Waste Management of North America, Inc.
3003 Butterfield Road · Oak Brook, Illinois 60521

A-88-09
II-D-13

January 29, 1988

Mr. Jack R. Farmer
Director
Emissions Standards and Engineering Division
USEPA
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

Dear Mr. Farmer:

This document contains Waste Management of North America's (WMNA's) response to the October 30, 1987, information request sent to WMNA by USEPA. The information contained was agreed to by Jack Durham and the Radian Corporation at our meeting on December 7, 1987, and discussed in our confirming letter to you of December 18, 1987.

In that letter, we offered to provide five major types of information:

1.) Site-specific data for landfill gas characteristics, including gas generation rates where available. This site-specific information is attached. Note that this information relates to gas within the landfill and gas removed from the landfill by suction.

2.) A discussion of factors influencing gas characteristics at specific sites. See Section B for this discussion.

3.) Capital and operating costs for electric generating gas recovery and gas collection systems. This information is contained in Section C.

4.) An extended discussion of technology, economics, and environmental data for electric generating gas recovery systems in place. This discussion is also included in Section C.

5.) A discussion of design and operating methods used by WMNA. See Sections A and D for information on gas migration control and gas testing respectively.

Most of the information in this report is kept confidential within the company for business reasons. We are in ongoing negotiations to secure electric power purchase agreements with utilities, to secure gas rights from municipalities and to purchase equipment and services to complete gas recovery projects. We are also searching for other ways to profitably use landfill gas. Release of the information herein could cause major harm to the company's trade. We have labelled those portions of the information which we view as confidential business information subject to protection as a trade secret, and we request that you protect this information as required under 40 CFR, Part 2.

We are also concerned that the information may be used and misused out of context. Use of this information out of context would be materially misleading. For example, use of the gas recovery program data to draw inferences about gas emissions would be a

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use of the information out of context. The legal discussion which follows addresses this issue and the general issue of New Source Performance Standards in more detail.

The United States Environmental Protection Agency ("EPA") proposes to establish New Source Performance Standards ("NSPS") for air emissions from certain landfills. In furtherance of that goal, EPA has requested that Waste Management of North America, Inc. ("WMNA") provide certain information necessary for the development and promulgation of those NSPS. Accompanying and included in this cover letter is the information requested from WMNA by EPA. WMNA wishes to place this factual data in the proper regulatory context -- in which the agency must carefully examine all aspects of the industry proposed to be regulated and give full and proper weight to the unique character of landfills which sets them apart from industries for which NSPS are typically promulgated.

Section 111 of the Clean Air Act, 42 U.S.C. Sec. 7411, governs standards of performance for new stationary sources. Section 111(a)(1) provides, in relevant part, that:

> A standard of performance shall reflect the degree of emission limitation and percentage reduction achievable through application of the best technological system of continuous emission reduction which (taking into consideration the cost of achieving such emission reduction, any non-air quality health and environmental impact and energy requirements) [EPA] determines has been adequately demonstrated. 42 U.S.C. Sec. 7411(a)(1).

As EPA itself recently acknowledged when it proposed standards for the polymeric coating of supporting substrates industry, NSPS must:

1.) realistically reflect best demonstrated control practice;

2.) adequately consider the cost, non-air quality health and environmental impacts, and the energy requirements of such control;

3.) be applicable to existing sources that are modified or reconstructed as well as to new installations; and

4.) meet these conditions for all variations of operating conditions being considered anywhere in the country. EPA, Polymeric Coating of Supporting Substrates -- Background Information for Proposed Standards: Draft EIS 2-6 (Apr. 1987).

Toward this end, WMNA is pleased to provide EPA with the data it requested. WMNA is convinced that, upon its review of this data, EPA will realize that imposing an NSPS on landfills and doing so in compliance with the mandates of Section III will be an extremely difficult task. In particular, gaseous emissions from landfills cannot be regulated as easily as can emissions from typical industries where input, output and the intermediate processes are relatively constant or cyclically repetitive if batch processing is used. Each landfill is unique. The following variables must be considered for the landfills proposed to be regulated if an accurate determination is to be made, first, as to the uncontrolled emissions from the landfill, next as to whether particular pollution control technology is demonstrably applicable to the industry segment under consideration and, finally, whether proposed standards are feasible and appropriate given their non-air quality, economic and energy impacts:

1.) The nature and quantity of materials in each landfill;
2.) The amount of moisture or liquid in the landfill;
3.) The methods of liquid and leachate management used at the landfill;
4.) Biological and other changes to landfill materials which have occurred over time or which might occur in the future;
5.) The size of the landfill;
6.) The age of the landfill;
7.) The configuration of the landfill site;
8.) The geological characteristics of the site;
9.) The climate at the site;
10.) The nature of any cap in place at the site;
11.) Whether the site utilizes a gas recovery system or some other type of control on gaseous emissions; and
12.) Natural variability of the gas stream.
13.) The commercial value, if any, of the type and quantity of gas recovered from the landfill.

