378-1600
FAX: 708-378-2200

DATE: 2-22-91

TIME: 11:00

SENDER: Debi Edwards / Ems Kalz
NAME

FAX NUMBER: (708) 378-2200

RECEIVER: Bill Lin
NAME

CWM
COMPANY

513-6401
FAX NUMBER

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