CARSON MARKETPLACE

ADDENDUM
to the
Final Environmental Impact Report

SCH No. 2005051059

JULY 2009

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Table of Contents

Page

List of Figures

Page

List of Tables

Page

I. Summary

A. Introduction

This document is an Addendum to the Final Environmental Impact Report (the "Final EIR") (State Clearinghouse No. 2005051145) for the Carson Marketplace Project which was certified by the City of Carson in 2006 (the "Approved Project"). One component of the Approved Project is the use of a flare system as part of the Project site's overall landfill gas collection system. Since the Final EIR was prepared and certified by the City, the SCAQMD, for reasons that have nothing to do with the Approved Project, has temporarily suspended the issuance of permits for flare systems. In light of this temporary circumstance, the Applicant is proposing an alternate method to the handling of landfill gas emissions. With the exception of this change, the Modified Project is identical to the Approved Project. The overall purpose of this Addendum is to analyze this proposed change and to determine whether implementation of the Modified Project would result in any new significant environmental impacts which were not identified in the Final EIR or whether the previously identified significant impacts would be substantially more severe under the Modified Project. The Final EIR is hereby incorporated by reference.[1]

B. CEQA Authority for an Addendum

The California Environmental Quality Act ("CEQA") and CEQA Guidelines establish the type of environmental documentation that is required when changes to a project occur after an EIR is certified. Section 15164 (a) of the CEQA Guidelines states that:

> "The lead agency or responsible agency shall prepare an addendum to a previously certified EIR if some changes or additions are necessary but none of the conditions described in Section 15162 calling for preparation of a subsequent EIR have occurred."

Section 15162 of the CEQA Guidelines states that preparation of a subsequent EIR is required when there are substantial changes proposed to a project, or substantial changes occur with respect to circumstances, or new information becomes available which

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[1] *The Carson Marketplace Final EIR, January 2006, is available for review at the City of Carson, Planning Division, 701 E. Carson Street, Carson, California 90745.*

could lead to new significant environmental effects or a substantial increase in the severity of previously identified significant effects. Likewise, California Public Resources Code ("PRC") Section 21166 states that unless one or more of the following events occur, no subsequent or supplemental environmental impact report shall be required by the lead agency or by any responsible agency:

- Substantial changes are proposed in the project which will require major revisions of the environmental impact report;
- Substantial changes occur with respect to the circumstances under which the project is being undertaken which will require major revisions in the environmental impact report; or
- New information, which was not known and could not have been known at the time the environmental impact report was certified as complete, becomes available.

The analysis in this Addendum evaluates the proposed changes associated with the Modified Project in order to determine whether any significant environmental impacts that were not identified in the Final EIR would result or whether previously identified significant impacts would be substantially more severe. As demonstrated by the analysis herein, the Modified Project would not result in any additional significant impacts nor would it substantially increase the severity of previously anticipated significant impacts.

C. Summary of Environmental Effects, Mitigation Measures, and Level of Significance Mitigation

This Addendum analyzes the Modified Project and describes the modifications to the Final EIR that are necessary to reflect the Modified Project. For all environmental issues, the Addendum demonstrates that the Modified Project would not result in new significant impacts or substantial increases in the severity of previously identified impacts and that, as a result, no supplemental or subsequent environmental impact report is required.

II. Project Description

A. Project Location and Surrounding Uses

The Project site is located in the City of Carson, within the City's Redevelopment Project Area No. 1, Merged and Amended. Located in the South Bay area of Los Angeles County, this currently undeveloped site is located approximately 17 miles south of downtown Los Angeles and approximately 6.5 miles east of the Pacific Ocean, as shown in the regional and vicinity map provided in Figure 1 on page 4. The Project site is comprised of approximately 168 acres located southwest of the San Diego Freeway (I-405) at and north of the Avalon Boulevard interchange. The Project site consists of two components. The majority of the Project site, consisting of 157 acres, is located south of Del Amo Boulevard, while the remaining 11 acres are located north of Del Amo Boulevard.

The Project site is bounded by a nursery and the Dominguez Hills Golf Course to the north, the Torrance Lateral Flood Control Channel and residential uses to the south and west, industrial uses to the west and the I-405 Freeway to the east. An aerial photograph of the Project site that also identifies these adjacent uses is provided as Figure 2 on page 5.

B. Summary of the Approved Project and Modified Project

1. Approved Project

The Final EIR for the Approved Project analyzed the potential environmental impacts of constructing and operating 1,995,125 square feet (sq. ft.) of commercial floor area, a 300-room hotel, and 1,550 residential units (1,150 for-sale units and 400 rental residential units).[2] The Approved Project allows for a wide range of land uses in order to create a diversity of on-site activity that responds to the future needs and demands of the southern California economy. In order to fully respond to these demands, the

[2] *The total amount of commercial floor area includes 200,000 sq. ft. for the development of the 300-room hotel.*

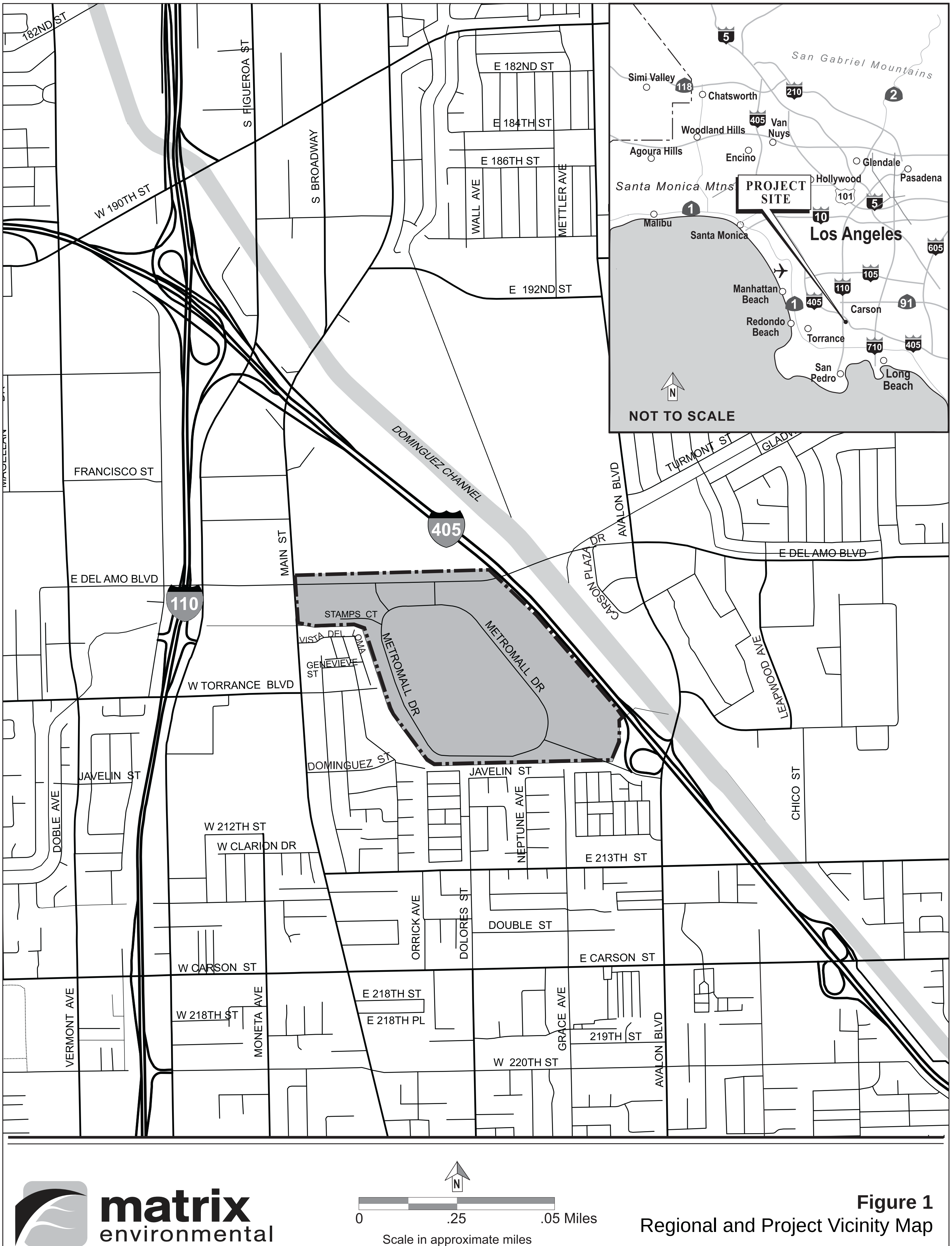

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Figure 1
Regional and Project Vicinity Map

Source: Thomas Guide 2004 and Matrix Environmental, 2009

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Figure 2
Aerial Photograph of Site and Surrounding Uses

Source: Keyhole 2004 and Matrix Environmental 2009

Approved Project included an Equivalency Program that allows the composition of on-site development to be modified in a manner that does not increase the Project's impacts on the environment. For example, office uses might be developed in place of retail uses subject to the provisions of the Equivalency Program as set forth in the Carson Marketplace Specific Plan.

(a) Former On-Site Landfill Operations

The 157-acre portion of the Project site that is located south of Del Amo Boulevard was used as a Class II landfill under an Industrial Waste Disposal Permit issued to Cal Compact, Inc. by the County of Los Angeles. Landfilling on the 157-acre site began in 1959, shortly after the banning of incinerators in Los Angeles County in 1957. Landfilling occurred from April 1959 to December 1964 with an approximate closing date of February 1965.

As a result of contamination on and adjacent to the landfill, the 157-acre site is listed by the State of California Department of Toxic Substances Control (DTSC) as a hazardous substances site. On March 18, 1988, Remedial Action Order No. HSA87/88-040 was issued for the Project site requiring the implementation of remedial activities.

Due to the size and complexity of the former landfill site, DTSC divided its remediation into two operable units.[3] The Upper Operable Unit (Upper OU) consists of the site soils, the waste zone above and within the Bellflower Aquitard, and the Bellflower Aquitard down to but not including, the Gage Aquifer. The Lower Operable Unit (Lower OU) is composed of the Gage, Lynwood, and Silverado Aquifers, and all other areas impacted by the geographic extent of any hazardous substances which may have migrated or may migrate from the aforementioned areas or from the Upper OU. The operable units are also established to prioritize the remedial response to the areas of known impacts (Upper OU) versus potential impacts (Lower OU).

Investigations of the Upper OU documented the presence of landfill gases (methane and carbon dioxide) as well as volatile organic compounds (VOCs) and metals in the landfill's soil and groundwater. A Remedial Action Plan (RAP) was prepared and approved

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[3] *Federal regulations at 40 CFR 300.5 define an operable unit as "…a discrete action that comprises an incremental step toward comprehensively addressing site problems. This discrete portion of a remedial response manages migration, or eliminates or mitigates a release, threat of release, or pathway of exposure. The cleanup of the site can be divided into a number of operable units, depending on the complexity of the problems associated with the site. Operable units may address geographical portions of a site, specific site problems, or initial phases of an action, or may consist of any set of actions performed over time or any actions that are concurrent but located in different parts of a site."*

by DTSC for the Upper OU in 1995. A RAP for the Lower OU was prepared to address the Lower OU. The RAP for the Lower OU was approved by DTSC on January 24, 2005.

Implementation of the Upper OU RAP is required to make the site safe for the Approved Project. Implementation of the Lower OU RAP would be protective of groundwater resources but is not required to make the site safe for the Approved Project.

(b) Site Remediation

The recommended remedial action set forth in the Upper OU RAP included: (1) containment of the impacted soil and buried waste through the use of a clay cap; (2) extraction and treatment of the groundwater; (3) collection and treatment of landfill gas extraction; and (4) long-term monitoring of the groundwater and landfill gases.