Failure by EPA to adequately consider each of these factors could mean that the resulting administrative record is inadequate, and any regulations promulgated on the basis of such a record are unlikely to carry out the mandate of the Clean Air Act or to be legally sound.

The truism that regulations must be based on a thoroughly developed factual record is worth emphasizing here because many of the crucial facts about landfill gas emissions and controls are not easily established or understood. We will address a number of these areas in turn.

Establishing Baseline Emissions. Section III standards are directed to emission limitations and the percentage reduction of emissions. It follows that the starting point for a Section III inquiry must be to establish what uncontrolled emissions are. This is not easy. As we show below, there are no standard, generally accepted methods for measuring uncontrolled emissions from landfills; the rate of uncontrolled emissions is not directly related to gas recovery from a landfill, and the rate of gas generation varies materially between landfills. These basic facts make it difficult to carry out the rest of the analysis of technological and economic feasibility that Section III calls for. Despite its difficulty, this factual development is the foundation on which the regulatory structure must be built.

Regulations that are based on insufficient or inadequate data cannot stand. Reliance by EPA on minimal data, erroneous data or unreliable data will invalidate the regulations. Portland Cement Association v. Ruckelshaus, 486 F.2d 375, 393, 402 (D.C. Cir. 1973), cert. denied, 417 U.S. 921 (1974). For instance, in the cited case, the court found that where EPA did not use continuous sampling or did not sample while facilities were operating at maximum capacity, but required in the resulting regulation that the regulated community do so, the data on which the standards were based was inadequate. Id.

Economic And Technological Feasibility. Much of the information EPA is seeking relates to existing gas recovery systems. Landfill gas recovery systems, unlike many pollution control systems, frequently serve the purpose of collecting an economically valuable commodity for sale. This basic fact plays an important part in considering the economic and technological feasibility of landfill gas control systems and requires that insofar as EPA gives weight to the economic incentives for gas collection it must be sure that the landfills addressed in the regulations will in fact be able to produce, at a commercially acceptable price, the quantities and type of gas which support investment in a gas recovery system. EPA may not require a level of pollution control that is either technologically or economically infeasible. Bunker Hill Co. v. Environmental Protection Agency, 572 F.2d 1286, 1293 (9TH Cir. 1977) (remanding NSPS when EPA did not exercise "reasonable discretion" in concluding a certain emissions control standard was technologically feasible). If, in promulgating its emission or effluent standards, EPA relies on technology that is either unreliable or cost-prohibitive, such standards will not be found to comply with the statute. American Meat Institute v. EPA, 526 F.2d 442, 465-66 (7th Cir. 1975) (Clean Water Act). EPA is required to consider the costs that compliance with the proposed standards will impose on the industry regulated. The agency's exploration of the facts should reflect a "serious, careful, and comprehensive study of (those) costs." Kennecott Copper Corp. v. EPA, 612 F.2d 1232, 1242 (10th Cir. 1979) (Clean Water Act). For instance, in American Iron & Steel Institute v. Environmental Protection Agency, 568 F.2d 284, 299 (3d Cir. 1977), cert. denied, 435 U.S. 914 (1978) (Clean Water Act), the court remanded EPA's effluent regulations for the iron and steel industry because EPA failed to consider the age of the facilities reviewed as age pertained to the cost and feasibility of retrofitting plants with new pollution control technology. An adequately demonstrated system of pollution control is one that is reasonably reliable, reasonably efficient and reasonably expected to serve the interest of pollution control without being exorbitantly expensive. Although the system need not already be routinely in use within the industry, it cannot be either purely theoretical or experimental. National Asphalt Pavement Association v. Train, 539 F.2d 775, 785-86 (D.C. Cir. 1976); Essex Chemical Corp. v. Ruckelshaus, 486 F.2d 427, 433-34 (D.C. Cir. 1973), cert. denied, Appalachian Power Co. v. EPA, 416 U.S. 969 (1974).

