Comments on Waste Management's
Thorhild Landfill Re-Zoning Application Binder
Dated February 2009

Submitted by
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The Concerned Citizens of Thorhild County requested that I review the materials submitted by Waste Management (WM) as part of the "Rezoning Application" for its proposed landfill in Thorhild County, with respect to the potential for the landfill as proposed to protect public health, groundwater and surface water quality, and the interests of those in Thorhild County for as long as the wastes proposed for deposition in the landfill will be a threat. Presented herein are my comments on these issues.

Overall Assessment

I find that the WM-proposed landfill would have adverse impacts on the residents of Thorhild County and be adverse to the general interests of the County; it would pose significant threats to public health, groundwater and surface water quality. The proposed site is a very poor location for a landfill such as is proposed; there are many nearby properties that depend on groundwater that stand to be contaminated by the landfill. The proposed design of the landfill containment system will, at best, only postpone releases of hazardous and other deleterious chemicals that can be a threat to human and animal health, the quality of groundwater and surface water resources, and air quality in the area of the landfill.

As proposed, the WM landfill proposed for Thorhild County will likely become a significant financial burden to Thorhild County residents and possibly other Albertans. The WM Rezoning Application grossly overstates the ability and reliability of the proposed landfill waste containment, monitoring and maintenance systems/approaches to protect public health and the environment during the period that the wastes in this landfill will be a threat to escape from this landfill.

The WM Rezoning Application misleads the County officials and the public to assume that the initial protection afforded by the engineered features, if properly engineered and installed, will be sustained over the very long period of time during which the wastes in the landfill will be a threat to public health and environmental quality. WM fails to reveal that the waste in this proposed landfill will be a threat over very long periods of time, well-beyond the period for which Alberta Environment requires postclosure monitoring, maintenance, and remediation (landfill care) of environmental pollution by this landfill. The funds needed for landfill care after WM, as proposed, will no longer be responsible for monitoring, maintenance and remediation, will far-exceed any host fees that the County will receive from WM during the active life of this landfill as compensation for hosting the landfill. Failure to provide adequate funds for true postclosure funding to monitor, maintain and perform remediation of the polluted environment

for as long as the wastes in the landfill will be a threat will lead to environmental pollution by wastes in this landfill. A credible landfill application should address all of these issues in a meaningful and reliable manner in order to provide for full disclosure of the potential impacts of a proposed landfill.

There is no question that there is need for landfills that can serve as a receptacle for wastes that cannot be recycled. However, such landfills must be sited with adequate buffer lands, and designed, constructed, operated, closed, and supplied with assured postclosure funding and a plan to monitor and remediate any adverse effects to truly protect public health and the environment for as long as the wastes in the landfill will be a threat. The proposed WM Thorhild County Landfill falls far-short of providing this level of protection. Therefore, the rezoning of the land to enable the development of this proposed landfill should not be approved by the County.

Qualification to Make Comments

The comments presented in this report are based on my more than 45 years of experience in examining the impacts of municipal solid waste landfills in several areas of the USA, Canada, and other areas of the world. I earned my BA degree in public health protection from San Jose State College, Master of Science in Public Health degree from the University of North Carolina-Chapel Hill, and PhD degree in environmental engineering with minors in aquatic chemistry and public health. The PhD degree was awarded in 1960. I then held university graduate faculty positions for 30 years during which time I taught university graduate-level environmental engineering courses, conducted more than $5-million in research in water quality and waste management issues, and published about 500 papers and reports on that research. My research included investigation of landfill liner issues with support of the US EPA. In 1989, I retired from university teaching and research and expanded my part-time private and public consulting activities into a full-time activity. I conduct my consulting through my firm, G. Fred Lee & Associates, in which Dr. Anne Jones-Lee and I are the principals. We specialize in water supply water quality, water and wastewater treatment, water pollution control for both surface and groundwaters, and solid and hazardous waste impact investigation and management. Since 1989 we have developed another approximately 600 papers and reports on our activities in these areas. Many of our past and recent papers and reports are available on our website, www.gfredlee.com.

During my almost 50-year professional career I have investigated about 85 landfills. Reports and papers on our work on impacts of landfills are available on our website in the Landfills-Groundwater section [http://www.gfredlee.com/plandfil2.htm]. Two key publications synthesize much of our work on landfill impacts, review much of the technical literature, and provide links to the published literature. These publications are,

Guidance for Evaluating the Potential Environmental Quality Impacts of a Landfill
http://www.gfredlee.com/Landfills/EvaluationImpactLF.pdf

Lee, G. F., and Jones-Lee, A., "Flawed Technology of Subtitle D Landfilling of Municipal Solid Waste," Report of G. Fred Lee & Associates, El Macero, CA, December (2004). Updated December (2008).
http://www.gfredlee.com/Landfills/SubtitleDFlawedTechnPap.pdf

In the discussion of the deficiencies of the WM-proposed Thorhild County landfill presented below, I make reference to the "Flawed Technology" paper cited above. Many of the papers and reports cited in that review are from peer-reviewed literature authored by others as well as us. The Flawed Technology review has a table of contents which enables the reviewer to readily locate the section of this review discussed in the comments made below.

An understanding of groundwater quality issues is a key aspect of evaluating the deficiencies in the WM-proposed Thorhild Landfill. I have extensive background and experience in evaluation and management of groundwater quality; this includes studying groundwater hydrology at Harvard University, teaching groundwater courses to graduate students at several US universities, conducting numerous research projects on groundwater quality issues, and for several years serving on the editorial board of the Journal *Groundwater* where my responsibility was to review the technical merit of groundwater quality papers.

Additional information on my qualification to make these comments is presented in an appendix to this report.

Specific Comments on the Rezoning Application

The WM Rezoning Application contains a series of reports and correspondence on the proposed WM landfill development issues. Presented herein are comments on selected issues presented in those sections.

Section 4 of the Rezoning Application, "**Project Correspondence**," contains a letter sent by Cam Hantiuk Director, Public Affairs, Waste Management of Canada Corporation, which states in part:

"*Waste October 5, 2007*
Mr. Dan Small, County Manager The County of Thorhild No. 7 P.O. Box 10
Thorhild, AB TOA 3J0
Re: Proposed County By-Law No. 1096-2007

Dear Mr. Small,
Thank you for your October 3, 2007 letter requesting additional information in support of our re-districting application. Waste Management is pleased to provide the following response:
1. How your company will deal with potential surface water and ground water impacts on neighboring dugouts and water wells of neighboring property owners

Waste Management is prepared to warrant the following, which may be incorporated into a formal Host Agreement or other such document as required.

WM will provide a guarantee that it will fix any groundwater or surface water contamination issues caused by the landfill including, if necessary, replacing an affected person's water supply, provided that any recourse to this commitment would not be available if the affected resident did not assist in establishing a baseline."

That response to the County Manager is an example of the inadequate information being provided by WM in its Rezoning Application. Someone not familiar with some of the issues that

need to be considered in evaluating the long-term threats of the proposed landfill to pollute groundwaters would be lead to believe that the proposed WM Thorhild Landfill will not be a threat to the quality of the County's groundwater or surface water resources. As summarized above, the wastes in the proposed landfill will be a threat well-beyond the period for which Alberta Environment requires postclosure care. The minimum postclosure funding period as defined by Alberta Environment's "Standards for Landfills in Alberta" is only 25 years. Waste Management apparently proposes to provide funding for landfill monitoring, maintenance, and remediation just for that minimum period. If the County proceeds to consider approval of the rezoning application, it should require that Waste Management expand the wording of its application to include "**for as long as the wastes in this landfill, when contacted by water, will generate leachate**." WM should be required to provide a binding financial instrument that defines how WM will provide assured funding through a dedicated fund of sufficient amount held by an independent agency to fund monitoring, maintenance, and remediation for as long as the wastes in this landfill are a threat to generate leachate, which will extend essentially in perpetuity. Without such long-term assured funding for this proposed landfill, the above statement by WM of providing replacement water supply is inadequate to address the true long-term needs for funding for true postclosure care.

In the ***Impact/Benefit (IB) Program*** section states,
"*The Impact Benefits program will be designed to compensate residents in vicinity of Thorhild project for impacts of landfill (LF) nuisances. While we will be able to manage most, if not all nuisance issues,"*

A review of the WM-proposed landfill relative to adjacent properties that will likely be impacted by what are typically considered to be "nuisance" impacts such as odours, birds, fugitive wastes, trucks, noise, etc. (i.e., those impacts that cause justified NIMBY (not in my back yard)) it is clear that the proposed landfill provides inadequate buffer lands between the edge of waste deposition and adjacent property lines. Justified NIMBY issues are discussed in the "Flawed Technology" review. In the quoted statement WM admits that the proposed landfill may cause trespass of waste-derived constituents onto adjacent and nearby properties. At many landfills such adverse impacts extend for several miles from the landfill. Based on my experience, the proposed WM landfill will be significantly adverse to properties even several miles from the landfill. Of particular concern are the releases of landfill odours that are not only obnoxious but are also a threat to human and animal health.

WM also stated in that paragraph,
"*Residents who have subsequently moved into immediate did so with full knowledge of the project and would not benefit from the program*."

Why should WM control how current and future owners/users of nearby lands use their lands without adverse impacts of the WM landfill? The owners of adjacent and nearby properties should be able to use their properties at their property lines without being adversely impacted by the landfill releases. The County should inform Waste Management that if trespass of waste-derived constituents occurs onto an adjacent property, the landfill will be closed and WM will be directed to initiate closure of the landfill.

The section devoted to, "*Program Principles*
"*Families living within PVP area (primary residence) are eligible. Payments will be linked to receipt of waste into the landfill. Payments will be made quarterly.*
3 separate "impact zones" each with differing levels of payment — see attached map.
Applies to families living within PVP area at the time of WM receiving required permits to operate."

This approach is stacked in favor of Waste Management and against the interests of the nearby properties owners/users by minimizing the cost to WM at the expense of the future owners of impacted properties. Why should WM be allowed to provide payments for adverse impacts on nearby properties only while WM is gaining financial support of the landfill? It is known that releases from the landfill can occur after landfill closure, during the postclosure period and beyond. WM should be responsible for adverse impacts to nearby land owners forever. Those who dispose of wastes in a landfill should pay the true cost of landfilling wastes. Those costs should not be transferred to those in the sphere of influence of a landfill.