The Applicant proposed to implement the RAP for the Upper OU, with refinements in certain technologies based on improvements in science and engineering since 1995, but with the same performance goals of controlling exposure pathways and migration. More specifically, the Applicant proposed to use a Linear Low Density Polyethylene (LLDPE) membrane cap rather than a clay cap for the waste prism. In addition, the Approved Project identified alternative designs that may be used to enhance gas control and groundwater treatment. The Landfill Gas Extraction and Treatment System identified in the Final EIR would be similar to the system described in the RAP but would be improved by adding both horizontal and vertical wells within the site and not just around the landfill site boundary. The system would be designed to automatically collect condensate and deliver landfill gas to a treatment facility that would include a flare system.

Based on the size of the landfill site and the need of the perimeter landfill gas control, the RAP indicated that the landfill gas treatment will likely require the construction of a flare unit including related collection headers, blowers, and gas sampling and processing components. The RAP provides that collected landfill gas will be delivered from the header system to the flare by a blower. The gas is to pass through an automatic shut-off valve and a flame arrestor to prevent flash back. Landfill gas would be mixed with dilution air for efficient combustion at the flare burner elements. Dilution is to be automatically introduced into the flare by a dilution air valve regulated by the combustion temperature. Supplemental fuel (natural gas or propane) would be automatically introduced into the flare to maintain the required combustion temperature and thermal efficiency. The flare, which is subject to SCAQMD requirements, would be equipped with standard safeguard controls and other required air emission control devices to monitor operating conditions and shut down the system when appropriate. The flare would be constructed or shielded from the traveling motorists to minimize or reduce the potential for visual distraction.

Subsequent to completion of the Final EIR, a permit application was prepared for the construction and operation of a landfill gas treatment system, which is consistent with the preferred landfill gas control, collection and treatment system in the Final RAP.[4] The permit application and supporting documentation are provided as Attachment 1 of this Addendum.

The proposed treatment system would consist of the following major equipment: (1) centrifugal gas blowers; (2) combustion gas blowers; (3) purge blower; (4) flame arrestors; and (5) Zink Ultra Low Emission Flares. The two enclosed flares would have a 99 percent minimum destruction efficiency for non-methane hydrocarbons (NMHCs) with a retention time of 0.7 seconds at 1,800 degrees Fahrenheit. Flare 1 would be rated at a maximum of 250 standard cubic feet per minute (scfm) with a diameter of four feet and height of 40 feet. Flare 2 would be rated at a maximum of 450 scfm with a diameter of five feet and also with a height of 40 feet. If extracted landfill gas contains less than 30 percent methane, the use of supplemental fuel (natural gas or propane) may be required. As such, provisions would be made to connect a natural gas line or propane tank line to the flare station.

2. Modified Project

The Applicant is seeking one modification to the Approved Project from what was previously entitled by the City. This change is discussed in detail below, but generally consists of introduction of an alternate treatment method to the proposed flare system.

The reason an alternate method to the flare system has been proposed is that the SCAQMD is required to make substantial changes to its permitting program as a result of a recent court ruling regarding an invalidated rule.[5] Because of this decision, the SCAQMD cannot at this time issue Permits to Construct that rely on credits from Rule 1309.1 Priority Reserve, or that rely on a Rule 1304 offset exemption. This moratorium on issuance of certain permits includes thermal destruction treatment systems (flares). The SCAQMD plans to readopt the invalidated rule, or other appropriate program, but it is expected that it will likely take at least a year. Since the SCAQMD will only issue a complete permit to construct/operate, the permit would have to cover both the extraction and collection system and the treatment system. As a result, if the Applicant proceeds using the original design with a thermal destruction treatment system, then a substantial delay in the issuance of a SCAQMD permit could occur. Therefore, the Applicant would be forced to postpone

[4] *Bryan A. Stirrat & Associates, Application for Permit to Construct and Permit to Operate Landfill Gas Treatment System, August 2008.*

[5] *SCAQMD, Barry Wallerstein, Executive Officer, Memorandum Regarding Moratorium on Issuance of Certain Air Permits, dated January 9, 2009.*

construction of the landfill gas collection and extraction system until the rule change is complete. The Applicant has worked with both DTSC and SCAQMD to develop an interim treatment system that would satisfy the requirements of the RAP, but would also not be impacted by the recent court ruling. The proposed treatment system is a granular activated carbon and potassium permanganate (GAC) system intended to provide landfill gas treatment in the interim until the originally proposed flare system can be permitted by the SCAQMD and installed. The proposed modification to the treatment system will allow the Applicant to proceed with the construction of the collection and extraction system. Further, should the SCAQMD not be able to issue permits for flare systems in the future, the GAC system would be kept operational on an on-going basis.

GAC treatment of landfill gas has proven to be a cost effective method for removal of toxic air contaminants (TACs), especially on older, inactive landfills where higher British thermal unit (BTU) landfill gas and flow rates are not possible. Also, due to the phasing of development of the site and build-out of the gas extraction system, the GAC system is suited for treatment of the low volume of landfill gas expected to be extracted from the initial phases of the system.

The GAC treatment system would utilize the same landfill gas extraction and condensate handling system's basic elements as those anticipated to be originally used in support of the Approved Project. The GAC system would be designed to process a maximum of 350 scfm of landfill gas in comparison to the flare system at 750 scfm. The inlet of the treatment facility would be equipped with a knockout vessel rated for removal of particulates and free liquids and would be designed to operate with one blower in operation, and one blower as a 100 percent backup. These blowers would be designed for an operational capacity of 500 scfm of landfill gas each as they would also be used for the future flares or expansion of the GAC as the landfill gas flow increases with gas extraction system additions.

After the landfill gas enters the suction side of the operating blower, it would be discharged under positive pressure into a series of four 2,000 pound carbon vessels, each containing 2,000 pounds of GAC. The flow through these vessels is as follows: the extracted landfill gas will flow through three canisters connected in series, with the fourth canister serving as a standby to be utilized when any one of the three primary GAC vessels is saturated and requires servicing, such as carbon change-out. By use of valves, the landfill gas can be routed to any or each of these GAC vessels. During normal operation the landfill gas is routed into the primary GAC vessel, out of the primary and into the secondary and tertiary vessels. The output from the GAC vessel system is then discharged to a second series of two 2,000 pound treatment vessels which each contain 2,000 pounds of potassium permanganate. The first vessel will act as the treatment vessel with the second vessel serving as a standby to be utilized when the primary vessel is saturated and requires servicing, such as potassium permanganate change-out. The exhaust from the potassium permanganate vessel is discharged through a flame arrestor with differential pressure indicator and then out to the atmosphere through a vent stack with a maximum height of 50 feet.

During operations, monitoring of Total Gaseous Non-Methane Non-Ethane Organic Compounds (TGNMNEOCs) would be performed at the inlet and outlet of the GAC and recorded on a routine basis using a Photo Ionization Detector (PID). When the monitoring indicates the primary vessels are approaching saturation with VOCs, the gas stream would be routed to the backup vessel while the primary vessel is being replenished.

C. Necessary Actions

This Addendum, along with the Final EIR, is intended to cover all discretionary approvals that may be required to construct or implement the Modified Project. The following action is addressed by this Addendum, and is added to those approvals listed in the Approved Project's Final EIR:

- Approval of an amended Mitigation Monitoring and Reporting Program (City of Carson, Planning Division).

III. Environmental Impact Analysis

This section provides a comparative analysis of the environmental impacts of the Modified Project with those of the Approved Project as set forth in the Final EIR. As the proposed modification to the Approved Project is very limited in scope, the analytic part of this Addendum starts with an analysis which determines which environmental topics are affected by the Modified Project and require detailed analysis. As such, the following is an issue-by-issue review of all of the Final EIR's environmental analysis sections. This analysis identifies those issues that require further analysis, and where appropriate, provides the supporting rationale for the determination that no additional analysis is required in support of the Modified Project.

- *IV.A, Land Use:* The proposed modifications to the Approved Project would not result in any changes to the approved land uses. Therefore, the Modified Project would be consistent with the findings of the Final EIR for the Approved Project with regard to land use, and no further analysis of the Modified Project is required.

- *IV.B, Visual Resources:* The proposed modifications to the Approved Project would not result in any changes to the approved land uses or other development parameters that affect visual resource issues. In addition, major equipment associated with the GAC system would generally fit within the same footprint as the flare system associated with the Approved Project. Therefore, the Modified Project would be consistent with the findings of the Final EIR for the Approved Project with regard to visual resources, and no further analysis of the Modified Project is required.

- *IV.C, Traffic,* Circulation, and Parking: The proposed modifications to the Approved Project would not result in any changes to the approved land uses. As a result, the Approved Project's trip generation, circulation and parking requirements would not change with the incorporation of the Modified Project. Therefore, the Modified Project would be consistent with the findings of the Final EIR for the Approved Project with regard to traffic, circulation, and parking, and no further analysis of the Modified Project is required.

- *IV.D, Hazards and Hazardous Materials:* The proposed modification to the Approved Project would not result in any changes to the approved land uses. As a result and consistent with the Final EIR, operation of the Modified Project would involve the limited use and storage of hazardous materials associated with residential and commercial uses, such as cleaning solvents and pesticides. As concluded in the Final EIR, the use and storage of such materials would occur in compliance with applicable standards and regulations. Therefore, the use and storage of these materials would not pose significant hazards to the public or the environment through the transport, use, or disposal of hazardous materials. Based on this conclusion, no further analysis of this aspect of Approved Project construction and operations is needed. However, as the Applicant proposes an alternate method to the proposed flare system, potential hazard impacts related to air toxic emissions are analyzed in detail later on in this Addendum.

- *IV.E, Geology and Soils:* As with the Approved Project, the Modified Project would be in compliance with City and State regulations and is not expected to expose people or structures to any unstable geologic conditions or seismically related geologic hazards that would result in substantial damage to structures or infrastructure or exposure of people to risk of loss, injury, or death. Since the Modified Project would not exceed the thresholds of significance relative to City and State regulations, or expose persons to geologic hazards, no unavoidable significant impacts would occur. Therefore, the Modified Project would be consistent with the findings of the Final EIR for the Approved Project with regard to geology and soils, and no further analysis of the Modified Project is required.

- *IV.F, Surface Water Quality:* The proposed modifications to the Approved Project would not result in any changes to the approved land uses or changes in construction activities that would alter impacts to surface water quality. As with the Approved Project, the Modified Project through the implementation of proposed drainage and erosion control plans, Best Management Practices, and water filtering and flood control devices, would not increase existing pollution and contamination, create a nuisance as defined in Section 13050 of the California Water Code, cause regulatory standards to be violated, or result in a permanent, adverse change to the movement of surface water sufficient to produce a substantial change in the current or direction of flow. Therefore, impacts associated with surface water quality would be less than significant. Therefore, the Modified Project would be consistent with the findings of the Final EIR for the Approved Project with regard to surface water quality, and no further analysis of the Modified Project is required.

- *IV.G, Air Quality:* The Approved Project included a flare system, which is considered a combustion source and would generate approximately 11.5 pounds per day of NOx, 27.5 pounds per day of CO, 9.6 pounds per day of PM_{10} and $PM_{2.5}$, and 3.6 pounds per day of SOx.[6] The alternate treatment method to the proposed flare system (GAC system), would produce no NOx, CO, SOx, or measurable PM_{10} and $PM_{2.5}$. The calculation for total VOCs is less than 0.5 pounds per day from the vent stack for the system operating at 350 scfm, which is comparable to the flare system (0.22 lbs/day of VOCs). The health risk implications are discussed in Section IV.D, Hazards and Hazardous Materials.