Non-Air Quality Impacts. Although there are mechanisms which increase gas production and, hence can allow gas recovery to operate at an economically feasible level, EPA must consider the non-air quality environmental effects of implementing those mechanisms. For instance, the practice of recycling leachate enhances gas generation, making gas recovery economically viable. It, however, also means that there is a greater quantity of liquid in the landfill. As a generality, the regulatory agencies with responsibility for solid and hazardous waste have sought to reduce the quantity of liquid in landfills. Since Section 111(a)(1)(C) mandates that EPA consider "non-air quality health and environmental impact(s)," the agency must reach a final position which coherently balances these possibly competing interests.

Variability Within Industry. For purposes of developing a meaningful and achievable NSPS for landfills, it is essential that EPA take into account the diversity between landfills which differ markedly in content, cap, leachate management and climatic conditions to name only a few of the most obvious variables. In the past, EPA has done this by subcategorizing industries, taking into account differences in industrial processes and other factors. Even further subdivision of those subcategories often may be in order when faced with variables within the industry. Indeed, in promulgating Clean Water Act effluent discharge regulations for the pulp and paper mill industry, EPA developed sixteen subcategories and 66 subdivisions and averaged the results within each subdivision, so as to further account for differences between facilities. Weyerhauser Co. v. Costle, 590 F.2d 1011, 1053 (D.C. Cir. 1978) (Clean Water Act). Similar careful categorization is likely to be needed in addressing landfills.

Distinctions among segments of an industry (e.g., size, age, process, climate, rainfall, location) frequently warrant the imposition of different emission or effluent standards. E.I. DuPont de Nemours & Co. v. Train, 430 U.S. 112 (1977); Kennecott Copper Corp., 612 F. 2d at 1244-45; Tanners' Council of America, Inc. v. Train, 540 F.2d 1188 (4th Cir. 1976) (regulations remanded as EPA did not adequately consider the effect of cold weather on either the treatment process or on the characteristics of waste going into the treatment system); FMC Corp. v. Train, 539 F.2d 973, 980 (4th Cir. 1976); Hooker Chemicals & Plastics Corp., 537 F.2d at 636 (all Clean Water Act cases).

If facilities tested by EPA are not representative of those to which the regulations will be applied, the resulting regulations cannot stand. National Lime Ass'n v. Environmental Protection Agency, 627 F.2d 416, 432-33 (D.C. Cir. 1980). The data assembled by EPA must be representative of the sources tested. Although obviously dealing with a quite different industry, the National Lime case is quite instructive on this basic point. In National Lime Ass'n, the court remanded an NSPS promulgated by EPA which was not based on samples representative of the regulated universe. Among other things, EPA failed to consider the following: 1) that feedstock variations -- such as size and chemical composition -- affect the quantity of particulates produced, 2) that variations in gas velocity caused by, inter alia, the percentage of capacity at which the plant is operating and variations in the rate of rotation of the kiln, affect the quantity of particulates produced, 3) that variations in the use of coal and types of coal used affect the content of particulates emitted, 4) that the size of particulates emitted, which varies greatly, causes differences in pollution control efficiency and 5) that considerations such as stack diameter, particulate size and shape and stack gas exit velocity affect the opacity of emissions. Id. at 435-48. The court concluded that EPA had not met its burden of showing that the plants tested and test conditions were representative. Id. at 448-53. The parallel range of variables at landfills must be given the same sort of fine-grained analyses.

Furthermore, the standards set must be capable of being met under most adverse conditions reasonably expected to occur. A standard that does not account for routine variations in conditions is unachieveable unless there is evidence in the record that the "costs" of adjusting such variations have been considered by EPA and determined to be affordable. National Lime Ass'n, 627 F.2d at 431 n.46.