In a letter dated June 15, 2007, signed by Steve Johnson of WM, to Barry A. Sjolie Brownlee LLP Suite 2200, Commerce Place 10155-102 Street Edmonton, AB T5J 4G8
Re: Waste Management Application for Amendment to Land Use Bylaw 989-98 Information it is stated:
"*a preliminary phasing plan for the proposed land uses and explanation of the life cycle of the proposed land uses, including discussion of future reclamation levels and future consequential development limitations,*
This will be included in the preliminary closure plan when complete. The intent is to stage landfilling from the south to the north as shown on the attached diagram. The site will be capped to a minimum of either 0.6 m compacted clay, 0.35 m of subsoil, and 0.2 m topsoil or 0.6 m clay and background soil conditions. Waste Management will also be investigating other capping designs and will modify them as necessary to meet new legislation."

As discussed in a subsequent section of these comments, the proposed landfill cover will not keep the wastes in the proposed landfill dry and thereby prevent the generation of leachate. Water will penetrate through the low-permeability layer of the cover and generate leachate that can lead to groundwater and surface water pollution.

The Rezoning Application contains the Millennium EMS Solutions August 27, 2007 report to Waste Management entitled, "**Hydrogeologic Suitability of Proposed Thorhild Landfill,**" which presents some information on groundwater issues for the proposed landfill, states,
"*The horizontal hydraulic conductivity of the saturated glacial till has a geometric average of 12 x 10-9 m/sec. Using the average documented gradient of 0.005 m/m or the highest gradient of 0.02 m/m and an estimated effective porosity of 0.2, the groundwater flow velocity within the glacial till is between 9.5 x 10-3 m/year and 38 x 10-3 m/year, respectively. Unconsolidated clayey deposits such as this typically have a horizontal to vertical anisotropy greater than 1:1 (Freeze & Cherry, 1979). This means that the vertical flow velocities through this material should be considered to be less than the calculated horizontal flows. Both the horizontal and vertical flow through this material is insignificant and it is considered an aquiclude. The*

migration of a dissolved solute, such as landfill leachate, through this material would likely be dominated by diffusion across a concentration gradient as opposed to advection."

In its presentation of information on the hydraulic characteristic of the aquifer underlying the proposed landfill, Millennium used average rather than the highest conditions that were found in its studies. The threat of failure of the landfill liner to pollute groundwater should be based on the fastest rate at which an offsite groundwater well could be polluted by landfill leachate. Presenting the hydraulic conductivity as a "geometric average" and the "average gradient" rather than the highest hydraulic conductivity and the greatest gradient misleads those interested in the protection of offsite wells regarding how soon offsite groundwater pollution of groundwater can occur.

A critical review of the above-quoted statement shows that a hydraulic conductivity of about 1 x 10^{-6} cm/sec is about 10 times that apparently allowed by Alberta Environment for siting of landfills. The claim that diffusion would likely be the dominant transport mechanism for leachate-derived pollutants in groundwater is not in accord with the writing of Daniels and Shackelford which indicates that diffusion control does not begin to be important until about 10^{-7} cm/sec,.

Daniel, D. E. and Shackelford, C. D., "Containment of Landfill Leachate with Clay Liners," In: Sanitary Landfilling: Process, Technology and Environmental Impact, T. H. Christensen, R. Cossu and R. Stegmann (eds.), Academic Press, San Diego, CA (1989).

With that potential rate of migration of leachate-polluted groundwater, it is only a matter of time until the leachate that will eventually leak through the liner will migrate in groundwater to offsite groundwaters.

The Millennium report states,
"*Millennium has been advised by Waste Management of Canada that:*
The proposed landfill will be underlain by a composite lining system with a minimum 60 cm thickness of compacted clay; and

The proposed landfill footprint will entirely overlie continuous glacial till (i.e. landfill cell development will not occur over several areas that have been identified to be underlain by sand deposits that extend continuously off-site).

Based on the findings presented within the above referenced report and the 2 conditions that have been identified by Waste Management of Canada, it is Millennium EMS Solutions Ltd. Professional opinion that the Site is suitable for landfill development. However, as the geologic setting underlying the Site has been shown to vary, mitigative measures in the event that unforeseen geologic conditions are encountered during landfill cell construction should be developed by Waste Management of Canada and approved by appropriate regulatory agencies."

There is inconsistency in the application. In one instance the Rezoning Application states that the proposed landfill will be lined with a composite liner, yet in another section WM states that a only a clay liner will be used. There are significant differences between the ability of a clay layer and that of a clay layer with plastic sheeting layer in a composite liner, to prevent leachate

that penetrates through the liner to pollute groundwater. These issues are discussed in a subsequent section of these comments.

This report states in section **1.1 Project Objectives**
"*The objectives of this project were to meet the requirements for a hydrogeological investigation that are set out in the Standards for Landfills in Alberta (AENV 2004). These requirements state that evidence must be provided "to the Director that the groundwater quality will not exceed the performance standards at the points of compliance." This standalone hydrogeological assessment has been provided to Alberta Environment to facilitate future decisions related to an acceptable method of producing this evidence."*

This statement is misleading in that the groundwater compliance with the performance standard only applies to the funded postclosure period. As discussed in a subsequent section, the approach allowed by Alberta Environment for assessing the end of the postclosure period can be in error and can allow significant environmental pollution problems to occur after Alberta Environment has allowed WM to terminate postclosure monitoring, maintenance, and remediation responsibilities.

Section 2,2,1 Bedrock states,
"*The upper bedrock sequences are dominated by shale with thin bedded sandstone layers. Deeper sandstone layers, which are locally used as aquifers, are capable of yielding between 6.5 m3/day and 33 m3/day. Groundwater in these aquifers primarily drains into the North Saskatchewan River and its tributaries (Borneuf, 1973).*

That quoted statement acknowledges that the groundwaters in the landfill area discharge to surface waters; therefore polluted groundwaters can cause surface water pollution. This type of situation was encountered in British Columbia near Cache Creek. In a March 29, 2009 news account,
[http://www.cbc.ca/canada/british-columbia/story/2009/03/20/bc-chemicals-water-arsenic.html]
[http://www.ctvbc.ctv.ca/servlet/an/local/CTVNews/20090320/BC_cache_creek_dump_090320/20090320/?hub=BritishColumbiaHome
regarding surface water pollution by a city of Vancouver lined landfill near Cache Creek in British Columbia stated
"The dump located near Ashcroft is sealed with a liner and supposed to be secure from leaks for at least 200 years. But environmental consultants found traces of leachate almost everywhere they looked outside the site, as well as in groundwater."

Those sources discuss the failure of the liner system well-ahead of the expected failure date, and the resultant pollution of surface waters. This is the type of situation that can be expected if the WM-proposed Thorhild landfill is approved.

In Section 3.5.4, **Response Tests**, the Millennium report indicates that slug tests were used to estimate the hydraulic conductivity of the area under the proposed landfill. Page 14 Table 2 "Hydraulic Conductivity Test Results" presented the results of the slug tests of hydraulic conductivity. Examination of those results shows that the natural strata provide little natural protection that would prevent leachate that will eventually pass through the liner, from polluting

groundwaters of the region. It should be understood that slug tests can be highly unreliable for estimating the hydraulic conductivity of a heterogeneous aquifer like that underlying the proposed WM landfill. Each slug test only assesses the horizontal permeability of a very small area of the strata near where the slug test is conducted. The 200-m investigation grid used by Millennium could readily fail to find areas of very high permeability that would allow more rapid transport of leachate-polluted groundwater to offsite properties than projected based on the information available.

Page 9 states,
"*Silty sand deposits were periodically observed within the till matrix. These deposits typically contain some clay, were moist to wet, and regularly sloughed into the boreholes when they were saturated. The average sand:silt:clay ratio of seven samples of this material was 51:27:20, with the remaining 2% being gravel. Twenty-one of the 96 drill locations contained these deposits and indicate that they may extend off site."*

That statement provides another indication that the site for the proposed landfill is not one that would provide a high degree of natural protection for the groundwater resources of the area of the landfill. Silty sand deposits can serve as areas of rapid transport of leachate-polluted groundwater to offsite properties.

Page 10 4.2 Groundwater Flow states,
"*Groundwater level measurements were collected in October and December 2006 by MEMS. The measurements, presented in Table 1, indicate that the surficial groundwater table is typically 1.5 m to 3.5 m below surface, with variations controlled by topographical highs and lows."*

One of the issues that needs to be considered in evaluating the suitability of the site for the proposed landfill is the proposed depth of the landfilled wastes below the ground surface. This information is not presented in the Rezoning Application. Without this information it is not possible to evaluate the distance between the bottom of the wastes in the landfill and the maximum height of the water table. Regulatory agencies typically require at least 5 feet of separation between the maximum height of the water table and the bottom of the wastes. This is required to keep groundwater from entering the landfill and generating leachate. Information on this issue is in the WM "**Thorhild Landfill Project** Report to Residents" December 2006 Issue # 2. Page 6 contains the following question and WM response,

"Q. How deep will the landfill be? How high do you anticipate the highest point of the cap will be after the landfill is closed?
A. *Although the final design has not yet been completed, WM expects the landfill to be about five to 10 meters deep and 30 to 40 meters high. However, these measurements are dependent on geologic conditions, site constraints and a range of other environmental and operating factors. Once WM completes its final design for the application to Alberta Environment, we will have a better idea of the measurements.*
We will share this information when it is available."

A landfill that is projected to be 10 m deep below the ground surface will be below the "typical" water table for the area as reported above by Millennium. Millennium should have reported the maximum elevation of the water table rather than just the "typical" depth to groundwater. The location of the shallow groundwater near the land surface means that that site is not suitable for a landfill.