[6] *Bryan A. Stirrat & Associates, Application for Permit to Construct and Permit to Operate Landfill Gas Treatment System, August 2008.*

As a result, the Modified Project would not result in air quality impacts that are greater than those of the Approved Project. Therefore, the Modified Project would be consistent with the findings of the Final EIR for the Approved Project with regard to air quality, and no further analysis of the Modified Project is required.

- *IV.H, Noise:* The proposed modifications to the Approved Project would not result in any changes to the approved land uses or potential sources of noise. Therefore, the Modified Project would be consistent with the findings of the Final EIR for the Approved Project with regard to noise, and no further analysis of the Modified Project is required.

- *IV.I, Public Services:* The proposed modifications to the Approved Project would not result in any changes to the approved land uses or the required public services associated with these uses. Therefore, the Modified Project would be consistent with the findings of the Final EIR for the Approved Project with regard to public services, and no further analysis of the Modified Project is required.

- *IV.J, Utilities:* The proposed modifications to the Approved Project would not result in any changes to the approved land uses or the required utility demands (e.g., water demand) associated with these uses. Therefore, the Modified Project would be consistent with the findings of the Final EIR for the Approved Project with regard to utilities, and no further analysis of the Modified Project is required.

Based on the analyses presented above, the Modified Project would not result in a new significant impact or substantially worsen a previously identified significant impact with regard to all of the environmental issues analyzed in the Final EIR, with one exception. As such, additional analysis of potential impacts with regard to the issue of hazards and hazardous materials is required. This additional analysis is presented in the following section of this Addendum.

A. Hazards and Hazardous Materials

1. Approved Project Impacts

The remediation of the 157-acre landfill is being implemented as part of the Approved Project in compliance with the approved Final Remedial Action Plans (RAPs). Due to the size and complexity of the former landfill site, DTSC divided the landfill site vertically into two principal operable units (subsurface contamination in soil and groundwater).[7,8] Remedial Action Plans (RAPs) were approved by the California Department of Toxic Substances Control (DTSC) for the Upper and Lower Operable Units. The RAP for the Upper Operable Unit (OU) and the RAP for the Lower OU were both approved by DTSC in 2005. Copies of the approved RAPs were provided in Appendix E of the Final EIR. DTSC conducted its own environmental review as part of the approval process for the RAPs. These analyses concluded that implementation of the RAPs would result in less than significant impacts with regard to all environmental issues of concern. As such, the Final EIR did not provide an analysis of the RAPs but instead provided information regarding the RAPs to place the Approved Project in a context of its existing regulatory approvals. A summary of the pertinent information regarding the RAPs is provided below.

a. Remedial Action Plans

(1) Final Remedial Action Plan for the Lower Operable Unit

The Final Remedial Action Plan (Final RAP) for the Lower OU addressed the potential impact of groundwater contamination in the Upper OU on the Lower OU. The Lower OU is defined as the deeper hydrostratigraphic unit beginning at the Gage aquifer and extending down to the Silverado aquifer. Based on groundwater monitoring and

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[7] *Federal regulations at 40 CFR 300.5 define an operable unit as "…a discrete action that comprises an incremental step toward comprehensively addressing site problems. This discrete portion of a remedial response manages migration, or eliminates or mitigates a release, threat of release, or pathway of exposure. The cleanup of the site can be divided into a number of operable units, depending on the complexity of the problems associated with the site. Operable units may address geographical portions of a site, specific site problems, or initial phases of an action, or may consist of any set of actions performed over time or any actions that are concurrent but located in different parts of a site."*

[8] *Impacts to surface water quality are addressed in Section IV.F, Surface Water Quality.*

chemical fate and mobility modeling data, in conjunction with remedial actions for the Upper OU, the risk posed to the Lower OU was considered to be minimal. The Final RAP for the Lower OU concluded that additional remedial investigation of the Lower OU was not warranted since no VOCs were present at detectable concentrations in the Gage aquifer (Lower OU).[9] However, because of the potential for contamination of drinking water and to satisfy the applicable regulatory provisions,[10] a response action was selected as the remedy for the Lower OU as it will provide the necessary controls to detect any future chemical impacts to the Lower OU. Under the DTSC-approved remedy, the groundwater monitoring would be conducted on a quarterly basis for a period of two years, followed by semi-annual monitoring for an additional two years, and annual monitoring every third year thereafter for up to 50 years. If any VOC is detected in the Lower OU during that period, the monitoring events would be increased to quarterly for a period of two years.

(2) Final Remedial Action Plan for the Upper Operable Unit

A Final RAP was prepared for the Upper OU and approved by DTSC in 1995. The Final RAP was based on site-specific data gathered from the Remedial Investigation (RI) for the Upper OU. The Final RAP summarized the findings of the RI, Baseline Health Risk Assessment (BRA), and Feasibility Study (FS). The Final RAP described the remedial alternative chosen for the Upper OU, how the Remedial Action Objectives were to be met, and an implementation schedule. The primary remedial action objective was to provide protection for human health and the environment. More specifically, objectives included: control surface water infiltration into the waste prism to reduce the generation of leachate; prevent direct contact with contaminated soil or buried waste; capture, control, and treat on-site contaminated groundwater and the plume that is now off site; and control or prevent potential releases of landfill gas to the atmosphere.

Based on the RI and the BRA, the RAP indicated that the remedial action should include a combination of the following actions:

- Construction of a low-permeability clay cover system for the entire landfill site;[11]
- Installation of groundwater extraction and treatment systems along the downgradient side of the landfill site;
- Installation of a perimeter landfill gas extraction, control, and treatment system along the perimeter of the landfill site within the waste zone;

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[9] *URS, Op. Cit, page 7.*

[10] *The regulatory provisions include CERCLA, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 Code of Federal Regulations [CFR] Section 300.415(b)(2)), and the California Health and Safety Code section 25323.*

[11] *Please note that the type of landfill liner is being revised and reviewed by DTSC.*

- Implementation of long-term monitoring of the groundwater and landfill gases; and

- Long term maintenance of the cap.

The RAP requires the installation of a landfill gas extraction, control, and treatment system. The primary objectives of the landfill gas control system are to prevent the migration and accumulation of combustible gas into enclosed buildings and to prevent off-site landfill gas migration.

The RAP provides that the preferred landfill gas control, collection and treatment system consist of (1) a series of vertical gas extraction wells placed within the outer edges of the waste cells along the perimeter of the landfill; (2) thermal destruction of collected gas using a flare unit, and (3) other gas monitoring and venting systems, if determined necessary and applicable.

Based on the size of the landfill site and the need for perimeter landfill gas control, the RAP indicates that the landfill gas treatment would likely require the construction of a flare unit including related collection headers, blowers, and gas sampling and processing components. The RAP provides that collected landfill gas would be delivered from the header system to the flare by a blower. The gas is to pass through an automatic shut-off valve and a flame arrestor to prevent flash back. Landfill gas would be mixed with dilution air for efficient combustion at the flare burner elements. Dilution is to be automatically introduced into the flare by a dilution air valve regulated by the combustion temperature. Supplemental fuel (natural gas or propane) would be automatically introduced into the flare to maintain the required combustion temperature and thermal efficiency. The flare, which is subject to SCQAMD requirements, would be equipped with standard safeguard controls and other required air emission control devices to monitor operating conditions and shut down the system when appropriate. The flare would be constructed or shielded from the traveling motorists to minimize or reduce the potential for visual distraction.

b. SCAQMD Permit Application

Subsequent to certification of the Final EIR by the City, a permit application was prepared for the construction and operation of a landfill gas treatment system, which is consistent with the preferred landfill gas control, collection and treatment system called for in the Final RAP.[12] The permit application and supporting documentation are provided as Appendix A to this Addendum.

[12] *Bryan A. Stirrat & Associates, Application for Permit to Construct and Permit to Operate Landfill Gas Treatment System, August 2008.*

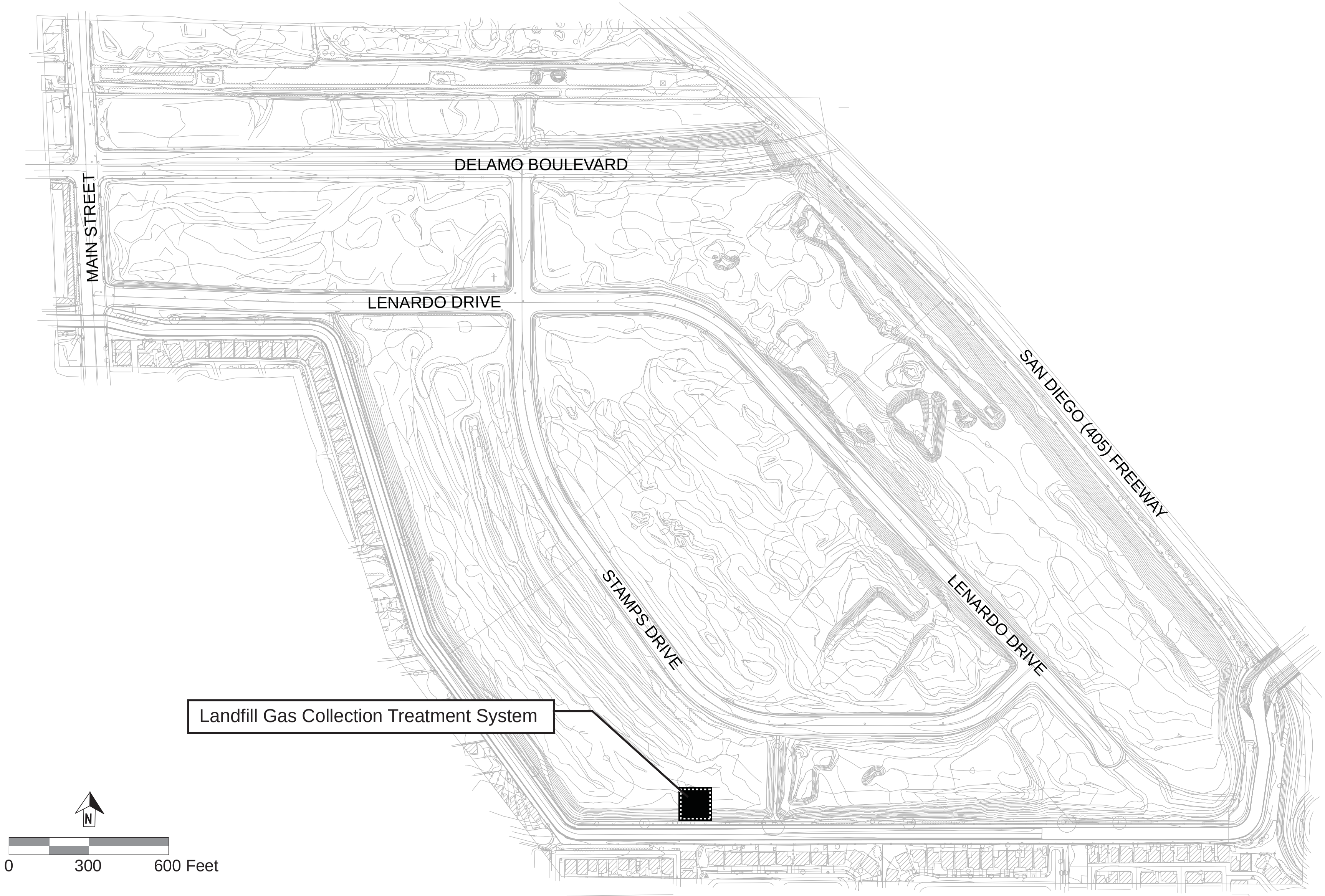
The originally proposed landfill gas treatment system would consist of the following major equipment: (1) centrifugal gas blowers; (2) combustion gas blowers; (3) purge blower; (4) flame arrestors; and (5) Zink Ultra Low Emission Flares. The two enclosed flares would have a 99 percent minimum destruction efficiency for non-methane hydrocarbons (NMHCs) with a retention time of 0.7 seconds at 1,800 degrees Fahrenheit. Flare 1 would be rated at a maximum of 250 standard cubic feet per minute (scfm) with a diameter of four feet and height of 40 feet. Flare 2 would be rated at a maximum of 450 scfm with a diameter of five feet and also with a height of 40 feet. If extracted landfill gas contains less than 30 percent methane, the use of supplemental fuel (natural gas or propane) may be required. As such, provisions would be made to connect a natural gas line or propane tank line to the flare station.