Consideration of Alternatives. Both because of the variety of conditions in which landfill gas recovery units operate and the range of economic and pollution control functions which the systems fulfill, there will be a large number of alternative regulatory approaches and standards for the agency to consider. It is essential to the public exchange which will follow EPA's proposal of regulations that these alternatives be fully explicated. EPA should state its assumptions, reveal its processes, explain its rejection of alternative theories and alternative courses of action and provide a rationale for its proposal and ultimate decision.Id. at 453. Specifically, the agency should: 1) identify and verify as relevant or irrelevant specific variable conditions that may contribute substantially to the amount of emissions or otherwise affect the efficiency of the emission control systems considered, and 2) where test results are relied on, select or use test results so as to provide assurance of the achievability of standards for the industry as a whole, given the range of variable factors found relevant to the standards' achievability. Id. at 433. Only by this process can the proposed NSPS be tested so that the final regulations will be both fair and effective.

Thus, in order for EPA to establish NSPS for landfills, it must assure that the proposed standards are realistically achievable by all parts of the industry to which they would apply, and that the technological system of pollution control relied on in establishing those standards has been adequately demonstrated in all segments of the industry to which it would be applied. Amoco Oil Co. v. EPA, 501 F.2d 722, 739 (D.C. Cir. 1974). The agency must "explicate fully its course of inquiry, its analysis and its reasoning." National Crushed Stone Association v. epa, 601 F.2d 111, 118 (4th Cir. 19797), rev'd on other grounds, 449 U.S. 64 (1980) (Clean Water Act). As noted above, there are a number of variations between landfills that EPA must consider as it develops the NSPS if it is to adequately subcategorize the industry and fairly establish standards applicable to the universe it aims to regulate. A more specific discussion of the technical aspects of these variations follows.

SECTION A: CONTROLLING LANDFILL GAS MIGRATION

Several viable approaches can be considered when addressing a landfill gas migration or odor control concern. These approaches are categorized as:

- passive,
- active collection, and
- active air induction.

Many different factors influence the design chosen since landfill and geological conditions can vary from site to site.

The following presents a short description of each of these systems along with factors which may effect their selection.

1.) Passive System

   A.) Outside limit of refuse

      1.) Impermeable Barrier - A polyvinyl chloride (PVC) or high density polyethylene (HDPE) material draped along the sidewall of a trench or a bentonite grout wall.

      2.) Venting Trench - A gravel backfilled trench to provide a path of least resistance to the migrating gas.

   These approaches are generally effective in controlling the migration of landfill gas beyond their point of installation. However, the bottom of these trench excavations must contact an underlying impermeable soil or a saturated zone. Due to the limitations of excavation equipment, these systems are usually limited to a depth of twenty feet.

B.) Inside limit of refuse

1.) Venting Trench - A slotted horizontal collection pipe surrounded by a gravel pack in a trench with one or several riser pipes. May or may not be flared.

2.) Venting Well - A vertical PVC well casing usually slotted from 15 to 20 feet below grade to the bottom of refuse. May or may not be flared.

These systems are generally effective in controlling landfill gas odors by reducing the internal landfill gas pressures, thereby, decreasing the amount of gas venting through the cover soils. This interior passive system may also be used to limit migration if landfill pressures are causing the subsurface movement of gas.

Passive systems are generally not effective in influencing landfill gas which has previously migrated. The natural diffusion of these gases would have to be assumed.

2.) Active Collection System

Discussion

If a passive system is not effective in controlling landfill gas migration or odor concerns, or is not a viable approach, an active collection system would be installed. This type of system could be installed either within the limits or outside the limits of refuse.

In either case, the system would consist of vertical extraction wells and/or trenches connected to a common header collection pipe. A high pressure blower would create a vacuum within this header pipe that would be applied to the wells. The landfill gases are extracted through the well and header pipe and incinerated using a flare located at the discharge side of the blower.

The gas extraction well is comprised of an 8 inch PVC pipe that extends the entire depth of a 36 inch borehole. The bottom of this borehole will generally come within several feet or contact the base of refuse. The lower portion of the PVC pipe is slotted and surrounded by a 1 to 2 inch washed gravel packing for gas collection purposes. The annulus between the borehole and the solid pipe is backfilled using on-site soils with a bentonite seal located near the surface.

The distance from the surface to the top of the slotted pipe is determined using the following criteria:

- assumed radius of influence
- thickness of landfill cover
- permeability of landfill cover
- moisture content of refuse

- overall depth of the well
- location of the well (site perimeter or interior)

The radius of influence is the radial distance from a well that the applied vacuum will direct the movement of gas towards the well.

The gas is directed from the well into the collection pipe with a wellhead assembly that sits atop the well. The wellhead consists of a flexhose to allow for settlement, a valve to throttle the vacuum applied to the well and other miscellaneous pipe.