Page 17 in the section 5.0 CONCLUSIONS states,
"*The site specific investigation has confirmed the regional information which indicates the presence of glacial till overlying low permeable shale and siltstone sequences. The 200 m investigation grid was refined around several silty sand deposits that were observed within the till matrix. Landfill development at this site must be designed in a matter that:*
• performance standards are met at points of compliance for groundwater quality; and
• a minimum 50 m setback is established from the mapped boundary of the continuous silty sand deposits."

It is clear that the proposed WM Thorhild Landfill will not achieve Alberta Environment's performance standard at the point of compliance for groundwater monitoring over the very long period of time that this proposed landfill will be a threat to pollute groundwater with leachate.

The Waste Management Application for Rezoning contains a "***Final Report*** **Evaluation of the Potential for Landfill Gas Generation and Gas Composition of Greenfield Class 2 Landfill Site in the County of Thorhild**," that was developed by CH2MHILL dated March 14, 2008.

That report presents information on expected landfill gas generation in the proposed WM Thorhild Landfill. The section Landfill Gas Production states,
"*The LFG production was estimated using the United States Environmental Protection Agency (USEPA 2005) Landfill Gas Emissions Model (LandGEM, Version 3.02).*" Information on this model is available at http://www.epa.gov/ttn/catc/dir1/landgem-v302-guide.pdf.

The estimated rate of landfill gas production by the WM-proposed landfill as presented in Figure 2 of the CH2MHILL report will be in error for several reasons. A discussion of the issues pertinent to landfill gas production in municipal solid waste (MSW) landfills is presented in the Lee and Jones-Lee (2008) "Flawed Technology" review. As discussed therein, the rate of gas production is highly dependent on the moisture content of the wastes. At low moisture content, such as just after closure of the landfill with a low-permeability cover of the types proposed for use at the proposed landfill, gas production will stop. At some time in the future, as the cover loses its ability to prevent entrance of water into the landfilled wastes, landfill gas production will again start. The rate of gas production is directly dependent on how much water enters the landfilled wastes. There is no reliable way to estimate the pattern or amount of water that will enter the wastes through the cover over the very time of the postclosure period during and beyond the minimum postclosure period that WM proposes to provide postclosure funding for monitoring and maintenance of the landfill cover. This makes the estimation of landfill gas production rates unreliable.

Another factor that will influence landfill gas production is the fact that substantial amounts of household garbage in Alberta is deposited landfills in plastic bags. While those plastic bags may

be crushed as part of landfilling as part of waste compaction, they are not shredded. This will result in the hiding of solid wastes in the crushed bags until the plastic bags decompose. As discussed in the "Flawed Technology" review, many of the types of plastic bags used for household garbage disposal are resistant to decomposition. The rate of landfill gas production from the crushed, plastic-bagged garbage is not predictable, but can be delayed for very long periods of time, such as decades to hundreds of years.

The CH2MHILL report contains a small section entitled, "**Nonmethane Organic Compound Concentration (NMOC).**" No mention was made in it, however, of the composition of that fraction of the landfill gas. That information would be of interest to the County officials and the public. Information on this issue is available on the US EPA website discussing landfill gas production rates cited above. The NMOC contains a variety of carcinogens that are a threat to cause cancer in people and animals. As presented in the "Flawed Technology" review there are increasing reports of human health problems among those living near landfills. Gaseous emissions from the landfill appear to be a cause of those problems.

Overall, about all that can be said with certainty is that the MSW that will be deposited in the WM-proposed landfill will produce landfill gas at some unknown rate. A substantial amount of that gas production could take place after WM is longer operating and maintaining the landfill gas collection and monitoring system. This can result in the release of substantial amounts of conventional landfill gas components (methane and carbon dioxide) as well as highly hazardous landfill gas components, including carcinogenic compounds to the atmosphere in the vicinity of the landfill where they will pose a threat to public health, animal health, and the environment.

Aldantar Consulting prepared "**Thorhild Landfill Preliminary closure concepts**" that is included in the Waste Management Rezoning application.

Page 3 of that report presents "2**.0 Preliminary closure concepts 2.1 Conceptual landform,**" which states,
"*The final landfill slopes will not exceed approximately 3H:1V and the final height of the landfill above surrounding ground will be approximately 45m."*

A landfill rising 45 m above the ground surface will represent a "small mountain" for this area and provides a substantial area from which leachate breakouts (seeps) can occur above the natural ground surface. Such seeps represent a threat to cause surface water pollution in stormwater runoff from the above-ground-surface landfill area. These seeps can be detected if WM is properly inspecting and maintaining the landfill cover on the sides of the landfill, and conducting proper stormwater runoff water quality monitoring and maintenance for the landfill. However, the leachate seep-pollution of the surface waters of the area can occur over the very long period of time following the postclosure period that WM plans to provide postclosure funding for landfill care. No provisions are made in the Rezoning Application to address the long term of controlling surface water pollution by leachate seeps.

Page 4, states,
"*These operational cover layers will be intended to control surface water infiltration, deter vectors, control odours, control dust and control litter*."

That statement serves to mislead the County and the public to believe that these types of problems that are commonly associated with landfills will not occur at the proposed-WM Thorhild Landfill. If WM had confidence that it would effectively prevent these types of justifiable NIMBY problems over the very long period of time that such adverse impacts can occur, WM would not have to offer to purchase nearby properties and would not need to mention "nuisance" conditions discussed above. As discussed above, the County should mandate that WM will be force to close the landfill if offsite releases from the landfill occur. WM should not be allowed to use private property for dissipation of odorous and other releases from this landfill.

Page 6 in the section, ***2.6 Post-capping activities*** states,
"Post-capping inspections and maintenance will be undertaken immediately following capping operations, and will be continued until no longer needed or otherwise instructed by Alberta Environment. Final closure will comprise the placement of the last portions of the cap, and the removal of infrastructure that is not required during the post-closure period."

As discussed below there is considerable uncertainty about how long WM will be required to provide postclosure monitoring, maintenance, and remediation of groundwater and surface waters. The current Alberta Environment "Code of Practice for Landfills" (as downloadable from the Internet at http://www.qp.alberta.ca/570.cfm) states on page 3,

"(n) "post-closure period" means the period of 25 years from final closure of a landfill, or so long as leachate that does not meet the performance criteria set out in Table 1 is generated at a landfill;"

The 2007 updated **Standards for Landfills in Alberta** states in section ***6.3 Post-closure Care Period***,
"(a) The Post-Closure Care Period shall be a minimum period of 25 years following the final closure of the landfill.

(b) In addition to 6.3 (a), the Post-Closure Care Period shall continue until the following circumstances occur:

> *(i) groundwater quality performance standards are met within the compliance boundary;*
> *(ii) subsurface landfill gas concentrations are below explosive limits set out in Table 5.4 at subsurface gas monitoring locations; and*
> *(iii) the leachate constituents are lower than the parameter concentrations required by Table 5.3, unless otherwise authorized in writing by the Director to use baseline groundwater quality; or*
> *(iv) the accumulated volume of leachate is equal to or less than the previous years accumulated volume of leachate for five consecutive years;"*

Twenty five years is a very small part of the time that the wastes in the proposed landfill will be a threat to produce leachate that can cause groundwater and surface water pollution. The period of threat from these problems can readily extend for many decades, to hundreds or a thousand years or more.

Basing the postclosure period on the presence and/or composition of leachate as stated by Alberta Environment Standards in the passage quoted above is not reliable for establishing the length of the postclosure period. It is, however, the approach that Waste Management corporate has been trying to get the US agencies responsible for regulating landfills to accept. As discussed in the Lee and Jones-Lee (2008) "Flawed Technology" review, the generation of leachate is controlled by the integrity of the landfill cover to prevent water from entering the landfilled wastes. It is possible that a landfill cover could be constructed and maintained to prevent entrance of water through the landfill cover into the buried wastes for a period of time following proper construction. With no evidence of leachate generation, achieving that "prevention" for that period of time can mislead regulatory agencies into believing that the postclosure period can be terminated. However, as discussed in the "Flawed Technology" review, the temporary cessation of leachate generation during the period that the integrity of landfill cover is sufficiently maintained does not mean that the landfill will not generate leachate when the integrity of cover is no longer adequately maintained.

The California Integrated Waste Management Board has rejected the approach advocated by WM as being unreliable because it does not properly consider the need for funds to reliably inspect and repair the low-permeability layer in the cover over the entire time that the wastes in the landfill, when contacted by water, will generate leachate. While Alberta Environment may allow WM to terminate its postclosure period of funding while the wastes in the landfill can still generate leachate when contacted by water, Thorhild County should require that WM provide postclosure funding for the entire period that the wastes in the landfill are a threat to generate leachate, as part of permitting the proposed landfill. Failure to do so will mean that the proposed WM Thorhild landfill will eventually pollute groundwaters and surface waters of the area.

Page 5, in section ***2.4 Final capping of waste (progressive closure)*** states,
"The final capping structure will generally comprise the following components:

- ***a barrier layer****, comprising compacted site soil or a geomembrane, to control the infiltration of moisture into the waste; and*
- ***a surface layer****, comprising organic material capable of supporting vegetation in a sustainable configuration."*

A compacted soil layer is not a reliable low-permeability layer that can be relied upon to prevent water from entering landfilled wastes for as long as the wastes in the landfill will be a threat. As discussed in the "Flawed Technology" review, studies have shown that soil landfill covers develop deep cracks that can allow large amounts of water to enter the landfilled wastes. This approach is not allowed by the US EPA for MSW landfills.

If properly installed, a geomembrane as the low-permeability layer in a landfill cover can effectively prevent entrance of moisture into the landfilled wastes when cover is new. However, plastic sheeting geomembrane will deteriorate over time and fail to prevent the entrance of moisture into landfilled wastes. Since geomembrane plastic sheeting is buried beneath the surface soil layer, it is not possible to visually detect and identify areas of deterioration of the plastic sheeting layer in the cover. As discussed in the "Flawed Technology" review it is possible to develop a leak-detectable cover that can indicate when the plastic sheeting has deteriorated to the point at which it is no longer effective in preventing water from entering the

landfilled wastes. However, owners of landfills have not supported the use of leak-detectable covers because it would mean that funds would have to be made available to operate and maintain the leak-detectable cover forever.