As part of the SCAQMD permit application and in compliance with SCAQMD Rules 212 and 1401, a screening risk assessment using SCAQMD guidelines was conducted for air toxics to evaluate compliance with SCAQMD standards. The flare system would also result in combustion emissions and, therefore, an air quality impact analysis for criteria pollutants was also conducted. The full report of the air dispersion modeling and health risk assessment is included in Appendix A to this Addendum. The health risk screening analysis was conducted in compliance with the guidelines presented in SCAQMD's "Risk Assessment Procedures for Rules 1401 and 212", Version 7.0, July 2005.

The originally proposed landfill gas treatment system would consist of a gas collection system and two flares which are designed with Lowest Achievable Emission Rate (LAER) and incorporate Best Available Control Technology for air toxics (T-BACT). The HRA and air quality impact analyses were conducted based on two flares operating at a maximum process flow rate of 700 scfm combined (worst case). As shown in Figure 3 on page 18, the control element of the landfill gas collection and control system would be located in a small parcel at the southwest corner of the Project site. The system would operate 24 hours per day, 365 days per year.

(1) Emission Rates

Representative emissions of the landfill gas were derived from a combination of sample gases collected from the Project site. Eighteen carcinogenic and toxic contaminants were targeted and analyzed, including the list of contaminants listed in the Core Group as specified by SCAQMD Rule 1150.1. A copy of the landfill gas analysis is included in Appendix A to this Addendum. Table 1, as presented below, shows a list of the contaminants, corresponding CAS numbers, uncontrolled emissions at maximum flow rate, and controlled emissions calculated based on a control efficiency of 99 percent.



Source: Tetra Tech, Inc. 2005; Matrix Environmental, 2009

matrix environmental

Figure 3

Location of Landfill Gas Collection Treatment System

Table 1
Air Toxic Emissions from Flare Operations

Contaminant	CAS #	Emission Data: Uncontrolled Emissions (mg/m^3)	99 Percent Controlled (mg/m^3)	Total Max Flares at 700 scfm (gm/sec)
Benzene	71-43-2	26.61	0.27	8.79E-05
1,4-Dichlorbenzene	106-46-7	4.33	0.04	1.43E-05
1,2-Dichlorethane	107-06-2	2.60	0.03	8.58E-06
1,1-Dichloroethylene	75-35-4	130	0.01	4.31E-06
Tetrachloroethylene	127-18-4	39.14	0.39	1.29E-04
Toluene	108-88-3	53.50	0.54	1.77E-04
Trichlorethylene	79-01-6	33.60	0.36	1.11E-04
Vinyl Chloride	75-01-6	13.80	0.14	4.56E-05
Xylenes	1330-20-7	91.18	0.91	3.01E-04
Chlorobenze	108-90-7	67.67	0.68	2.24E-04
1,1-Dichloroethane	75-34-3	0.30	0.003	9.84E-07
Dichlormethane	75-09-2	9.28	0.09	3.06E-05
Hydrogen Sulfide	7783-06-4	4.43	0.04	1.46E-05
			Total Contaminants	**1.15E-03**

Source: E-Tech Environmental, 2008.

(2) Dispersion Modeling and Health Risk Assessment

The U.S. EPA approved ISCST3 model was used in the assessment. SCAQMD recommends the use of this model, along with a full year of meteorological data, to estimate the maximum annual average ground-level air pollutant concentrations that could occur at any point outside the property lines of the landfill operations center. The results of the dispersion modeling are considered as conservative and tend to over-estimate the exposure to the population.

Approaches used for the health risk assessment were based on algorithms developed by Office of Environmental Health Hazard Assessment (OEHHA) and health risk calculation methodology established by the SCAQMD. Cancer risk caused by each carcinogenic contaminant was calculated using cancer potency, dose through inhalation, and daily breathing rate. As recommended by the SCAQMD's HRA guidelines, an exposure value factor (EVF) was used for off-site worker receptors of 0.38 based on 245 days per year of exposure over 40 years. Residential receptors used an EVF of 0.96 based on 350 days per year of exposure over 70 years.

Table 2
Summary of Flare Operation Hazard Impacts

Contaminant	Cancer Risk Commercial	Cancer Risk Residential	Chronic Risk Commercial	Chronic Risk Residential	Acute Risk Commercial	Acute Risk Residential
Benzene	4.17E-09	3.72E-09	1.22E-05	2.14E-06	1.08E-05	8.24E-06
1,4-Dichlorbenzene	2.71E-10	2.42E-10	1.48E-07	2.61E-08		
1,2-Dichlorethane	2.93E-10	2.62E-10	1.78E07	3.14E-08		
1,1-Dichloroethylene			5.11E-07	9.00E-08		
Tetrachloroethylene	1.29E-09	1.15E-09	3.07E-05	5.40E-06	1.03E-06	7.88E-07
Toluene			4.89E-06	8.62E-07	7.61E-07	5.82E-07
Trichlorethylene	3.69E-10	3.29E-10	1.54E-06	2.71E-07		
Vinyl Chloride	5.84E-09	5.21E-09			4.03E-06	3.09E-08
Xylenes			3.57E-06	6.29E-07	2.18E-06	1.67E-06
Chlorobenze			1.86E-06	3.27E-07		
1,1-Dichloroethane	2.66E-12	2.38E-12				
Dichlormethane	5.09E-11	4.54E-11	6.36E-07	1.12E-07	3.48E-07	2.67E-07
Hydrogen Sulfide			1.22E-05	2.14E-06	5.55E-05	4.25E-05
Total Risk	**1.23E-08**	**1.10E-08**	**6.83E-05**	**1.20E-05**	**7.06E-05**	**5.41E-05**

Source: E-Tech Environmental, 2008.

The results of the health risk assessment are included in Table 2 below. The results of the health risk assessment indicate that the MICRs at the nearest commercial and residential building are less than the ten in a million (1.0 E-05) threshold[13] and the acute and chronic health indices are less than the 1.0 threshold. The modeled results and risk assessment show that emissions from landfill gas collection and treatment would not cause significant cancer risks to the closest receptors and operation of the system would be in compliance with SCAQMD Rule 1401. It is also important to note that modeled results of maximum concentrations of each of the criteria pollutants are also well below the regulated thresholds as specified by both State and federal ambient air quality standards (see Appendix A to this Addendum).

(3) Landfill Gas Monitoring

The RAP requires quarterly air and soil monitoring of landfill gas. The purpose of the monitoring is to provide early warning of potential off-site migration and to ensure proper control of the landfill gases. With regard to air sampling, requirements for the gas monitoring include the following: (1) the concentration of methane gas must not exceed 1.25 percent by volume in air within on-site structures, (2) the concentration of methane gas must not exceed 5 percent by volume in air at the landfill property boundary, and

[13] *SCAQMD recommends a cancer risk significance threshold of 10 in a million for facilities that implement best available control technology for toxics (T-BACT).*

(3) trace gases must be controlled to prevent adverse acute and chronic exposure to toxic and/or carcinogenic compounds. The monitoring data would be used to adjust the gas collection and treatment measures as necessary so that the gas control and treatment system would be properly implemented.

The landfill monitoring system would also include a perimeter gas monitoring network. The monitoring network would use 18 monitoring wells/probes distributed along the entire landfill property perimeter within the native soil. Spacing of the wells would be approximately 1,000 feet along the north and east boundaries and 500 feet along the south and west boundaries near the neighboring residential area. The perimeter gas monitoring would include the analysis of air contaminants, in particular, benzene, vinyl chloride and total organic compounds measured as methane. The monitoring program would be conducted on a quarterly basis for 30 years.

2. Modified Project Impacts

Consistent with the Approved Project, the Modified Project would implement requirements of the Final RAP, which include the installation of a landfill gas extraction, control, and treatment system. The primary objectives of the landfill gas control system are to prevent the migration and accumulation of combustible gas into enclosed buildings and to prevent off-site landfill gas migration. As discussed above, the Modified Project would include the use of a granular activated carbon and potassium permanganate (GAC) system intended to provide landfill gas treatment in the lieu of the originally proposed flare system on an interim basis, while also recognizing the potential that the GAC treatment system may also be used in lieu of the flare system in the event the SCAQMD is not able to issue operating permits for flare systems into the future. Use of a GAC treatment system would provide the necessary treatment level and would be consistent with the preferred landfill gas control, collection and treatment system in the Final RAP. The proposed modification to the treatment system would allow the Applicant to proceed with the construction of the collection and extraction system until such time the SCAQMD is able to issue operating permits for flare systems.

The GAC treatment system would utilize the same basic elements of the landfill gas extraction and condensate handling systems as those for the Approved Project. The GAC system would be designed to process a maximum of 350 scfm of landfill gas in comparison to the flare system which would operate at a maximum operating capacity of 700 scfm. Consistent with the Approved Project, the GAC system would also be located in a small parcel at the southwest corner of the site. The system would operate 24 hours per day, 365 days per year.

During operations, monitoring of Total Gaseous Non-Methane Non-Ethane Organic Compounds (TGNMNEOCs) would be performed at the inlet and outlet of the GAC and recorded on a routine basis using a Photo Ionization Detector (PID). When the monitoring indicates the primary vessels are approaching saturation with VOCs, the gas stream would be routed to the backup vessel while the primary vessel is being replenished.

a. SCAQMD Permit Application

A SCAQMD permit application was prepared for the GAC landfill gas treatment system.[14] The permit application and supporting documentation are provided as Appendix B to this Addendum. Using the laboratory data on samples collected from the GAC system vent stack outlet during the Pilot Test, the GAC system produced no NOx, CO, SOx, or measurable PM_{10} and $PM_{2.5}$. The calculation for total VOCs or TGNMEOCs indicated less than 0.5 pounds per day of VOC emissions from the vent stack for the system operating at 350 scfm. This VOC emission rate is comparable to the flare system (0.22 pounds per day).

As part of the SCAQMD permit application and in compliance with SCAQMD Rules 212 and 1401, a screening risk assessment using SCAQMD guidelines was conducted for air toxics to evaluate compliance with SCAQMD standards. The health screening risk assessment is included in Appendix B to this Addendum and was conducted in compliance with the guidelines presented in SCAQMD's "Risk Assessment Procedures for Rules 1401 and 212", Version 7.0, July 2005.