The gas is collected from each of the wells with a common header collection pipe. This pipe is made of HDPE and is buried a minimum of 3 feet below grade. The pipe is buried to protect it from above ground vehicle traffic, weather conditions and vandalism. The header pipe is sloped to allow the drainage of condensate to barometric drip-legs and/or condensate collection tanks.

The gas is sucked into the high pressure blower (typically Aerovent) and discharged through an exit pipe to a flame arrester (typically Protectoseal) and flare.

The two types of flares used by WMNA are elevated or open flare, and ground or enclosed flare. These systems can be designed to automatically relight, if desired.

A.) Active collection system outside limit of refuse

This type of active system would be a viable option only for migration control when the geological conditions along the site property line consist of permeable soils. In this situation, the wells and/or trenches would extract the migrating gas directly from the surrounding soils. An outside of refuse active collection system has the following advantages:

1.) Does not effect landfill operations since it is located away from truck traffic.

2.) Eliminates long-term maintenance concerns associated with resloping header collection pipe since differential settlement is minimized in virgin soils.

3.) Reduces the potential for air intrusion into the landfill.

4.) Collects smaller amounts of condensate since the landfill gas cools as it moves away from the limit of refuse.

Although the above listed advantages make this system appealing, it is usually disregarded due to the following:

1.) Forces migration away from the refuse toward the system (or property line).

2.) Requires closer well spacing to control migration.

3.) Requires more condensate collection locations since surface grades usually are relatively flat.

4.) The landfill gas collected is usually diluted below the level (20 percent methane) at which a stable flame can be maintained. This direct venting may create odor concerns. Also if the system's methane concentration is between 5 and 15 percent then safety is a special concern since flame propagation could occur within the collection system and nearby soils if ignited.

B.) Active collection system inside limit of refuse

1.) The most effective method used to control migration and odor is an active collection system located within the limits of refuse. By extracting the gas where it is produced, the pressure within the landfill will not be great enough to force the gas in either a lateral or vertical direction.

2.) WMNA prefers this type of active system although it usually involves long-term maintenance due to settlement within the landfill and more frequent monitoring to prevent air intrusion. This system is used when gas is collected for a resource recovery project.

3.) <u>Air Induction System</u>

An air induction system is only used for migration control and is similar to an active collection system located outside the limit of refuse except that it injects air into the ground. By injecting air into the ground, a positive pressure curtain is formed which will prevent landfill gas migration by forcing it back towards the refuse.

WMNA has not designed and does not currently operate a perimeter injection system because they require more wells, very high operating pressures, and may force air into the landfill and create the potential for a fire.

SECTION B: GAS PRODUCTION PREDICTIONS AND MODELS

1.) <u>Predicting Gas Production</u>

The prediction of the rate of gas production within a given landfill is complex; there are numerous site specific factors that can influence gas generation. Major factors influencing gas production include refuse composition, moisture, temperature, PH, alkalinity and nutrients, site topography and landfilling methods. We do not fully understand how these factors affect the dynamics of gas generation. This general lack of insight into the dynamics affecting gas generation is exacerbated by the presence of "micro-environments" within the landfill (heterogeneous environments co-existing throughout the site).

- Most mathematical models currently used to predict landfill gas production are based on general models that describe the growth kinetics of bacterial populations. The key assumption is that the anaerobic decomposition occurring in landfills should approximate these models.

  Currently WMNA utilizes a simplified model consistent with fundamental principles and adjusts the model for such variables as moisture, temperature, waste composition, site topography and gas generation rate. The basis for the adjustments is more experience than theory.

2.) <u>The WMNA Gas Model</u>
(Section B.2 contains confidential business information).

The WMNA gas model is programmed solely for the prediction of total/recoverable landfill gas volumes from a given landfill. The gas model does not have the capacity to 1) quantify the major gas constituents (CH_4, CO_2, N_2, O_2) in the gas volume or 2) estimate the quantities of trace components in the gas. WMNA relies on the extensive gas sampling performed during the gas recovery testing of a given site to provide the actual landfill gas composition.

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The major assumption in the model is the theoretical amount of gas produced per pound. It has not been determined whether the value we use is representative of what is produced in a landfill. This value cannot be determined by a mechanical test as with the gas generation rate. It is impossible to capture all the gas produced and relate that to the mass producing it on a large scale such as a landfill. Therefore, the gas production data can only be used to estimate gas production.