It is unclear what is meant by "*a surface layer, comprising organic material*" in the passage quoted above. Normally a top-soil surface layer is incorporated as the top layer of the landfill cover to support vegetation in order to reduce erosion of the landfill cover.

Page 7, states in section ***2.8 End use,***
"WMCC is currently considering a number of end use options for the site, including wildlife habitat and/or passive recreation. It is expected that these and other options will be discussed between WMCC and the County during both the initial permitting process and during the life of the site."

In considering and establishing the end use of the landfill area, the County should require that any allowed use of the area not disrupt the integrity of the cover, i.e., its ability to prevent water from entering the wastes in the landfill for as long as the landfilled wastes could generate leachate when exposed to moisture. As discussed in the "Flawed Technology" review, Waste Management is attempting to portray an unrealistic picture of the appearance and utility of closed landfill areas, as evidenced by the picture on the cover page of the Rezoning Application. While its advertising and pictures portray scenic wildlife areas with water ponds, etc., such ponds and water features must not be constructed on a landfill surface since they would increase the potential for water to enter the landfilled wastes and thereby contribute to groundwater and surface water pollution.

The Rezoning Application contains a section "**Presentations_Newsletters"** that contains a "**Project overview by Cam Hantiuk to County of Thorhild regarding re-zoning of lands for waste management facility 28th August 2007."** As discussed in these comments review of the presentations in that section shows that the public has been provided unreliable information on the ability and likelihood of the landfill as proposed to protect public health, groundwater and surface water resources, and the environment from adverse impacts of the proposed landfill for the entire period during which the wastes in the landfill will be a threat.

Page 7 states, *"**These lands are "suitable for the proposed re-zoning because:***
• limited impact on the use and enjoyment of adjacent lands:"

That statement is an admission that the proposed landfill will, in fact, be adverse to adjacent lands, but has deemed that impact to be "limited." The inevitability of impact on adjacent lands is related to the fact that the proposed landfill does not have adequate buffer lands between the location where wastes will be deposited and adjacent properties. This will lead to trespass of waste-derived constituents onto adjacent properties.

Page 8 upper slide on the **Environmental Performance** states,
"• site is confirmed as suitable for landfill development in accordance with regulatory requirements"

The landfilling regulations in Alberta require that the landfill not be adverse to public health and the environment. The proposed landfill falls far-short of meeting this level of performance.

The lower slide on page 8 **Environmental Performance (con't)** states,
"• site is underlain primarily by low permeability clay"

As discussed above, the so-called "low permeability clay" is sufficiently permeable to allow the transport of leachate-polluted groundwater that will develop when the liner system fails to contain the leachate, allowing it to pass into the area's groundwater and surface waters.

Page 9 on slide **Use and enjoyment of adjacent lands** states,
"• municipal setbacks will be easily met or exceeded due to the size of the property"

The so-called "municipal setbacks" provided are not sufficient to prevent releases from the proposed landfill from trespassing onto adjacent properties.

That slide on page 9 also states,
"• proposed run-off waters will be returned to natural system after testing and meeting established criteria"
"*• proposed contact water (leachate) will be collected and treated"*

Again, the claims being made are significantly misleading in that WM only proposes to test run-off waters while it is providing postclosure funds, not for the entire period of time that this landfill will be able to release chemicals that will pollute surface waters, such as from seeps from the sides of the landfill and by the surfacing of polluted groundwaters in the springs (groundwater discharge points) of the area. The collection and treatment of leachate by WM is proposed to be undertaken only while WM is providing postclosure funding, which, as discussed above, is a very small portion of the time that this proposed landfill would be able to generate leachate.

The Rezoning Application contains a section **Presentation to County of Thorhild Regarding Re-zoning of Lands for Waste Management Facility February 12th, 2008** which on page 2 states,
"Surface Water and Groundwater
• Surface water and groundwater will be managed and monitored at the site in accordance with the Alberta Environment Standards.
• Ongoing monitoring confirms effectiveness of surface water system.
• Groundwater monitoring confirms effectiveness of leachate management system (lining and leachate removal)."

Review of the Alberta Environment updated Standards for Landfills in Alberta shows, as discussed below, that the Alberta Environment Standards for surface and groundwater management and monitoring are not adequate to ensure protection of public health, and groundwater and surface water resources for as long as the wastes in the proposed landfill will be a threat to release hazardous and otherwise deleterious chemicals to the environment.

The above quoted statement about the monitoring approach's meeting Alberta Environment standards is grossly inadequate to confirm *the effectiveness of the surface water system and leachate management system.* Further, it avoids the entire issue of the release of waste-derived pollutants after the end of the postclosure period that WM proposes to fund postclosure care; as discussed elsewhere, the anticipated funded postclosure period is but a small part of the time that the surface water system and leachate management system will need to function with a high degree of reliability relative to the period during which the wastes in the proposed landfill will be a threat to pollute the environment. This slide presents grossly misleading claims regarding the reliability of the protection of surface and groundwaters in the vicinity of the proposed landfill.

A review of the Waste Management website for this proposed landfill, www.thorhildproject.ca, shows that WM has been actively promoting information that is misleading at best, regarding the protective nature of the proposed landfill. For example, the WM "**Thorhild Landfill Project** Report to Residents" December 2006 Issue # 2 and other issues contain unreliable and inadequate information on the protective nature of this landfill upon which County officials and the public can reliably evaluate the suitability of rezoning the area to allow the construction of this landfill.

The Rezoning Application contains a **PUBLIC INVOLVEMENT REPORT,** that contains a section entitled, "**Public questions and comments**." A review of the WM responses to questions raised by the public shows that WM has provided inadequate and in some cases unreliable responses to legitimate concerns that members of the public have about the ability of the proposed landfill to protect public health, groundwater and surface water quality, the environment, and the interests of the County and those within the sphere of influence of the proposed landfill.

The Rezoning Application contains a section **Subsurface Landfill Gas Monitoring Program – Greenfield Site in the County of Thorhild** that was prepared by CH2MHILL. That report repeats unreliable information that CH2MHILL presented in another section of the Rezoning Application that has been discussed above.

That report states on page 2, **Gas Monitoring System**
"*Subsurface gas monitoring probes will be installed around the perimeter of the landfill and adjacent to onsite buildings. The horizontal spacing of probes is recommended not to exceed 300 m. The horizontal spacing will be reduced in half if offsite structures are located within 300 m of the site boundary."*

The heterogeneous nature of the subsurface strata in the vicinity of the landfill through which landfill gas can migrate can lead to off-site gas migration that will not be detected by the proposed subsurface gas monitoring probes. An issue not discussed in this Rezoning Application is the fact that landfill gas migration has been found to be a significant cause of groundwater pollution that can occur upgradient of the direction of groundwater flow. This issue is discussed in the "Flawed Technology" review. Further, as discussed above, this proposed landfill will have the potential to generate landfill gas long after WM would no longer be providing postclosure funds for maintenance and sampling of the gas monitoring probes.

The Rezoning Application contains a section **Surface Water Management**, which consists of the report by UMA Engineering, Ltd. primarily devoted to the design of the surface water conveyance system for run-on and runoff from the proposed Thorhild Landfill. That drainage system would require maintenance for as long as the wastes in the proposed landfill will be a threat to release pollutants to the environment. The key issue that is not addressed in that UMA report is who will provide the funds for and conduct the necessary maintenance of the surface water drainage system after WM's postclosure period. Without such maintenance the drainage system will deteriorate and the "protective" nature of this system that may have been achieved when new, will be lost.

Page 24 of that report states in section **5.5 Water Quality**,
"*In addition to controlling runoff from developed areas, SWM Facilities provide water quality enhancement Alberta Environment requires that a minimum of 85% of sediments with a particle size of 75 μm or greater be removed from stormwater runoff before discharge occurs (Alberta Environment, 2001). Planned discharges from the stormwater ponds will be subject to testing to ensure the water quality is not detrimental to the surrounding environment."*

What testing will be done to ***ensure*** that the water quality of the water discharged from the stormwater ponds is not detrimental to the surrounding environment? Who will fund this monitoring and maintenance of the ponds, such as removal and handling of accumulated sediment, when WM is no longer providing postclosure monitoring and maintenance funds? The County should have clear commitments of the postclosure funding for as long as the wastes in the proposed landfill will be a threat before potentially rezoning of the area for this landfill.

The WM Rezoning Application contains a section, **Waste Management of Canada Corporation Thorhild Class II Landfill Draft* Operations Plan Updated February 2009.**
Section **2.1 Site Capacity and Service Life** states,
"*With an estimated average tonnage of 500,000 tonnes the service life would be calculated to be 40 to 65 years assuming the compaction of waste is maintained at 800kg/m3."*

The WM-proposed Thorhild Landfill will be a very large landfill that is expected to receive wastes over a very long period of time.

Section **3.4 Liner Thickness**
"*The clay liner constructed will have a minimum thickness of 0.6 meters. The liner could be constructed thicker under the leachate collection system and/or as a sacrificial layer based on the engineering design. The design report will specify the liner design and thickness."*

Review of information provided by Workman and Keeble (1989) in their paper, "Design and Construction of Landfill Systems," shows the breakthrough time for water (leachate) through a 3-ft-thick clay layer having a permeability of 10^{-7} and under 1 ft of head will be between 5 and 7 years.

Workman, J., and Keeble, R., "Design and Construction of Landfill Systems," IN: **Sanitary Landfilling: Process, Technology and Environmental Impact**, Academic Press, San Diego, CA, pp. 301-309 (1989).

Clay liners are not effective in preventing leachate from polluting the groundwaters of the area of the landfill.