(1) Emission Rates

As with the Approved Project, representative emissions of the landfill gas were derived from a combination of sample gases collected from then Project site. Eighteen carcinogenic and toxic contaminants were targeted and analyzed, including the list of contaminants listed in the Core Group as specified by SCAQMD Rule 1150.1. A copy of the landfill gas analysis is included in Appendix B to this Addendum. Table 3 on page 23 shows a list of the contaminants, corresponding CAS numbers, uncontrolled emissions at maximum flow rate, and controlled emissions calculated based on a control efficiency of 99 percent. Both the concentration of air toxic contaminates in the untreated gas and the control efficiency of the treatment system would be identical whether treatment includes a GAC system or landfill gas flare system. However, as the GAC system is limited to a maximum exhaust flow rate of 350 scfm and the landfill gas flare system is designed at 700 scfm, the emissions of air toxic contaminants from the GAC treatment system would

[14] *Bryan A. Stirrat & Associates, Application for Permit to Construct and Permit to Operate Landfill Gas Treatment System—GAC/KMN, February 2009.*

Table 3
Air Toxic Emissions from GAC Operations

Contaminant	CAS #	Emission Data: Uncontrolled Emissions (mg/m^3)	Emission Data: 99 Percent Controlled (mg/m^3)	Emission Data: Total Max at 350 scfm (gm/sec)
Benzene	71-43-2	26.61	0.27	4.40E-05
1,4-Dichlorbenzene	106-46-7	4.33	0.04	7.15E-06
1,2-Dichlorethane	107-06-2	2.60	0.03	4.29E-06
1,1-Dichloroethylene	75-35-4	130	0.01	2.16E-06
Tetrachloroethylene	127-18-4	39.14	0.39	6.45E-05
Toluene	108-88-3	53.50	0.54	8.85E-05
Trichlorethylene	79-01-6	33.60	0.36	5.55E-05
Vinyl Chloride	75-01-6	13.80	0.14	2.28E-05
Xylenes	1330-20-7	91.18	0.91	1.51E-04
Chlorobenze	108-90-7	67.67	0.68	1.12E-04
1,1-Dichloroethane	75-34-3	0.30	0.003	4.92E-07
Dichlormethane	75-09-2	9.28	0.09	1.53E-05
Hydrogen Sulfide	7783-06-4	4.43	0.04	7.30E-06
			Total Contaminants	**5.75E-04**

Source: E-Tech Environmental, 2008 and Bryan A. Stirrat & Associates, 2009.

represent approximately 50 percent of the emissions associated with the landfill gas flare system. As the GAC system is intended to be an interim treatment system, 350 scfm would be adequate. If the GAC treatment system were designed at 700 scfm, toxic air contaminant emission rates would be anticipated to be the same as the landfill gas flare system for the Approved Project. As the GAC system does not rely upon combustion as the means of TAC removal, the system would also not release criteria pollutant emissions related to combustion. However, methane emissions destroyed during use of the landfill gas flare system would be released with use of the GAC system and represent approximately 54 percent of the exhaust stream. The issue of methane gas is discussed further below.

(2) Health Risk Assessment

A Tier 2 screening risk assessment was conducted for the GAC system in compliance with the guidelines presented in SCAQMD's "Risk Assessment Procedures for Rules 1401 and 212", Version 7.0, July 2005. Based on the modeling results presented below, a more refined analysis using dispersion modeling is not necessary as screening models generally yield greater, and thus more conservative, impacts than with a dispersion model (e.g., ISCST3).

The results of the screening level analysis indicate that the risk associated with GAC system operations is approximately 0.03 in one million (see Appendix B to this Addendum) and thus, well below the screening level significance threshold of one in one million. These results are generally consistent with the health risk assessment results conducted for the Approved Project's landfill gas flare system. Although the health risk impacts identified for the Approved Project using a detailed HRA were substantially lower, the difference in impacts are related to the methodology employed (use of dispersion modeling and site specific parameters) rather than the quantity of TAC emissions released. Given that the stack height, location, and velocity are similar for both the flare and GAC systems and that the GAC exhaust emissions of TACs are approximately 50 percent of the flare system, it would be anticipated that a detailed HRA using ISCST3 would demonstrate that the health risk associated with the GAC system would also result in approximately 50 percent of the health risk of the landfill gas flare system. As a result, the use of a GAC system, in lieu of the originally proposed flare system, would result in a less than significant impact.

(3) Landfill Gas Monitoring

The landfill gas is approximately 53 percent methane. Methane is not toxic. However, it is flammable and may form explosive mixtures with air. Consistent with the Approved Project, the Modified Project would implement requirements of the Final RAP, which requires quarterly air and soil monitoring of landfill gas to provide early warning of potential off-site migration and to ensure proper control of the landfill gases. The landfill gas collection system would be the same for both the Approved Project and the Modified Project. As such, the blowers and ducting systems would have sufficient capacity to vent the gas through the flare or the GAC system (i.e., overcome pressure drops for either system) to ensure that the concentration of methane gas would not exceed 1.25 percent by volume in air within on-site structures and 5 percent by volume in air at the landfill boundary. In addition, the landfill gas would pass through a flame arrestor with a differential pressure indicator prior to discharging through a vent stack to further limit the potential of explosive mixtures with air. Thus, impacts associated with methane emissions under the Modified Project would be less than significant.

(4) Odor

Potential odiferous emissions from the landfill gas system would primarily be related to VOC emissions. The VOC content in the untreated gas and the control efficiency of the treatment system would be identical whether treatment includes a GAC system or landfill gas flare system. As a result, a 99 percent VOC control efficiency combined with a well engineered stack height and flow rate would effectively reduce any potential odors such that noticeable odors would not occur in the surrounding area. In addition, the GAC system or a landfill gas flare system would be required to comply with mandatory SCAQMD Rules (e.g., SCAQMD Rule 402 (Nuisance), which would further limit the potential odor impacts. Therefore, odor impacts would be less than significant.

3. Mitigation Measures

Mitigation Measures D-1 through D-5 for the Approved Project are required to ensure that any revisions to the RAP are approved by DTSC and that access to the necessary areas for monitoring programs required in the RAPs would be provided. As the Modified Project could include a GAC treatment system or a flare treatment system, Mitigation Measure D-5 has been revised to remove the specific reference to a flare system and replaced with a more general description of the treatment system. In addition, Mitigation Measure D-6 has been included to ensure compliance with the requirements in the RAP in the event that the GAC system is expanded beyond 350 scfm.

The mitigation measures for the Modified Project are as follows:

Mitigation Measure D-1: To the extent the Applicant desires to refine or modify requirements in the RAP, the Applicant shall provide documentation to the City indicating DTSC approval of such refinements or modifications.

Mitigation Measure D-2: The Applicant shall provide documentation to the City indicating DTSC shall permit the proposed residential uses in Development District 1 prior to issuance of any permits for such residential development in Development District 1.

Mitigation Measure D-3: The Applicant shall provide documentation to the City indicating both on- and off-site risks associated with RAP construction have been evaluated to the satisfaction of the DTSC, and at a minimum, perimeter air monitoring shall be completed for dust, particulates, and constituents determined to be Constituents of Concern (COCs).

Mitigation Measure D-4: The Applicant shall provide to the City, documentation indicating that (1) a post remediation risk assessment has been prepared by the Applicant and approved by DTSC; and (2) DTSC has certified that the remedial systems are properly functioning prior to issuance of a Certificate of Occupancy.

Mitigation Measure D-5: The Applicant shall provide documentation to the City indicating that applicable remedial systems and monitoring plans, including the location of the landfill gas treatment facility are in accordance with applicable SCAQMD regulations.

Mitigation Measure D-6: To the extent the Applicant desires to expand the GAC system beyond 350 scfm, the Applicant shall provide documentation to the City indicating DTSC approval of such refinements or modifications. In addition, the Applicant shall provide documentation to the City indicating compliance with SCAQMD requirements and that both on- and off-site risks associated with modification have been evaluated to the satisfaction of the DTSC and SCAQMD.

Mitigation Measure D-7: In the event the SCAQMD in the future is able to issue permits to construct and operate flare stations, the Applicant at that time, shall process an application with the SCAQMD for the originally proposed flare unit, in a timely manner, and commence the installation, and subsequent operation, of the flare unit upon the issuance of the SCAQMD permit.

4. Conclusion

The Modified Project would not introduce new significant impacts or substantially worsen previously identified impacts with regard to hazards. Thus, the environmental impacts of the Modified Project would be consistent with those analyzed in the Final EIR.

IV. List of Preparers

Lead Agency

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- Sheri Repp-Loadsman, Planning Manager
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CARSON MARKETPLACE

ADDENDUM
to the
Final Environmental Impact Report

SCH No. 2005051059

JULY 2009

Appendix A: Application for Permit to Construct and Permit to Operate Landfill Gas Treatment System, August 2008

matrix environmental

Application for Permit to Construct and Permit to Operate Landfill Gas Treatment System

The Boulevards at South Bay, LLC

August 2008

Prepared For:

The Boulevards at South Bay, LLC
c/o LNR Properties
4350 Von Karman Avenue, Suite 2000
Newport Beach, California 92660

Submitted To:

South Coast Air Quality Management District
21865 East Copley Drive
Diamond Bar, California 91765

Prepared By:

Bryan A. Stirrat & Associates
1360 Valley Vista Drive
Diamond Bar, California 91765
(909) 860-7777

TABLE OF CONTENTS

THE BOULEVARDS AT SOUTH BAY, LLC
APPLICATION FOR PERMIT TO CONSTRUCT AND PERMIT TO OPERATE
LANDFILL GAS TREATMENT SYSTEM

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ATTACHMENTS

THE BOULEVARDS AT SOUTH BAY, LLC

SECTION 1.0

APPLICATION

1.0 APPLICATION FOR PERMIT TO CONSTRUCT AND PERMIT TO OPERATE LANDFILL GAS TREATMENT SYSTEM

1.1 APPLICANT

The Boulevards at South Bay, LLC
C/o LNR Properties
4350 Von Karman Avenue, #2000
Newport Beach, California 92660

1.2 CONSULTANT

Bryan A. Stirrat & Associates (BAS)
1360 Valley Vista Drive
Diamond Bar, California 91765
Contact: G.E. Andraos
Phone: (909) 860-7777, ext. 226

1.3 BACKGROUND

The former Cal Compact Landfill (Figure 1) was operated from its opening in April 1959 through its closure in February 1965. The 157 acre Class II landfill accepted both municipal solid waste and specified industrial liquid wastes. Available records indicate that over 90 percent of the liquid wastes were drilling fluids which consisted primarily of water and clay mixtures, with minor heavy metal additives and oily residue. Other wastes received included solvents, oils, sludges, heavy metals, paint sludges, and inorganic salts. The landfill operations consisted of excavation of trenches and the placement and covering of wastes in the trenches. A total of five cells were constructed in the landfill. An interim soil cap overlies all five cells that comprise the entire landfill area. The interim landfill soil cap varies in thickness from approximately 2 feet to over 30 feet and averages approximately 11 feet in thickness across the Site.

The site has been approved for development by the California Environmental Protection Agency's Department of Toxic Substance Control to become the "The Boulevards of South Bay", with requirement of several remedial measures to protect the public and future users. One of these remedial systems is a landfill gas collection and treatment system. The purpose of proposed temporary extraction system is to develop landfill gas generation and composition data in order to design the required permanent collection system. The landfill gas collection and treatment system will be comprised of vertical and horizontal gas wells connected to a header circumscribing the site (Figure 2). The header will terminate at the flare station where the gas will be combusted in one or two (as needed) enclosed flares.

1.4 EQUIPMENT LOCATION

Former Cal-Compact Landfill
20300 Main Street
Carson, California 90745
Contact: Javier Weckmann, VP, TetraTech, Inc.
See Figure 1 and 2

1.5 DESCRIPTION OF GAS TREATMENT EQUIPMENT SKID

This is an application to install a Landfill Gas Treatment Equipment Skid that is designed to process up to a maximum flow of 700 standard cubic feet per minute (scfm) of landfill gas at The Boulevards of South Bay site.