SECTION C: ECONOMICS AND COSTS OF GAS RECOVERY PROJECTS

(Section C contains confidential business information)

1.) Selecting Sites for Gas Recovery Tests

Waste Management of North America, Inc. has an active program to recover and use landfill gas at its own landfills and at landfills owned by others. Gas recovery projects, as opposed to gas control projects are primarily driven by economics. The economics of gas to electric projects are described below.

The major determinants of whether development of a gas recovery project is attempted are:

A. Presence of adequate amounts of gas.

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B. Nearby users for the landfill gas or favorable electric power purchase rates. With no customer there is no project.

C. Compatibility with gas control and other environmental program needs.

D. Supportive community attitude. The benefits to the community generally assure a favorable attitude, but local opposition could kill a project.

E. Fit with other business objectives at the site.

2.) Why focus on gas to electric projects for analysis?

The profitable implementation of a gas recovery project is highly dependent on having a consumer for the recovered gas. The highest value is generally found when the gas can be sold to a nearby industrial or commercial user who can directly displace natural gas or fuel oil. Unfortunately, this situation is rare. With the Federal PURPA there is always a purchaser of electrical energy produced from landfill gas. The rate at which the electricity is purchased ranges from full avoided cost in areas that need capacity (generally about 5.5 cents/KWH in areas where coal fired plants could be built) down to incremental avoided cost in areas with no need for added capacity (as low as 1.6 cents/KWH in areas with coal fired capacity).

3.) What is the approach, the assumptions, and the analysis used?

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4.) The economic evaluation of gas recovery projects has been developed as follows:

A.) Costs are estimated in 4 major blocks; collection system with blower, power generating plants and equipment, electrical interconnection and project development costs including capitalized permitting, legal and development fees. Cost estimates are planning numbers we would use before obtaining site specific estimates. Actual costs may vary widely from these planning numbers.

The following costs are generally considered for budgeting an active gas collection system:

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B.) Depreciation schedules are calculated using straightline depreciation and a 15-year life for the project, with 7 years for the collection system costs.

C.) Corporate tax rates are assumed to be 40% on a combined federal and state basis.

D.) Cash operating costs are presented on a cents per net kwh basis. These costs are our planning assumptions without site specific input.

E.) Direct operating costs and electricity generating revenues are assumed to rise 5% per year to reflect general inflation.

TABLE 1

Summary of Gas Recovery Economic and Environmental Considerations
Table 1 Contains Confidential Business Information

	Unit of measure	Electric Generating Equipment				
		1 recip	2 recip	3 recip	1 turbine	2 turbine
Gas Flow	mscfd	450	900	1,350	2,000	4,000
NOx Emissions	tons/year	55*	110*	165	38**	76**
CO Emissions	tons/year	20*	39*	59*	152*	304*
Rated Net Output	kw/h	717	1,362	2,104	2,754	5,507
Initial Cost						
Gas Collection						
Power Plant						
Utility Inter-connection Cost						
Project Development Costs						
Cash Operating Costs						
Required Buyback Rate						

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* Data supplied by manufacturer for engines fueled by natural gas, actual experience has shown reduced values.

** Data supplied by manufacturer for engines fueled by landfill gas.

F.) The electric power sale contract is assumed to be energy only with no capacity payment. The vast majority of our landfills are in areas with little or no desire to pay for capacity. This also simplifies the math considerably.

G.) We have assumed no investment, energy, or gas production tax credits. Our understanding is that none of these would be available for systems installed after 1989.

H.) We have calculated the first year buyback rate necessary to provide a net present value of zero REDACTED: CONFIDENTIAL BUSINESS INFORMATION Comparison of this rate with current buyback rates in various areas could indicate the possible economic value of the project.

I.) The project capital structure is assumed to be

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J.) Project life is 15 years with 90% capacity factor.

5.) Air Emissions from Gas Recovery Plants

Table 1 shows manufacturer's representations for emissions from selected equipment.

Table 2 shows air emissions data from two gas turbine electric generating plants operated by WMNA.