Page 10 in section ***9 Landfill Monitoring Plan*** *states,*
"Section 5.1 of The Standards for Landfills in Alberta outlines the requirements of a Landfill Monitoring Plan. The proposed Thorhild Landfill will require the following monitoring programs.
1) Groundwater
2) Surface water
3) Subsurface landfill gas
4) Active landfill gas
5) Leachate"

The copy of the Standards for Landfills in Alberta (dated 8-10-2007) is available on the Internet at http://environment.gov.ab.ca/info/posting.asp?assetid=7316&categoryid=20. Those updated Standards for Landfills in Alberta are more protective than those set forth in the Code of Practice for Landfills in Alberta with regard to monitoring requirements. However, while they prescribe a much more comprehensive set of monitoring parameters for groundwater monitoring, there are several aspects that need improvement. The monitoring parameters should include low-molecular-weight chlorinated solvents. Such chemicals are commonly found in MSW leachate in the USA; they are highly persistent chemicals in landfills and the environment and are carcinogens (can cause cancer).

Another deficiency is that the new Standards only require that two samples from the groundwater monitoring wells be collected each year. Groundwater monitoring wells should be sampled at quarterly intervals throughout the active life of the landfill and during the first five years of the postclosure period. It may be decreased after that time to twice a year as long as there is no evidence of groundwater pollution.

By far the greatest deficiency is that the new standards allow groundwater monitoring wells to be spaced as much as 200 m apart at the point of compliance for groundwater monitoring. As discussed in the "Flawed Technology" review, the spacing of vertical monitoring wells more than a few feet apart at the point of compliance can result in failure to detect the initial failure of the landfill liner system as evidenced by leachate contamination's first reaching the point of compliance for groundwater monitoring. Failure to detect incipient pollution will lead to violation of the Performance Standards for releases from the landfill.

The new standards do not provide sufficient information on *Subsurface landfill gas, Active landfill gas* to evaluate the adequacy of the required monitoring of those systems. Further, WM does not provide such information in its Rezoning Application, with the result that the County and the public cannot evaluate whether the proposed WM Thorhild Landfill will be adequately monitored for releases of hazardous and otherwise deleterious chemicals that are a threat to public health, groundwater and surface water resources, and the environment.

Page 12 includes **9.2 Groundwater Monitoring Program** that states,

"***Groundwater Sampling Program***
The groundwater-monitoring plan for the landfill will include the collection and analysis of on site groundwater wells (twice per annum)."

While this frequency of groundwater monitoring is allowed under the updated Alberta Landfill Standards, as discussed above, it is not adequate during the active life of a landfill and during the initial part of the postclosure period to reliably detect initial groundwater pollution by landfill leachate.

Page 12 also includes **Groundwater Sampling Program** that states,
"*The groundwater shall be tested for the parameters listing in Table 4."*

Table 4 should be expanded to include low-molecular-weight chlorinated solvents. Justification for the inclusion of those parameters was discussed above.

Page 13 includes **9.3 Surface Water Monitoring Plan.** That plan includes Table 5 that lists the proposed surface water monitoring parameters. Total suspended solids and turbidity should be added to that list to check for erosion of the landfill surface that is not adequately controlled by the stormwater detention basins.

Page 14 includes **9.4 Leachate Management Plan.** That plan states in **Monitoring and Testing**
"*The site will also be inspected visually once a month for signs of landfill leachate breakouts."*

The inspection of landfill surface for leachate breakouts (seeps) will need to be conducted for as long as the wastes in the landfill can generate leachate when contacted by water. Who will provide the funds for that level of inspection/protection? The County should require that WM provide sufficient funds for that inspection/protection, unless the County intends to provide the many millions of dollars for this activity.

The inspection of the leachate collection system for leachate should be conducted monthly for as long as the wastes in the landfill can generate leachate when contacted by water. The ongoing inspection of the leachate collection system is needed even though the leachate collection system has not yielded leachate for a period of time, i.e., while the landfill cover is preventing water from entering the landfill, in order to detect when the landfill cover fails to prevent water from entering the landfilled wastes. The presence of leachate in the leachate collection system is a clear indication that there is need to repair the landfill cover.

Page 14 provides Table 6 that lists the parameters that WM proposes to measure in leachate. TOC, low-molecular-weight chlorinated solvents, and sodium should also be measured.

Page 16, includes **11.2 Financial Assurance** that states,
"Waste Management requires every landfill to calculate its site's projected closure and postclosure costs. This amount is then calculated on a per tonne basis and then this amount is deducted from the revenue generated from each tonne received. This revenue is then placed in a special account and held to ensure that funds are available to cover the costs associated with the closure and post-closure. The calculation is reviewed annually."

This proposed approach is inadequate in that it only computes funding needed for postclosure activities during the period that WM anticipates providing postclosure care. As discussed above, that period will only be a small portion of the time that postclosure funding will be needed for monitoring, maintenance, and remediation of the landfill. The County should require as part of rezoning, that WM establish a special account for funding during the postclosure for as long as the wastes in the landfill will be a threat. This fund should be managed by an independent agency.

The approach outlined on Page 20 in **Odour Minimization & Investigation** is not satisfactory. MSW landfills are notorious for causing highly obnoxious offsite odours that at times can be detected several miles from a landfill. WM should be required to control offsite odours. If WM fails to prevent offsite migration of odours at the adjacent property lines, the landfill should be closed. This approach is justified based on the fact that offsite landfill odours are one of the most significant causes of justified NIMBY. In addition to their being a nuisance, it is now recognized that landfill odours can cause individuals to become ill from them. Further, as discussed in the "Flawed Technology" review, landfill odours are an indication of the presence of hazardous chemicals that are a threat to human health that are released from MSW landfills. See the "Flawed Technology" review for references to studies of adverse human health impacts from landfills.

Page 20 presents **Dust Control & Minimization.** As was the case with the addressing of offsite odours, prevention of offsite dust should be a condition for closing the landfill. The proposed use of dust suppressants must be done with adequate review to ensure that those chemicals do not cause water pollution in stormwater runoff from the site.

Page 25 in **15.2 Final Closure** states,
"*When the landfill has reached end of life for acceptance of waste, it will be closed. Closure will consist of placing a cap over the waste containment unit with additional layers of subsoil and topsoil placed on top of the barrier layer. The area will then be seeded with designated grasses and vegetative material native to the area as per the end use plan.*
The final cover system may consist of a one-meter thick layer of fill material comprised of separate layers.
(a) a clay barrier layer at least 60 centimeters thick of compacted clay perpendicular to the compacted waste surface, which achieves hydraulic conductivity of < 1 x 10-7 m/s, or alternative material with equivalent conductivity;
(b) a minimum subsoil layer 35 centimeters over the barrier layer;
(c) a minimum of 20 centimeters of topsoil"

WM proposes to use a somewhat permeable compacted-soil cover for the proposed landfill even though it is well-known that such covers are not effective in preventing water from entering a landfill and generating leachate. The Lee and Jones-Lee "Flawed Technology" review discusses work of others that has shown that compacted-soil landfill covers develop cracks that can be pathways for water to enter the landfill.

The second paragraph of page 26 mentions the possibility of using a geomembrane layer of plastic as an alternative to the compacted soil layer as the low-permeability layer in the cover. It is well-known that the plastic sheeting will deteriorate over time and will fail to prevent water

from entering the landfill. WM has not included any postclosure funding to replace the plastic sheeting layer in the cover. Another problem with plastic sheeting low-permeability layers in landfill covers is that their integrity cannot be monitored by visual inspection of the landfill surface with the result that its failure to prevent entrance of water into the landfill will have to be detected by monitoring leachate generation.

Page 26 in **15.3 Post-Closure** discusses the postclosure activities that WM plans to undertake during the time that it provides postclosure funding. No mention is made regarding who would fund postclosure activities after WM no longer funds them. The County should make it clear that WM will be required to provide this funding, or that the County will assume responsibility for the many millions of dollars of funds needed to provide postclosure care for the landfill.

The Rezoning Application contains **WATER WELL AND SURFACE WATER SURVEY – THORHILD** developed by Millennium EMS Solutions for water wells at the proposed landfill site. The information presented in that report shows that a large number of water wells exist that can be potentially impacted when the landfill containment system no longer prevents groundwater pollution by landfill leachate.

There are several surface water features in the area of the landfill such as ponds and streams that can be polluted by surface runoff from the landfill area and by the discharge of springs that discharge leachate polluted groundwater.

Also, Millennium has reported on the presence of wetlands in the area of the landfill that can be polluted by polluted surface and groundwaters.

The **County of Thorhild No. 7** Regional Groundwater Assessment Developed for Canadian Agriculture and Agri-Food Canada Prepared for Thorhild County July 1998 - **1 PROJECT OVERVIEW "Water is the lifeblood of the earth." - Anonymous**

"*How a county takes care of one of its most precious resources - groundwater - reflects the future wealth and health of its people. Good environmental practices are not an accident. They must include genuine foresight with knowledgeable planning. Implementation of strong practices not only commits to a better quality of life for future generations, but creates a solid base for increased economic activity.* ***This report, even though it is preliminary in nature, is the first step in fulfilling a commitment by the County toward the management of the groundwater resource, which is a key component of the well-being of the County, and is a guide for future groundwater-related projects"***

That statement reflects the importance of protecting the quality of the County's groundwater from pollution for the current and future generations. The rezoning of the area of the proposed WM Thorhild Landfill will be strongly contrary to protecting the groundwater resources of the County.

Appendix

Additional Information on the Qualification of G. Fred Lee

Dr. G. Fred Lee, PE(TX), BCEE
AAEE Board Certified Environmental Engineer

Expertise and Experience in Hazardous Chemical Site and Municipal/Industrial Landfill Impact Assessment/Management

Dr. G. Fred Lee's work on hazardous chemical site and municipal/industrial landfill impact assessment began in the mid-1950s while he was an undergraduate student in environmental health sciences at San Jose State College in San Jose, California. His course and field work involved review of municipal and industrial solid waste landfill impacts on public health and the environment.

He obtained a Master of Science in Public Health degree from the University of North Carolina, Chapel Hill, in 1957. The focus of his masters degree work was on water quality evaluation and management with respect to public health and environmental protection from chemical constituents and pathogenic organisms.

Dr. Lee obtained a PhD degree specializing in environmental engineering from Harvard University in 1960. As part of this degree work he obtained further formal education in the fate, effects and significance and the development of control programs for chemical constituents in surface and ground water systems. An area of specialization during his PhD work was aquatic chemistry, which focused on the transport, fate and transformations of chemical constituents in aquatic (surface and ground water) and terrestrial systems as well as in waste management facilities.