The proposed Treatment System will consist of the following major equipment:

- **Centrifugal Gas Blowers (B–103, B-104):** Mfr.: Houston Service Industries, Inc. HSI-5105 driven by a 40 HP TEFC motor equipped with VFD. A blower performance curve is included in Attachment 1. Tests have been performed to demonstrate no overheating when operating at 50 scfm flow. Also, space is provided on the blower skid for a third smaller blower, e.g., 25-50 scfm operating range. This small blower would either be rented or purchased and installed if the flows from the initial gas extraction area is consistently below 50 scfm.

- **Combustion Air Blowers (B-200, B-201):** Mfr.: TBD. Equipped with 10 HP motor, maximum flow rate 1785 scfm and 3200 scfm, pressure discharge 15 inches w.c. (See Attachment 2)

- **Purge Blower (B-204):** Mfr: TBD. 8" flange size, HP TBD

- **Flame Arrestors (FA-107, FA-108):** Mfr.: Enardo Flame Arrestors, FA-1, model Series 7 inline flame arrestor EN certified, FA-2, model free vent flame arrestor (FVFA) EN certified.

- **Zink Ultra Low Emissions Flare (I-1, I-2):** Mfr.: John Zink Company LLC. Enclosed ground flares. Flare I-1 maximum flow rate 250 scfm, 6.83 MM BTU/hr, 0.7 sec retention time at 1800 deg. F, size 4 ft diameter and 40 ft overall height. Flare I-2 maximum flow rate 450 scfm, 12.29 MM BTU/hr, 0.7 sec retention time at 1800 deg F, size 5 ft diameter and 40 ft overall height. Details provided by the manufacturer are included in Attachment 2.

Minimum Destruction Efficiency for Non Methane Hydrocarbons (NMHCs)	99%
Inlet Pressure	15″ W.C.
Maximum Pressure Drop through the Flare	15″ W.C.
Maximum Outside Skin Temperature	250 °F
Maximum of NOx per MMBTU	0.025 lbs
Maximum of CO Per MMBTU	0.06 lbs
Design MMBTU/Hr, maximum	6.83 for 250 SCFM flare, 12.29 for 450 SCFM flare
Minimum Residence Time (at 1800°F)	0.7 seconds

$700 \frac{ft^3}{min} \times 0.5 \times \frac{60\,min}{Hr} \times \frac{24}{day} \times (1 - 0.99)$ =

$\times (6.83 + 12.29) = 0.478\ lbs/Hr \times 24\ Hr/day = 11.5\ \frac{lb}{day}$

If extracted LFG contains less than 30% methane, the use of supplemental fuel (natural gas or propane) may be required. As such, provisions will be made to connect a natural gas line or propane tank line to the flare station. The flare burners will be of the type that can burn LFG, natural gas or propane efficiently.

A total of four thermocouples (at various elevations) will be installed in the flare stack to monitor the combustion temperature and to provide information to the temperature controller, which modulates the combustion air dampers to maintain the pre-selected flare temperature. Three thermocouples will be installed along the length of the stack, which will be selectable. This will allow the site engineer to select the most appropriate thermocouple elevation based on the flow of LFG at that time. One thermocouple will be used for high temperature control.

To allow for the system to efficiently operate throughout various flow conditions, a total of two LFG blowers will be provided, one of them serving as a back-up. Each blower is capable of processing the full range of the designed gas flows (0-700 SCFM) and up to 100 inch WC vacuum, as shown on the blower curves included in Attachment 1. Each blower will be equipped with its own Variable Frequency Drive (VFD), which will allow each blower's explosion proof motor RPM to be varied by changing the power frequency. Decreasing the blower RPM reduces the flow rate and also reduces the required horsepower requirements, resulting in savings of electrical power. The use of a VFD greatly enhances the degree to which the gas flow can be regulated. For the former Cal Compact landfill, each blower equipped with the VFD, will allow for an operational range of approximately 0 to 700 SCFM.

The multi-stage centrifugal blowers and motors will be provided by John Zink as part of a skid-mounted assembly, which will also include a moisture / particulate separator, various isolation and check valves, expansion joints and the control panel, as shown on Figure 4. Blower curves are included in Attachment 1.

The moisture / particulate separator (V-101) is designed to separate 99% of all liquid droplets, and particulates 10 microns and larger. The separator will be constructed of HDPE or stainless steel and will include the following:

- Drain connection;
- Level gauge (sight glass);
- Stainless steel mesh pad for moisture coalescing;
- Flanged top for accessibility and maintenance; and
- Differential pressure indicator gauge and ports for measuring pressure drop across the mesh pad.

Collected condensate will be pumped to the condensate storage tank (T-801A/B) for where it is automatically pumped to the on site liquids treatment plant (see separate permit application of Condensate Management System for details).

Flare station operations are anticipated to require 480 Volt, 3-phase electric service rated at an estimated 300 amps. Back-up power will be provided by a 300 kw natural gas generator to be located at the station. Structural loading for the equipment for pad and foundation design is included in the attached calculations (Appendix 1).
An evaluation of the heat plume from the flare was completed to aid in stack height determination and to locate the flares a safe distance from nearby buildings. A fire hydrant or equivalent water supply wire be provided on site prior to operations of the flare system.

THE BOULEVARDS AT SOUTH BAY, LLC

SECTION 2.0

AIR DISPERSION MODELING
AND
HEALTH RISK ASSESSMENT

2.0 AIR DISPERSION MODELING AND HEALTH RISK ASSESSMENT

In compliance with SCAQMD Rule 212 and 1401, a screening risk assessment analysis using SCAQMD guidelines was conducted for air toxics to evaluate compliance with SCAQMD standards. The full report of the air dispersion modeling and health risk assessment is included as Attachment 3.

The toxic compounds evaluated in the screening analysis are those listed in the SCAQMD Rule 1150.1 Toxic Air Contaminant core group and also listed in SCAQMD Rule 1401.

The health risk screening analysis was conducted in compliance with the guidelines presented in SCAQMD's "Risk Assessment Procedures for Rules 1401 and 212," Version 7.0, July 2005.

In an effort to characterize the landfill gas as necessary for the Health Risk Assessment, BAS installed five separate sample probes, one into the each of the five distinct individual landfill cells at the site. A summa canister was used to collect a representative sample of each cell's gas constituents. The collected samples were each tested by a Certified Laboratory for total gaseous non methane non ethane organic compounds (TGNMNEOCs), TO-15 and sulfur compounds, as well as permanent gases which include methane, carbon dioxide, oxygen and nitrogen.

The results of the screening risk assessment analysis which includes the Maximum Individual Cancer Risk (MICR) screening, and both the chronic and acute toxic screening show that the health risks associated with the emissions from the proposed treatment facility are in compliance with SCAQMD's Rules 1401 and 212.

THE BOULEVARDS AT SOUTH BAY, LLC

FIGURE 1

SITE LOCATION MAP

NOT FOR CONSTRUCTION

FORMER CAL COMPACT LANDFILL
CARSON MARKETPLACE LLC
AVALON AT SOUTH BAY

TETRA TECH, INC.

THE BOULEVARDS AT SOUTH BAY

SITE LOCATION MAP

FIG 1

THE BOULEVARDS AT SOUTH BAY, LLC

FIGURE 2

LANDFILL GAS EXTRACTION SYSTEM LAYOUT

NOT FOR CONSTRUCTION

REV NO.	DESCRIPTION	BY	DATE

FORMER CAL COMPACT LANDFILL
CARSON MARKETPLACE L.L.C.
AVALON AT SOUTH BAY

TETRA TECH, INC.

SCALE: 1"=100'
DATE: 8/2008
FILE: FIG 2 SCAQMD
DESIGNED: FMR
DRAWN: FMR
APPROVED: MLL

BAS
BRYAN A. STIRRAT & ASSOCIATES
CONSULTING CIVIL & ENVIRONMENTAL ENGINEERS
1360 VALLEY VISTA DRIVE
DIAMOND BAR, CALIFORNIA 91765
(909) 860-7777

THE BOULEVARDS AT SOUTH BAY
FIGURE 2 SCAQMD APPLICATION SUBMITTAL
LFG EXTRACTION SYSTEM LAYOUT

SHEET NUMBER
FIG 2

THE BOULEVARDS AT SOUTH BAY, LLC

FIGURE 3

FLARE STATION / LFG TREATMENT PROCESS FLOW DIAGRAM

T-801A/B
CONDENSATE HOLDING TANK
MFR: POLY PROCESSING, INC
MODEL: 2005400/2106300
PRIMARY TANK CAPACITY: 5,400 GALLON
WITH SECONDARY CONTAINMENT
OVERALL SIZE: 11'-11" O.D. X 9'-9" TALL
MATERIAL: HIGH DENSITY CROSS LINKED POLYETHYLENE
FITTINGS: 4-2" NPT FITTINGS ON TOP OF TANK
TWO PRIMARY TANK DRAINS, SECONDARY
CONTAINMENT TANK DRAIN, LADDER,
SIGHT GLASS/LEVEL GAUGE,
SEISMIC RESTRAINT SYSTEM

P-101A/B
PNEUMATIC DIAPHRAGM PUMP
MFR: ARO
MODEL NO.: 6661-A3-349-C
INLET: 1" FLANGE
OUTLET: 1" FLANGE
AIR INLET: 1/4" NPT (F)
FLOW RATE: 40 GPM MAX.
OPERATING PRESSURE: 120 PSI MAX.

V-101
MOISTURE SEPARATOR
MFR: JOHN ZINK
MATERIAL: HDPE
FITTINGS: FLANGED INLET & OUTLET,
DRAIN LINE, FLANGED TOP, SS DEMISTER PAD,
DPI GAUGE, LEVEL GAUGE

E-1
ELECTRIC GENERATOR (POWER BACK-UP)
SIZE: __kVA

CO-1A/B
COMPRESSOR & SPARE
SIZE: TBD
FLOW RATE: TBD
PRESSURE: 120 PSIG
DRYER: REFRIGERANT
RECEIVER: 120 GALLON

B-103/104
CENTRIFUGAL BLOWERS
MFR: HOUSTON SERVICE INDUSTRIES, INC.
MODEL: HSI 5105
DESIGN FLOW RATE: 700 SCFM @ 60°F
INLET VACUUM: 100.0 INCHES W.C.
DISCHARGE PRESSURE: 15.0 INCHES W.C.
MOTOR: 40 HP TEFC (VFD DRIVEN)

B-200
COMBUSTION AIR BLOWER
MFR: TBD
MODEL: TBD
FLOW RATE: 1,786 SCFM (MAXIMUM)
PRESSURE DISCHARGE: 15 INCHES W.C.
MOTOR: 10 HP