The data in Table 2 should be viewed in this context:

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SECTION D: MONITORING GAS MIGRATION & TESTING GAS RECOVERY POTENTIAL

1.) Gas Collection Systems Monitoring

In general, WMNA monitors its landfill gas collection systems twice a month. This frequency may be slightly increased or decreased depending on the operating conditions of a specific collection system. Note that bimonthly monitoring is a general standard for gas collection systems. Gas monitoring systems are generally tested quarterly.

TABLE 2

$NO_x/SO_2/O_2$ Emission Summary

Table 2 contains confidential business information

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This bimonthly monitoring is conducted at each of the wellheads and within the blower/flare station. The equipment used and the parameters monitored at each of these locations is presented below along with an explanation of how data is interpreted to assess the operation of a system is presented below.

A. Percent Methane - A Gas Tech NP-204 portable combustible gas meter is used to measure the percent methane. This meter is calibrated using a 50 percent methane, 40 percent carbon dioxide and a 10 percent nitrogen gas concentration since this closely resembles measurements tâken in the field.

Prior to the operation of the collection system, the methane concentration is measured at each wellhead to evaluate the status of methane concentrations within the landfill. These initial measurements are used as a baseline for future monitoring since a reduction in the methane value is an indicator of air intrusion into the landfill. As the methane concentration begins to decrease, the wellhead valve is adjusted to lower the applied vacuum in an effort to prevent further air intrusion.

In addition, methane is measured at the flare station to evaluate total system concentration and as a quality control to verify the integrity of the system (i.e. verifying no air intrusion into the header collection pipe).

B. Percent Oxygen - A Gas Tech IP-204 portable oxygen meter is used to measure the percent oxygen. This meter is calibrated to zero using a gas standard that contains no oxygen.

The oxygen concentration is measured at each wellhead to determine the amount of oxygen intrusion into the well and whether this oxygen is being drawn through the refuse or a damaged well casing. The percent oxygen is also measured in the flare station for the same reasons as those mentioned earlier for flare station methane.

C. Pressure - Dwyer magnehelics (inches water column) are used to measure the vacuum at each of the wellheads. During system monitoring the wellhead vacuum is increased or lowered depending on the methane concentration of the well and whether additional migration or odor control is necessary. Pressure measurements are also taken in the flare station to regulate the amount of vacuum applied to the header collection pipe.

D. Well Temperature - The landfill gas temperature is taken at the wellhead with a pocket type thermometer to monitor the potential for a landfill gas fire. A significant increase (twice the normal temperature) is most often indicative of composting (commonly known as a landfill fire) within the landfill. This composting can occur if excess air is drawn into the landfill due to the operation of the collection system.

E. Liquid Level - A slope indicator is used to measure the liquid level within the wells. If liquid levels are near the top or above the slotted pipe then the effectiveness of the well is greatly reduced or nonfunctional.

F. Flow Measurement - The total system is measured between the blower and flare with either an in place orifice plate or an inserted pitot tube.

2.) Landfill Gas Emissions Testing
(Section D.2 contains confidential business information)

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3.) Landfill Gas Recovery Test Program
(Section D.3. contains confidential business information)

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4.) Moisture Relationship to Gas Production

The moisture state of a landfill is determined during well boring. At five foot intervals, a representative sample of refuse is collected and subjectively evaluated for moisture. There are five general states of moisture: dry, damp, moist, wet, saturated.

Dry	- refuse is dry to the touch
Damp	- refuse feels moist, but leaves no visible moisture on hands when squeezed.
Moist	- refuse leaves moisture on hands when squeezed.
Wet	- water drips from refuse when squeezed.
Saturated	- Water drips from refuse without being squeezed.

This test is very subjective and only yields a qualitative picture of landfill moisture for a very small section of the total site.

The data shows that, generally, a wet or saturated environment is most favorable for gas production and that dry conditions tend to retard methanogenesis.

5.) Concentration Ranges
(Section D.5 contains confidential business information)

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SECTION E: COMMENTS AND CONCLUSIONS ON GAS RECOVERY TESTING

1.) Gas Recovery Testing - Limitations on Use of Data

Gas Recovery testing is specifically designed to determine the volume of landfill gas that can be economically recovered from a landfill without causing air intrusion. Waste Management gas recovery tests provide a single point in time measurement of gas recovery under a specific, mechanically-induced vacuum.

- These tests do not in themselves provide the generation rate of the landfill gas over time, and do not measure any outward dynamics of landfill gas flow.