For a 30-year period, he held university graduate-level teaching and research positions in departments of civil and environmental engineering at several major United States universities, including the University of Wisconsin-Madison, University of Texas at Dallas, and Colorado State University. During this period he taught graduate-level environmental engineering courses in water and wastewater analysis, water and wastewater treatment plant design, surface and ground water quality evaluation and management, and solid and hazardous waste management. He has published over 1,100 professional papers and reports on his research results and professional experience. His research included, beginning in the 1970s, the first work done on the impacts of organics on clay liners for landfills and waste piles/lagoons.

His work on the impacts of hazardous chemical site and municipal/industrial solid waste landfills began in the 1960s when, while directing the Water Chemistry Program in the Department of Civil and Environmental Engineering at the University of Wisconsin-Madison, he became involved in the review of the impacts of municipal solid waste landfills on groundwater quality.

In the 1970s, while he was Director of the Center for Environmental Studies at the University of Texas at Dallas, he was involved in the review of a number of municipal solid and industrial (hazardous) waste landfill situations, focusing on the impacts of releases from the landfill on public health and the environment.

In the early 1980s while holding a professorship in Civil and Environmental Engineering at Colorado State University, he served as an advisor to the town of Brush, Colorado, on the potential impacts of a proposed hazardous waste landfill on the groundwater resources of interest to the community. Based on this work, he published a paper in the Journal of the American Water Works Association discussing the ultimate failure of the liner systems proposed for that landfill in preventing groundwater pollution by landfill leachate. In 1984 this paper was judged by the Water Resources Division of the American Water Works Association as the best paper published in the journal for that year.

In the 1980s, he conducted a comprehensive review of the properties of HDPE liners of the type being used today for lining municipal solid waste and hazardous waste landfills with respect to their compatibility with landfill leachate and their expected performance in containing waste-derived constituents for as long as the waste will be a threat.

In the 1980s while he held the positions of Director of the Site Assessment and Remediation Division of a multi-university consortium hazardous waste research center and Distinguished Professor of Civil and Environmental Engineering at the New Jersey Institute of Technology, he was involved in numerous situations concerning the impact of landfilling of municipal solid waste on public health and the environment. He has served as an advisor to the states of California, Michigan, New Jersey and Texas on solid waste regulations and management. He was involved in evaluating the potential threat of uranium waste solids from radium watch dial painting on groundwater quality when disposed of by burial in a gravel pit. The public in the area of this state of New Jersey proposed disposal site objected to the State's proposed approach. Dr. Lee provided testimony in litigation, which caused the judge reviewing this matter to prohibit the State from proceeding with the disposal of uranium/radium waste at the proposed location.

Dr. Lee's expertise includes surface and ground water quality evaluation and management. This expertise is based on academic course work, research conducted by Dr. Lee and others and consulting activities. He has served as an advisor to numerous governmental agencies in the US and other countries on water quality issues. Further, he has served on several editorial boards for professional journals, including *Ground Water*, *Environmental Science and Technology*, *Environmental Toxicology and Chemistry*, etc. Throughout his over-49-year professional career, he has been a member of several professional organization committees, including chairing the American Water Works Association national Quality Control in Reservoirs Committee and the US Public Health Service PCBs in Drinking Water Committee.

Beginning in the 1960s, while a full-time university professor, Dr. Lee was a part-time private consultant to governmental agencies, industry and environmental groups on water quality and solid and hazardous waste and mining management issues. His work included evaluating the

impacts of a number of municipal and industrial solid waste landfills. Much of this work was done on behalf of water utilities, governmental agencies and public interest groups who were concerned about the impacts of a proposed landfill on their groundwater resources, public health and the environment.

In 1989, he retired after 30 years of graduate-level university teaching and research and expanded the part-time consulting that he had been doing with governmental agencies, industry and community and environmental groups into a full-time activity. A principal area of his work since then has been assisting water utilities, municipalities, industry, community and environmental groups, agricultural interests and others in evaluating the potential public health and environmental impacts of proposed or existing hazardous, as well as municipal solid waste landfills. He has been involved in the review of approximately 85 different landfills and waste piles (tailings) in various parts of the United States and in other countries, including 12 hazardous waste landfills, eight Superfund site landfills and five construction and demolition waste landfills. He has also served as an advisor to a hazardous waste landfill developer and to IBM corporate headquarters and other companies on managing hazardous wastes.

Dr. Anne Jones-Lee (his wife) and he have published extensively on the issues that should be considered in developing new or expanded municipal solid waste and hazardous waste landfills in order to protect the health, groundwater resources, environment and interests of those within the sphere of influence of the landfill. Their over 150 professional papers and reports on landfilling issues provide guidance not only on the problems of today's minimum US EPA Subtitle D landfills, but also on how landfilling of non-recyclable wastes can and should take place to protect public health, groundwater resources, the environment, and the interests of those within the sphere of influence of a landfill/waste management unit. They make many of their publications available as downloadable files from their web site, www.gfredlee.com.

Their work on landfill issues has particular relevance to Superfund site remediation, since regulatory agencies often propose to perform site remediation by developing an onsite landfill or capping waste materials that are present at the Superfund site. The proposed approach frequently falls short of providing true long-term health and environmental protection from the landfilled/ capped waste.

In the early 1990s, Dr. Lee was appointed to a California Environmental Protection Agency's Comparative Risk Project Human Health Subcommittee that reviewed the public health hazards of chemicals in California's air and water. In connection with this activity, Dr. Jones-Lee and he developed a report, "Impact of Municipal and Industrial Non-Hazardous Waste Landfills on Public Health and the Environment: An Overview," that served as a basis for the human health advisory committee to assess public health impacts of municipal landfills.

In 2004 Dr Lee was selected as one of two independent peer reviewers by the Pottstown (PA) Landfill Closure Committee to review the adequacy of the proposed closure of the Pottstown Landfill to protect public health, groundwater resources and the environment for as long as the wastes in the closed landfill will be a threat.

In addition to teaching and serving as a consultant in environmental engineering for over 40 years, Dr. Lee is a registered professional engineer in the state of Texas and a American Academy of Environmental Engineers (AAEE) board certified Environmental Engineer. The latter recognizes his leadership roles in the environmental engineering field. He has served as the chief examiner for the AAEE in north-central California and New Jersey, where he has been responsible for administering examinations for professional engineers with extensive experience and expertise in various aspects of environmental engineering, including solid and hazardous waste management.

His work on landfill impacts has included developing and presenting several two-day short-courses devoted to landfills and groundwater quality protection issues. These courses have been presented through the American Society of Civil Engineers, the American Water Resources Association, and the National Ground Water Association in several United States cities, including New York, Atlanta, Seattle and Chicago, and the University of California Extension Programs at several of the UC campuses, as well as through other groups. He has also participated in a mine waste management short-course organized by the University of Wisconsin-Madison and the University of Nevada. He has been an American Chemical Society tour speaker, where he is invited to lecture on landfills and groundwater quality protection issues, as well as domestic water supply water quality issues throughout the United States.

Throughout Dr. Lee's 30-year university graduate-level teaching and research career and his subsequent 20-year private consulting career, he has been active in developing professional papers and reports that are designed to help regulatory agencies and the public gain technical information on environmental quality management issues. Drs. Lee and Jones-Lee have provided a number of reviews on issues pertinent to the appropriate landfilling of solid wastes. Their most comprehensive review of municipal solid waste landfilling issues is what they call the "Flawed Technology of Subtitle D Landfilling of Municipal Solid Waste," which was originally developed in 1992, and redeveloped and updated in the fall of 2004. Between the two versions they have published numerous invited and contributed papers that provide information on various aspects of municipal solid waste landfilling, with emphasis on protecting public health and the environment from waste components for as long as they will be a threat. The "Flawed Technology" review has been periodically updated, including the most recent update in December 2008, which can be found on their website at
http://www.gfredlee.com/Landfills/SubtitleDFlawedTechnPap.pdf

This review provides a comprehensive, integrated discussion of the problems that can occur with minimum-design Subtitle D landfills and landfills developed in accord with state regulations that conform to minimum Subtitle D requirements. The "Flawed Technology" review contains a listing of the various reviews that Drs. Lee and Jones-Lee have developed, as well as peer-reviewed literature. Over 40 peer-reviewed papers are cited in "Flawed Technology" supporting issues discussed in this review.

Drs. Lee and Jones-Lee have developed guidance on the evaluation of the potential impacts of landfills. This guidance is available as,

Lee, G. F., and Jones-Lee, A., “Guidance on the Evaluation of the Potential Impacts of a Proposed Landfill,” Report of G. Fred Lee & Associates, El Macero, CA January (2007). http://www.gfredlee.com/Landfills/EvaluationImpactLF.pdf

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EDUCATION

Ph.D. Environmental Engineering & Environmental Science, Harvard University, Cambridge, Mass. 1960

M.S.P.H. Environmental Science-Environmental Chemistry, School of Public Health, University of North Carolina, Chapel Hill, NC 1957

B.A. Environmental Health Science, San Jose State College, San Jose, CA 1955

ACADEMIC AND PROFESSIONAL EXPERIENCE

Current Position:

Consultant, President, G. Fred Lee and Associates

Previous Positions:

Distinguished Professor, Civil and Environmental Engineering, New Jersey Institute of Technology, Newark, NJ, 1984-89

Senior Consulting Engineer, EBASCO-Envirosphere, Lyndhurst, NJ (part-time), 1988-89

Coordinator, Estuarine and Marine Water Quality Management Program, NJ Marine Sciences Consortium Sea Grant Program, 1986

Director, Site Assessment and Remedial Action Division, Industry, Cooperative Center for Research in Hazardous and Toxic Substances, New Jersey Institute of Technology et al., Newark, NJ, 1984-1987

Professor, Department of Civil and Environmental Engineering, Texas Tech University, 1982-1984

Professor, Environmental Engineering, Colorado State University, 1978-1982

Professor, Environmental Engineering & Sciences; Director, Center of Environmental Studies, University of Texas at Dallas, 1973-1978

Professor of Water Chemistry, Department of Civil & Environmental Engineering, University of Wisconsin-Madison, 1961-1973

Registered Professional Engineer, State of Texas, Registration No. 39906

American Academy of Environmental Engineers Board Certified Environmental Engineer, Certificate No. 0701 Chief Examiner Northern California for AAEE Board Certification including in the solid and hazardous waste management

PUBLICATIONS AND AREAS OF ACTIVITY

Published over 1,100 professional papers, chapters in books, professional reports, and similar materials. The topics covered include:

- Studies on sources, significance, fate and the development of control programs for chemicals in aquatic and terrestrial systems.
- Analytical methods for chemical contaminants in fresh and marine waters.
- Landfills and groundwater quality protection issues.
- Impact of landfills on public health and environment.
- Environmental impact and management of various types of wastewater discharges including municipal, mining, electric generating stations, domestic and industrial wastes, paper and steel mill, refinery wastewaters, etc.
  Stormwater runoff water quality evaluation and BMP development for urban areas and highways.
- Eutrophication causes and control, groundwater quality impact of land disposal of municipal and industrial wastes, environmental impact of dredging and dredged material disposal, water quality modeling, hazard assessment for new and existing chemicals, water quality and sediment criteria and standards, water supply water quality, assessment of actual environmental impact of chemical contaminants on water quality.