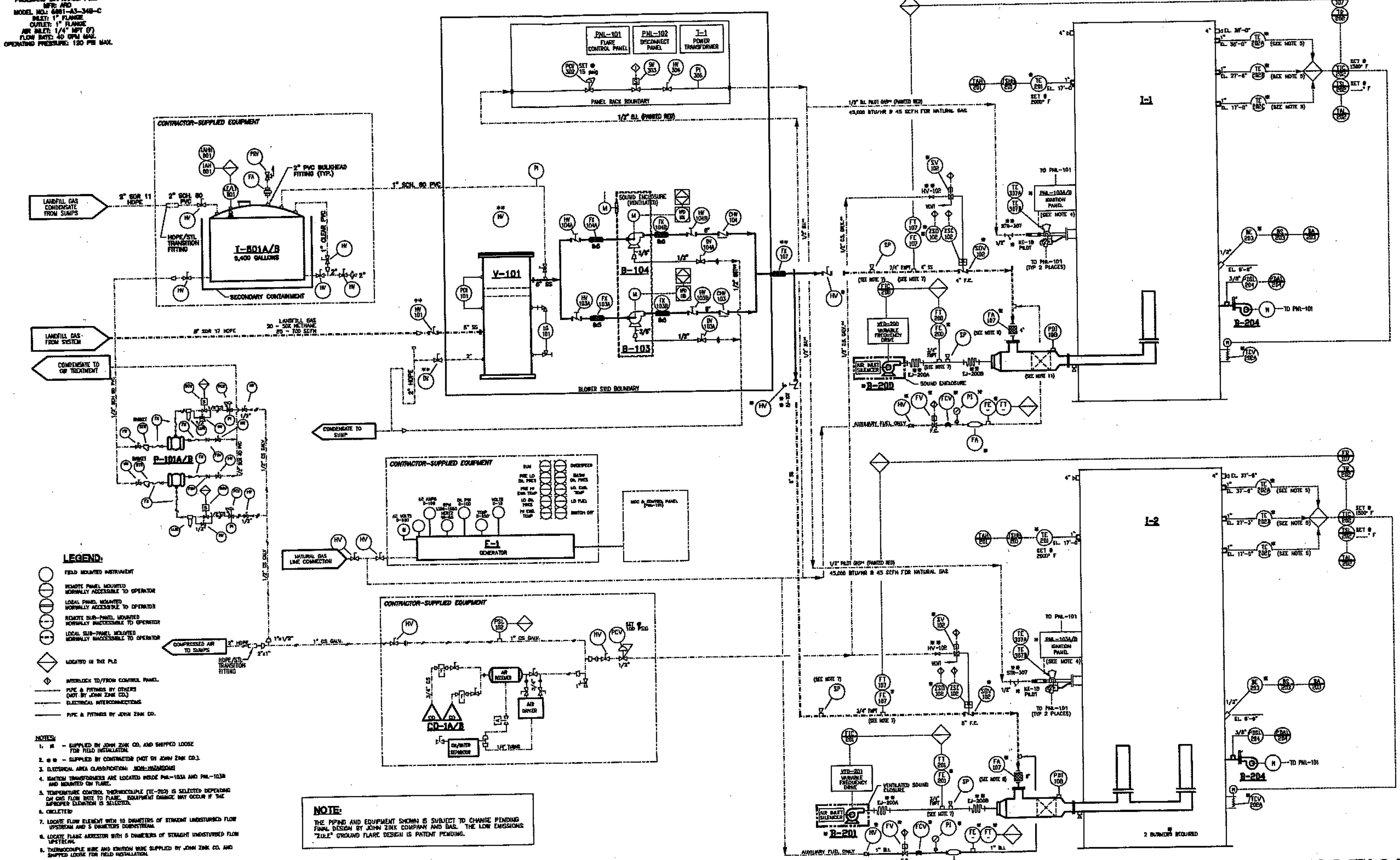
B-201
COMBUSTION AIR BLOWER
MFR: TBD
MODEL: TBD
FLOW RATE: 3,200 SCFM (MAXIMUM)
PRESSURE DISCHARGE: 15 INCHES W.C.
MOTOR: 25 HP

I-1
ENCLOSED GROUND FLARE
MFR: JOHN ZINK
MODEL: ZULE ULTRA LOW EMISSIONS (8.63MM BTU/hr MAX)
FLOW RATE: 250 SCFM (MAX)
SIZE: 4'-0" x 40'-0" OVERALL HEIGHT
RETENTION TIME: 0.7 SECONDS @ 1600°F (MIN)

I-2
ENCLOSED GROUND FLARE
MFR: JOHN ZINK
MODEL: ZULE ULTRA LOW EMISSIONS (12.21MM BTU/hr MAX)
FLOW RATE: 460 SCFM (MAX)
SIZE: 5'-0" x 40'-0" OVERALL HEIGHT
RETENTION TIME: 0.7 SECONDS @ 1600°F (MIN)

B-204
PURGE BLOWER
MFR:
MODEL:
SIZE: 8" FLANGE
HP:

FA-107
FLAME ARRESTOR
MFR: ENARDO
MODEL: 4" FOR I-1 AND 8" FOR I-2
HOUSING: ALUMINUM
ELEMENT: ALUMINUM
FITTINGS: DRAIN & DPI PORTS



LEGEND:
FIELD MOUNTED INSTRUMENT
REMOTE PANEL MOUNTED NORMALLY ACCESSIBLE TO OPERATOR
LOCAL PANEL MOUNTED NORMALLY ACCESSIBLE TO OPERATOR
REMOTE SUB-PANEL MOUNTED NORMALLY INACCESSIBLE TO OPERATOR
LOCAL SUB-PANEL MOUNTED NORMALLY INACCESSIBLE TO OPERATOR
LOCATED IN THE PLC
INTERLOCK TO/FROM CONTROL PANEL
PIPE & FITTINGS BY OTHERS (NOT BY JOHN ZINK CO.)
ELECTRICAL INTERCONNECTIONS
PIPE & FITTINGS BY JOHN ZINK CO.

NOTES:
1. * - SUPPLIED BY JOHN ZINK CO. AND SHIPPED LOOSE FOR FIELD INSTALLATION.
2. ** - SUPPLIED BY CONTRACTOR (NOT BY JOHN ZINK CO.).
3. ELECTRICAL AREA CLASSIFICATION: NON-HAZARDOUS
4. IGNITION TRANSFORMERS ARE LOCATED INSIDE PNL-103A AND PNL-103B AND MOUNTED ON FLARE.
5. TEMPERATURE CONTROL THERMOCOUPLE (TE-202) IS SELECTED DEPENDING ON GAS FLOW RATE TO FLARE. EQUIPMENT DAMAGE MAY OCCUR IF THE IMPROPER ELEVATION IS SELECTED.
6. DELETED
7. LOCATE FLOW ELEMENT WITH 10 DIAMETERS OF STRAIGHT UNDISTURBED FLOW UPSTREAM AND 5 DIAMETERS DOWNSTREAM.
8. LOCATE FLAME ARRESTOR WITH 5 DIAMETERS OF STRAIGHT UNDISTURBED FLOW UPSTREAM.
9. THERMOCOUPLE WIRE AND IGNITION WIRE SUPPLIED BY JOHN ZINK CO. AND SHIPPED LOOSE FOR FIELD INSTALLATION.
10. MAXIMUM WIRE LENGTH BETWEEN EACH VARIABLE FREQUENCY DRIVE AND THE CORRESPONDING MOTOR MUST NOT EXCEED 100 FT.
11. ON DUPLICATE REFERENCE NUMBERS, THE FLARE # (I-1 OR I-2) SHALL PRECEDE THE REFERENCE NUMBER.

NOTE:
THE PIPING AND EQUIPMENT SHOWN IS SUBJECT TO CHANGE PENDING FINAL DESIGN BY JOHN ZINK COMPANY AND BAS. THE LOW EMISSIONS "ZULE" GROUND FLARE DESIGN IS PATENT PENDING.

NOT FOR CONSTRUCTION

REV NO.	DESCRIPTION	BY	DATE

FORMER CAL COMPACT LANDFILL
CARSON MARKETPLACE L.L.C.
AVALON AT SOUTH BAY

TETRA TECH, INC.

SCALE: AS NOTED
DATE: 08/2006
FILE: FIG_3_SCAQMD
DESIGNED: SHA
DRAWN: SHA
APPROVED: MLL

BAS
BRYAN A. STIRRAT & ASSOCIATES
CONSULTING CIVIL & ENVIRONMENTAL ENGINEERS
1360 VALLEY VISTA DRIVE
DIAMOND BAR, CALIFORNIA 91765
(909) 860-7777

THE BOULEVARDS AT SOUTH BAY
FIGURE 3 SCAQMD APPLICATION SUBMITTAL
FLARE STATION/LFG TREATMENT FACILITY PROCESS FLOW DIAGRAM

SHEET NUMBER
FIG 3

THE BOULEVARDS AT SOUTH BAY, LLC

FIGURE 4

FLARE STATION / LFG TREATMENT FACILITY
MECHANICAL ASSEMBLY PLAN

CO-1A & 1B
COMPRESSORS

MFR: ATLAS COPCO
MODEL: GA 30 VSD
OVERALL SIZE: LENGTH=4.0' WIDTH=2.13' HEIGHT=4.6'

I-1
ENCLOSED GROUND FLARE

MFR: JOHN ZINK
MODEL: ZULE ULTRA LOW EMISSIONS (6.83MM BTU/hr MAX)
FLOW RATE: 250 SCFM (MAX)
SIZE: 4'-0" x 40'-0" OVERALL HEIGHT ±
WINDLOAD (PER ASCE 7-95, EXP. C) 110 MPH
SEISMIC (PER UBC-1994) ZONE 4 SHEAR AT BASE: 8.0 K
MOMENT AT BASE: 145.0 K-FT
DEADLOAD: 12.6 K

I-2
ENCLOSED GROUND FLARE

MFR: JOHN ZINK
MODEL: ZULE ULTRA LOW EMISSIONS (12.29MM BTU/hr MAX)
FLOW RATE: 450 SCFM (MAX)
SIZE: 5'-0" x 40'-0" OVERALL HEIGHT ±
WINDLOAD (PER ASCE 7-95, EXP. C) 110 MPH
SEISMIC (PER UBC-1994) ZONE 4
SHEAR AT BASE: 7.0 K
MOMENT AT BASE: 130.0 K-FT
DEADLOAD: 10.2 K

P-101A/B
PNUEMATIC DIAPHRAGM PUMP

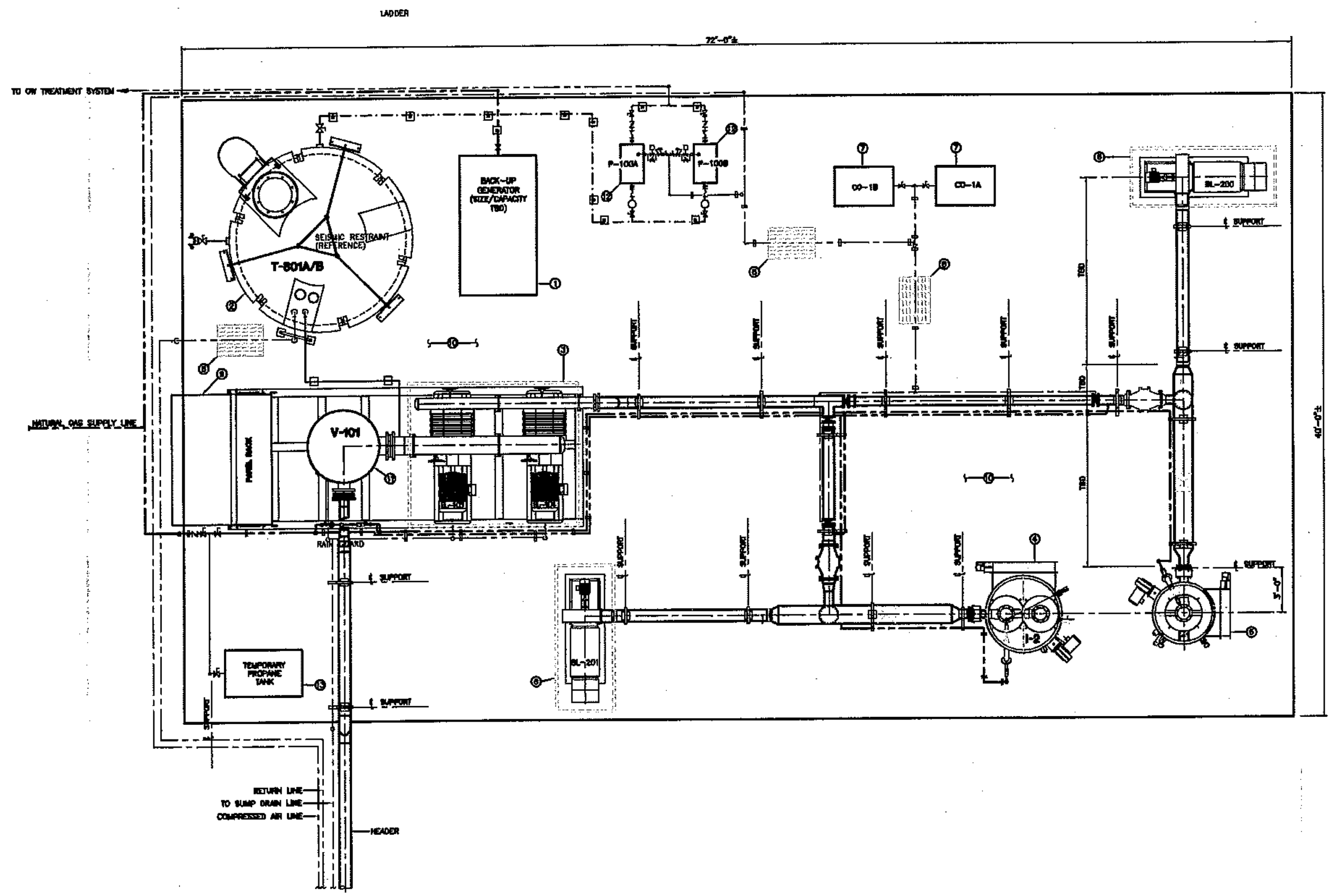
MFR: ARO
MODEL NO.: 6661-A3-34B-C
INLET: 1" FLANGE
OUTLET: 1" FLANGE
AIR INLET: 1/4" NPT (F)
FLOW RATE: 40 GPM MAX.
OPERATING PRESSURE: 120 PSI MAX.