2.) Limited Information of Landfill Gas Tests

When available, gas recovery tests are performed using an existing gas collection system. Usually a gas collection system is not available, and gas recovery testing is accomplished with temporary test wells. In most cases, cost constraints limit gas recovery tests to only a small portion of the landfill. Since the landfill is not homogeneous, there is always uncertainty regarding the gas recovery potential of the remaining portion of the landfill.

3.) No Ambient Air Sampling is Done with Gas Recovery Testing

The gas recovery test does not include any ambient air sampling. The gas recovery test is designed to measure the ability to recover gas from inside the landfill with a mechanically applied vacuum without causing air intrusion. Air intrusion is avoided for four main purposes:

A. Prevention of landfill fires - Introduction of air (oxygen) into a landfill can cause underground landfill fires.

B. Safety of personnel and equipment - Introduction of oxygen into a gas recovery plant can cause a potential personnel and equipment hazard, since an explosive combination of methane and oxygen could occur.

C. Operation of equipment - Almost all equipment processes used to recover or process landfill gas are extremely sensitive to oxygen concentration. For this reason, oxygen is kept out of the landfill gas by limiting the mechanical vacuum applied to a landfill.

D. Maintain anaerobic conditions - Prevention of air intrusion into the landfill is necessary to maintain an oxygen free environment to maintain methane production under anaerobic conditions.

4.) Purpose of Waste Management's Trace Component Analysis
(Section E.4. contains confidential business information.)

REDACTED: CONFIDENTIAL BUSINESS INFORMATION

5.) Trace Component Sampling
(Section E.5. contains confidential business information.)

REDACTED: CONFIDENTIAL BUSINESS INFORMATION

6.) Trace Component Lab Analysis
(Section E.6. contains confidential business information.)

REDACTED: CONFIDENTIAL BUSINESS INFORMATION

7.) Decreasing Gas Generation at Waste Management landfills due to Leachate Management

Recycling leachate into landfills is thought to accelerate gas generation since it may provide nutrients to enhance gas production. The carbon dioxide portion of landfill gas may also reach lower levels since it is soluble in water and can be partially carried away by leachate.

Waste Management attempts to minimize the liquids in a landfill. This program of removal of leachate from landfills with no recycling of liquids into the landfill has caused us to observe a significant reduction of gas generation at certain sites. It is years too early to tell the degree to which this will affect long-term gas generation. Waste Management's leachate management is changing the static and dynamic forces of landfill gas generation and recovery. Since we do not fully understand these dynamics, prediction of specific reductions in gas volumes and changes in gas quality would be speculative.

8.) Gas Recovery Operations - Limitations for Control Purposes

A gas recovery system is typically designed and operated to provide a quantity of gas with minimum fluctuation in gas quality. Variations in gas quality can significantly affect the operating efficiency of electrical generation equipment or methane recovery processing systems. Gas recovery plants are operated to avoid overstressing a landfill in the gas removal process, in order to maintain a relatively constant volume and quality of landfill gas. Therefore, a landfill gas recovery plant cannot always be used as an effective means of controlling offsite migration of landfill gas, since vacuum may be purposely constrained to prevent air intrusion.

9.) <u>Conclusions</u>

- Internal landfill gas dynamics cannot be used by themselves to explain external landfill gas emissions. Emissions are a function of site specific conditions.

- The potential of outward migration of landfill gas at any landfill into the atmosphere cannot be determined unless air quality is directly measured over time, taking into consideration naturally occurring ambient conditions as well as surrounding residential or industrial emissions.

- Measurement of landfill gas emissions from one site cannot be used to estimate landfill gas emissions from any other site. There are too many site specific variables and too little knowledge of the dynamics of landfill gas prediction and emission.

- Standard methods have not yet been developed for measurement of mass emission of landfill gas into the atmosphere. Standard methods would have to be developed before regulations of landfill gas mass emissions can be done.

We welcome an opportunity to discuss these topics at your convenience. We invite you to consider meeting with us at our Omega Hills Gas Recovery Plant near Milwaukee, Wisconsin. Please let us know if you would like to tour this twin-gas-turbine facility.

Sincerely,

David A. Stringham
Director of Environmental Management
Waste Management of North America

William H. Wolfe
Director of Gas Recovery
Waste Management of North America

Enclosure
DAS/REO/dlw

cc: Carolyn Lown (w/o enclosure)
File - Air Emissions Survey (w/enclosure)