LECTURES

Presented over 760 lectures at professional society meetings, universities, and to professional and public groups.

GRANTS AND AWARDS

Principal investigator for over six million dollars of contract and grant research in the water quality and solid and hazardous waste management field.

GRADUATE WORK CONDUCTED UNDER SUPERVISION OF G. FRED LEE

Over 90 M.S. theses and Ph.D. dissertations have been completed under the supervision of Dr. Lee.

ADVISORY ACTIVITIES

Consultant to numerous international, national and regional governmental agencies, community and environmental groups and industries.

Municipal Solid Waste Landfills and
Groundwater Quality Protection Issues Publications

Drs. G. Fred Lee and Anne Jones-Lee have prepared several papers and reports on various aspects of municipal solid waste (MSW) management and hazardous waste management by landfilling, groundwater quality protection issues, as well as other issues of concern to those within a sphere of influence of a landfill. These materials provide an overview of the key problems associated with landfilling of MSW and hazardous waste utilizing lined "dry tomb" landfills and suggest alternative approaches for MSW management that will not lead to groundwater pollution by landfill leachate and protect the health and interests of those within the sphere of influence of a landfill. Copies of many of these papers and reports are available as downloadable files from Drs. G. Fred Lee's and Anne Jones-Lee's web page (http://www.gfredlee.com). Recent papers and reports on landfilling issues are listed below. Copies of the papers and reports listed below as well as a complete list of publications on this and related topics are available upon request.

Publications are available in the following topics at http://www.gfredlee.com/plandfil2.htm

- **Overall Problems with "Dry Tomb" Landfills**
- **Liner Failure Issues**
- **Groundwater Pollution by Leachate**
- **Groundwater Monitoring**
- **Post-Closure Care**
- **Permitting of Landfills**
- **Fermentation/Leaching "Wet Cell" Landfills**
- **Landfill Mining**
- **Landfills and the 3R's**
- **NIMBY Issues**
- **Review of Specific Landfills**
- **Hazardous Waste Landfills**
- **Groundwater Protection Issues**

Landfills Evaluated by G. Fred Lee and Anne Jones-Lee

Arizona *(State Landfilling Regulations)*	Verde Valley - Copper Tailings Pile Closure Mobile – Southpoint Landfill
California *(State Landfilling Regulations)*	Colusa County - CERRS Landfill San Gabriel Valley - Azusa Landfill (Superfund Site) City of Industry - Puente Hills Landfill North San Diego County, 3 landfills San Diego County - Gregory Canyon Landfill El Dorado County Landfill Yolo County Landfill Half Moon Bay - Apanolio Landfill Pittsburg - Keller Canyon Landfill Chuckwalla Valley - Eagle Mountain Landfill Mountain View – Mountain View Landfill Barstow - Hidden Valley (Hazardous Waste) Mohave Desert - Broadwell Landfill (Hazardous Waste) Cadiz - Bolo Station-Rail Cycle Landfill University of California-Davis Landfills (4) (3 Superfund Site) San Marcos - San Marcos Landfill Placer County - Western Regional Sanitary Landfill Placer County – Turkey Carcass Disposal Pits Imperial County - Mesquite Landfill Los Angeles County - Calabasas Landfill and Palos Verdes Landfill Contra Costa County – Concord Naval Weapons Station Tidal LF (Superfund) Nevada County - Lava Cap Mine Area Landfill (Superfund Site) Sylmar - Sunshine Canyon Landfill Roseville - Roseville Landfill San Diego County – Campo Landfill Cortina Landfill – Colusa County,
Colorado (*State Landfilling Regulations)*	Last Chance/Brush – (Hazardous Waste Landfill) Denver - Lowry (Hazardous Waste Landfill) Telluride/Idarado Mine Tailings
Delaware	Various MSW landfills – Evaluate past disposal of industrial wastes
Florida	Alachua County Landfill
Georgia	Meriwether County – Turkey Run Landfill Hancock County – Culverton Plantation Landfill
Illinois (*State Landfilling Regulations*)	Crystal Lake - McHenry County Landfill Wayne County Landfill Kankakee County – Kankakee Landfill Peoria County – Peoria Waste Disposal (Hazardous Waste) Chemical Waste Unit at Clinton Landfill
Indiana (*State Landfilling Regulations*)	Posey County Landfill New Haven-Adams Center Landfill (Hazardous Waste)
Louisiana	New Orleans vicinity - Gentilly Landfill and Chef Mentuer Landfill

Michigan (*State Landfilling Regulations*)	Menominee Township - Landfill Ypsilanti- Waste Disposal Inc. (Hazardous Waste - PCB's)
Minnesota	Reserve Mining Co., Silver Bay - taconite tailings Wright County - Superior FCR Landfill
Missouri	Jefferson County - Bob's Home Service (Hazardous Waste)
New Jersey	Fort Dix Landfill (Superfund Site) Cherry Hill – GEMS (Superfund Site) Lyndhurst - Meadowlands Landfill Scotch Plains Leaf Dump
New York	Staten Island - Fresh Kills Landfill, Niagara Falls Landfill – (Hazardous Waste), New York City – Ferry Point Landfill
North Dakota	Turtle River Township - Grand Forks Balefill Facility Landfill
Ohio	Clermont County - BFI/CECOS Landfill (Hazardous Waste) Huber Heights - Taylorville Road Hardfill Landfill (C&DD) Morrow County – Washington and Harmony Townships C&DD Landfills
Pennsylvania	Pottstown – Pottstown Landfill
Rhode Island	Richmond – Landfill (C&D)
South Carolina	Spartanburg - Palmetto Landfill
Texas	Dallas/Sachse – Landfill Fort Worth - Acme Brick Landfill (Hazardous Waste) City of Dallas - Jim Miller Road Landfill Pasadena – Mobil Mining and Minerals industrial waste pile
Vermont	Coventry, Vermont - Coventry Landfill
Washington	Tacoma - 304th and Meridian Landfill
Wisconsin	Madison and Wausau Landfills
INTERNATIONAL LANDFILLS	
Alberta, Canada	Waste Management proposed Thorhild Landfill
Belize	Mile 27 Landfill
Ontario, Canada (*Prov. Landfilling Regulations*)	Greater Toronto Area - Landfill Siting Issues Kirkland Lake - Adams Mine Site Landfill Pembroke - Cott Solid Waste Disposal Areas
Manitoba, Canada	Winnipeg Area - Rosser Landfill
New Brunswick, Canada	St. John's - Crane Mountain Landfill

Nova Scotia, Canada	Sydney Tar Ponds and Coke Ovens Site
England	Mercyside Waste Disposal Bootle Landfill
Hong Kong	Three New MSW Landfills
Ireland	County Cork - Bottlehill Landfill County Clare - Central Waste Management Facility, Ballyduff
Korea	Yukong Gas Co. - Hazardous Waste Landfill
Mexico (*Haz. Waste Landfilling Reg.*)	San Luis Pontosi Landfill- (Hazardous Waste)
New Zealand	North Waikato Regional Landfill
Puerto Rico	Salinas - Campo Sur Landfill

Surface and Groundwater Quality Evaluation and Management
and
Municipal Solid & Industrial Hazardous Waste Landfills

http://www.gfredlee.com

Dr. G. Fred Lee and Dr. Anne Jones-Lee have prepared professional papers and reports on the various areas in which they are active in research and consulting including domestic water supply water quality, water and wastewater treatment, water pollution control, and the evaluation and management of the impacts of solid and hazardous wastes. Publications are available in the following areas:

Landfills and Groundwater Quality Protection
Water Quality Evaluation and Management for Wastewater Discharges
- Stormwater Runoff, Ambient Waters and Pesticide Water Quality Management Issues, TMDL Development, Water Quality Criteria/Standards Development and Implementation

Impact of Hazardous Chemicals -- Superfund
- LEHR Superfund Site Reports to DSCSOC
- Lava Cap Mine Superfund Site reports to SYRCL
- Smith Canal

Contaminated Sediment -- Aquafund, BPTCP, Sediment Quality Criteria
Domestic Water Supply Water Quality
Excessive Fertilization/Eutrophication, Nutrient Criteria
Reuse of Reclaimed Wastewaters
Watershed Based Water Quality Management Programs:
- Sacramento River Watershed Program
- Delta -- CALFED Program
- Upper Newport Bay Watershed Program
- San Joaquin River Watershed DO and OP Pesticide TMDL Programs

Stormwater Runoff Water Quality Newsletter

G. Fred Lee Advisory Services

G. Fred Lee & Associates was organized in the late 1960s to cover the part-time consulting activities that Dr. Lee undertook while a full-time university professor. In 1989, when Dr. Lee retired from 30 years of graduate-level teaching and research, he and Dr. Anne Jones-Lee, who was also a university professor, expanded G. Fred Lee & Associates into a full-time business activity. Examples of governmental agencies, consulting firms, citizens groups, industries and others for whom G. Fred Lee has served as an advisor include the following:

U.S. Environmental Protection Agency - Various Locations
Vison, Elkins, Searls, Connally & Smith, Attorneys - Houston, TX
International Joint Commission for the Great Lakes
U.S. Public Health Service - Washington, DC
Attorney General, State of Texas - Austin, TX
Madison Metropolitan Sewerage District - Madison, WI
Great Lakes Basin Commission - Windsor, Ontario
U.S. Army Environmental Hygiene Agency - Edgewood Arsenal, MD
City of Madison - Madison, WI
Council on Environmental Quality - Washington, DC
National Academies of Sciences and Engineering - Washington, DC
Water Quality Board State of Texas - Austin, TX
U.S. General Accounting Office - Washington, DC
U.S. Army Corps of Engineers - Vicksburg, MS
Tennessee Valley Authority - Various locations in Tennessee Valley
National Oceanic & Atmospheric Administration - Various locations
Organization for Economic Cooperation & Development - Paris
Attorney General, State of Illinois - Chicago, IL
State of Texas Hazardous Waste Legislative Committee - Austin
State of New Mexico Environmental Improvement Agency - Santa Fe
New York District Corps of Engineers - New York, NY
San Francisco District Corps of Engineers - San Francisco, CA
Wisconsin Electric Power Company - Milwaukee, WI
WAPORA - Washington, DC
Reserve Mining Company - Silver Bay, MN
United Engineers - Philadelphia, PA
Automated Environmental Systems - Long Island, NY
Procter & Gamble Company - Cincinnati, OH
Inland Steel Development Company - Chicago, IL
Kennecott Copper Corporation - Salt Lake City, UT
U.S. Steel Corporation - Pittsburgh, PA
Nekoosa Edwards, Inc. - WI
Zimpro, Inc. - Rothschild, WI
FMC Corporation - Philadelphia, PA
Acme Brick Company - Forth Worth, TX
Monsanto Chemical Company - St. Louis, MO
Gould, Inc. - Cleveland, OH
Illinois Petroleum Council - Chicago, IL
Inland Steel Corporation - Chicago, IL

Industrial Biotest Laboratories - Northbrook, IL
Wisconsin Pulp & Paper Industries - Upper Fox Valley, WI
Thilmany Pulp & Paper Company - Green Bay, WI
Chicago Park District - Chicago, IL
Nalco Chemical Company - Chicago, IL
Boise Cascade Development Company - Chicago, IL
Foley & Lardner, Attorneys - Milwaukee, WI
Timken & Lonsdorf, Attorneys - Wausau, WI
Strasburger, Price, Kelton, Martin & Unis, Attorneys - Dallas, TX
Rooks, Pitts, Fullagar & Poust, Attorneys - Chicago, IL
Jones, Day, Cockley & Reaves, Attorneys - Cleveland, OH
Sullivan, Hanft, Hastings, Fride & O'Brien, Attorneys - Duluth, MN
Hinshaw, Culbertson, Molemann, Hoban & Fuller, Attnys - Chicago, IL
Colorado Springs - Colorado Springs, CO
Mayer, Brown & Platt, Attorneys - Chicago, IL
Pueblo Area Council of Governments - Pueblo, CO
Platte River Power Authority - Fort Collins, CO
Linquist & Vennum, Attorneys - Minneapolis, MN
Norfolk District Corps of Engineers - Norfolk, VA
Spanish Ministry of Public Works - Madrid, Spain
The Netherlands - Rijkswaterstaat - Amsterdam, The Netherlands
U.S. Department of Energy - Various locations in US
King Industries - Norwalk, CT
Attorney General, State of Florida - Tallahassee, FL
State of Colorado Governor's Office - Denver, CO
Cities of Fort Collins, Longmont, and Loveland - CO
E.I. DuPont - Wilmington, DE
Allied Chemical Company - Morristown, NJ
Outboard Marine - Waukegan, IL
Amoco Oil Company - Denver, CO
Appalachian Timber Services - Charleston, WV
Mission Viejo Development - Denver, CO
Fisher, Brown, Huddleston & Gun, Attorneys - Fort Collins, CO
Tom Florczak, Attorney - Colorado Springs, CO
Wastewater Authority - Burlington, VT
Tad Foster, Attorney - Pueblo, CO
Holmes, Roberts & Owen, Attorneys - Denver, CO
Center for Energy and Environment Research - Puerto Rico
City of Brush - Brush, CO
Rock Island District Corps of Engineers - Rock Island, IL
Santo Domingo Water Authority - Dominican Republic
Ministry of Public Works and Environment - Buenos Aires, Argentina
Neville Chemical - Pittsburgh, PA
Fike Chemical Company - Huntington, WV
Stauffer Chemical Company - Richmond, CA
Adolph Coors Company - Golden, CO

Water Research Commission - South Africa
Grinnell Fire Protection Systems - Lubbock, TX
City of Lubbock Parks Department - Lubbock, TX
National Planning Council - Amman, Jordan
City of Olathe - Olathe, KS
City of Lubbock - Lubbock, TX
US AID - Amman, Jordan
Buffalo Springs Lake Improvement Association - Buffalo Springs, TX
Union Carbide Company - Charleston, WV
Canadian River Municipal Water Authority - Lake Meredith, TX
Mobil Chemical Company - Pasadena, TX
Unilever Ltd. - Rotterdam, The Netherlands
Brazos River Authority - Waco, TX
U.S. Army Construction Engineering Research Laboratory - Champaign, IL
James Yoho, Attorney - Danville, IL
Zukowsky, Rogers & Flood, Attorneys - Crystal Lake, IL
State of California Water Resources Control Board - Sacramento
Public Service Electric & Gas - Newark, NJ
Health Officer - Boonton Township, NJ
Scotland & Robeson Counties - Lumberton, NC
International Business Machines Corporation - White Plains, NY
Newark Watershed Conservation & Development Authority - NJ
State of Vermont Planning Agency - Montpelier, VT
CDM, Inc. - Edison, NJ
Attorney General, State of North Carolina - Raleigh, NC
City of Vernon - Vernon, NJ
Ebasco Services - Lyndhurst, NJ
Kraft, Inc. - Northbrook IL, with work in Canada, FL and MN
USSR Academy of Sciences - Moscow, USSR
Tillinghast, Collins & Graham, Attorneys - Providence, RI
City of Richmond, RI
Idarado Mining Company - Telluride, CO
Levy, Angstreich, Attorneys - Cherry Hill, NJ
Newport City Development - Jersey City, NJ
Orbe, Nugent & Collins, Attorneys - Ridgewood, NJ
Schmeltzer, Aptaker & Shepard, Attorneys - Washington, DC
CP Chemical - Sewaren, NJ
Dan Walsh, Attorney - Carson City, NJ
William Cody Kelly - Lake Tahoe, NV
NJ Department of Environmental Protection - Trenton, NJ
Hufstedler, Miller, Kaus & Beardsley, Attorneys - Los Angeles, CA
Main San Gabriel Basin Watermaster - CA
Metropolitan Water District of Southern California - Los Angeles, CA
San Diego Unified Port District - San Diego, CA
Delta Wetlands - CA
Simpson Paper Company - Humboldt County, CA

City of Sacramento - CA
Northern California Legal Services - Sacramento, CA
Rocketdyne - Canoga Park, CA
RR&C Development Co. - City of Industry, CA
American Dental Association - Chicago, IL
Emerald Environmental - Phoenix, AZ
Clayton Chemical Company - Sauget, IL
Stanford Ranch - Rocklin, CA
Public Liaison Committee - Kirkland Lake, Ontario
Miller Brewing Company, Los Angeles, CA
ASARCO Inc., Tacoma, WA
CALAMCO, Stockton, CA
Yunkong Gas Company, South Korea
Sutherlands, Pembroke, Ontario
Silverado Constructors, Irvine, CA
Agricultural Interests in Puerto Rico
City of Winnipeg, Manitoba
Strain Orchards, Colusa, CA
Davis South Campus Superfund Oversight Committee, Davis, CA
Monterrey County, California Housing Authority, Salinas, CA
CROWD, Tacoma, WA
Newport Beach, CA
SOLVE, Phoenix, AZ
Sports Fishing Alliance, San Francisco, CA
Caltrans (California Department of Transportation)
Citizens Group near St. John's, New Brunswick
Colonna Shipyards, Norfolk, VA
Clermont County, OH
Wright County, MN
Waikato River Protection Society, New Zealand
Drobac & Drobac, Attorneys, Santa Cruz, CA
Phelps Dunbar, L.L.P., Houston, TX
Walters Williams & Co, New Zealand
Environmental Protection Department, Hong Kong
NYPRIG New York City, NY
DeltaKeeper, Stockton
City of Stockton, CA
Central Valley Regional Water Quality Board, Sacramento, CA
Carson Harbor Village, Carson, CA
Sanitary District of Hammond, IN
South Bay CARES, Los Angeles, CA
Memphremagog Regional Council, Quebec, CANADA
Mobile, AZ
Pottstown Landfill Closure Committee, Pottstown, PA
Grand Forks County Citizens Coalition, Grand Forks, ND
Sunshine Canyon Landfill, Sylmar, CA
Meriwether County, GA
Hancock County, GA

Louisiana Environmental and Action Network, Baton Rouge, LA
OUTRAGE and POWER, Kankakee, IL
John Cobey et al., Morrow County, OH
Heart of Illinois Sierra Club and Peoria Families Against Toxic Waste, Peoria, IL
Sierra Club of Canada, Cape Breton Group, Nova Scotia
Tulane Environmental Law Center, New Orleans, LA
Backcountry Against Dumps, Boulevard, CA
The Roth Law Firm, Marshall, TX
Citizens group Meriwether, County, GA
North Sacramento Land Company, Sacramento, California
Macuga, Liddle & Durbin Detroit, Michigan
Lozeau & Drury, Alameda, CA
DeWitt County, IL
Concerned Citizens of Thorhild County Alberta, Canada