T-801A/B
CONDENSATE HOLDING TANK

MFR: POLY PROCESSING, INC
MODEL: 2005400/2106300
PRIMARY TANK CAPACITY: 5,400 GALLON WITH SECONDARY CONTAINMENT
OVERALL SIZE: 11'-11" O.D. X 9'-9" TALL
MATERIAL: HIGH DENSITY CROSS LINKED POLYETHYLENE
FITTINGS: 4-2" NPT FITTINGS ON TOP OF TANK TWO PRIMARY TANK DRAINS, SECONDARY CONTAINMENT TANK DRAIN, LADDER, SIGHT GLASS/LEVEL GAUGE, SEISMIC RESTRAINT SYSTEM

V-101
MOISTURE SEPARATOR

MFR: JOHN ZINK
MATERIAL: HDPE
SIZE: 2'-0" DIAMETER X 8'-5 1/8" TALL
FITTINGS: 6" FLANGED INLET & OUTLET, 2" DRAIN LINE, FLANGED TOP, SS DEMISTER PAD, DPI GAUGE, LEVEL GAUGE



CONSTRUCTION NOTES:

1. GENERATOR
2. WATER TANK AT FULL CAPACITY
3. LANDFILL GAS BLOWER SKID
4. FLARE 250 SCFM
5. FLARE 450 SCFM
6. FLARE BLOWER (ESIMATION FROM PANEL RACK BLOWER)
7. COMPRESSOR
8. FLOOR BRIDGE
9. ELECTRICL PANEL
10. CONCRETE STRUCTURAL SLAB (PER KPFF DRAWINGS)
11. MOISTURE SEPARATOR
12. PNUEMATIC DIAPHRAGM PUMP
13. PROPANE TANK

GENERAL NOTES:

1. MANY OF THE COMPONENTS PROVIDED BY JOHN ZINK ARE SHIPPED LOOSE. THE CONTRACTOR SHALL PROVIDE FINAL ASSEMBLY, AS NEEDED, TO COMPLETE THE INSTALLATION AS SHOWN.
2. THE PIPING AND EQUIPMENT SHOWN IS SUBJECT TO CHANGE PENDING FINAL DESIGN BY JOHN ZINK COMPANY AND BAS.

NOT FOR CONSTRUCTION

REV NO.	DESCRIPTION	BY	DATE

FORMER CAL COMPACT LANDFILL
CARSON MARKETPLACE L.L.C.
AVALON AT SOUTH BAY

TETRA TECH, INC.

SCALE: NOT TO SCALE
DATE: 08/2008
FILE: FIG 4 SCAQMD
DESIGNED: SHA
DRAWN: FMR
APPROVED: MLL

BAS
BRYAN A. STIRRAT & ASSOCIATES
CONSULTING CIVIL & ENVIRONMENTAL ENGINEERS
1360 VALLEY VISTA DRIVE
DIAMOND BAR, CALIFORNIA 91765
(909) 860-7777

THE BOULEVARDS AT SOUTH BAY
FIGURE 4 SCAQMD APPLICATION SUBMITTAL
FLARE STATION TREATMENT FACILITY MECHANICAL ASSEMBLY PLAN

SHEET NUMBER
FIG 4

THE BOULEVARDS AT SOUTH BAY, LLC

APPENDIX 1

SUPPORTING CALCULATIONS

CARSON MARKETPLACE
ATTACHMENT A
GAS SYSTEM CALCULATIONS

TABLE OF CONTENTS

1.0 LANDFILL GAS FLOW DESIGN BASIS

1.1 Problem Statement

To estimate the volume or flow rate of landfill gas (LFG) to be used for the design of the gas collection system for the former Cal Compact Landfill.

1.2 Methodology

- A Pilot Test was conducted
- The Landfill Gas Emissions Model (LandGEM) method was performed
- Judgment was applied to account for site specific conditions

1.3 Assumptions and Inputs

- Municipal Solid Waste
- The following are the input values for the LandGEM:

Lifetime of the landfill	1959-1965
The waste design capacity	2,000,000 short tons
Methane Generation rate, K	0.040 $year^{-1}$
Potential Methane Generation Capacity, L_0	170 m^3/Mg
NMOC Concentration	4,000 ppmv as hexane
Methane Content	25% by volume
Waste Acceptance Rates per year	short tons*

*Values in attached LandGEM Report

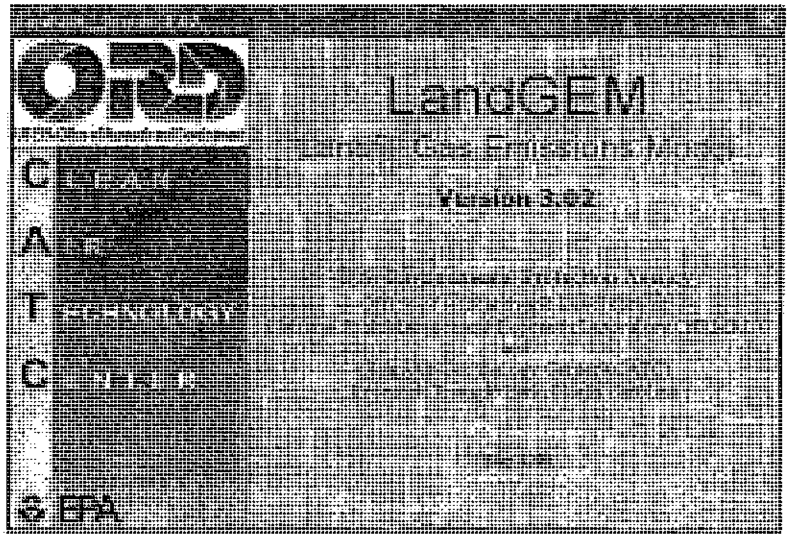
1.4 Calculations and Results

- The Pilot Test projected a minimum LFG flow of 14 standard cubic foot per minute (SCFM) and a maximum of 300 SCFM at 25% methane by volume for the year 2008.
- The Landfill Gas Emissions Model (LandGEM) estimated that the maximum LFG flow of about 3611 SCFM was reached in the year 1965, and has constantly decreased over time. In the year 2009, the minimum LFG flow is estimated to range from 510 SCFM to 650 SCFM. By the year 2100, the minimum and maximum LFG flow will be as low as 14 SCFM and 18 SCFM, respectively. See attached model output.
- Due to the disposal of a large volume (estimated at 6.3 million gallons) of liquids in the landfill experience indicates the probability of more LFG (at least in the early years of operation of the system) than predicted by the Pilot Test and LandGEM method. Therefore, a LFG flow of 700 SCFM (250 SCFM by one flare and 450 SCFM by the second flare) is recommended for design.

- The two flares provide coverage for a range of LFG flow from as low as 50 SCFM to 700 SCFM.
- As the amount of Methane flow declines, natural gas will be added to allow flares to continue operating

1.5 References

- U.S. Environmental Protection Agency; Landfill Gas Emissions Model (LandGEM), Version 3.02; http://www.epa.gov/ttnatw01/landfill/landflpg.html; 1200 Pennsylvania Avenue, N.W., Washington, DC 20460
- Bryan A. Stirrat & Associates. Appendix D - Estimate of Waste Tonnage for LFG Modeling. Expert Witness Report, 2003.
- Bryan A. Stirrat & Associates. CM-LFG_Pilot_Test_Results_Report_final draft-041708. April, 2008.



Summary Report

Landfill Name or Identifier: AVALON AT SOUTH BAY-HIGH END

Date: Wednesday, July 30, 2008

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

Where,

Q_{CH4} = annual methane generation in the year of the calculation *(m^3/year)*
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate *($year^{-1}$)*
L_o = potential methane generation capacity *(m^3/Mg)*

M_i = mass of waste accepted in the i^{th} year *(Mg)*
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year *(decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for conventional landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1959**	
Landfill Closure Year (with 80-year limit)	**1965**	
Actual Closure Year (without limit)	***1965***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity	**2,500,000**	*short tons*

MODEL PARAMETERS

Methane Generation Rate, k	**0.040**	*year^{-1}*
Potential Methane Generation Capacity, L_o	**170**	*m^3/Mg*
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**25**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1959	288,090	316,899	0	0
1960	384,123	422,535	288,090	316,899
1961	384,123	422,535	672,213	739,434
1962	384,123	422,535	1,056,335	1,161,969
1963	384,123	422,535	1,440,458	1,584,504
1964	384,123	422,535	1,824,581	2,007,039
1965	64,024	70,426	2,208,704	2,429,574
1966	0	0	2,272,727	2,500,000
1967	0	0	2,272,727	2,500,000
1968	0	0	2,272,727	2,500,000
1969	0	0	2,272,727	2,500,000
1970	0	0	2,272,727	2,500,000
1971	0	0	2,272,727	2,500,000
1972	0	0	2,272,727	2,500,000
1973	0	0	2,272,727	2,500,000
1974	0	0	2,272,727	2,500,000
1975	0	0	2,272,727	2,500,000
1976	0	0	2,272,727	2,500,000
1977	0	0	2,272,727	2,500,000
1978	0	0	2,272,727	2,500,000
1979	0	0	2,272,727	2,500,000
1980	0	0	2,272,727	2,500,000
1981	0	0	2,272,727	2,500,000
1982	0	0	2,272,727	2,500,000
1983	0	0	2,272,727	2,500,000
1984	0	0	2,272,727	2,500,000
1985	0	0	2,272,727	2,500,000
1986	0	0	2,272,727	2,500,000
1987	0	0	2,272,727	2,500,000
1988	0	0	2,272,727	2,500,000
1989	0	0	2,272,727	2,500,000
1990	0	0	2,272,727	2,500,000
1991	0	0	2,272,727	2,500,000
1992	0	0	2,272,727	2,500,000
1993	0	0	2,272,727	2,500,000
1994	0	0	2,272,727	2,500,000
1995	0	0	2,272,727	2,500,000
1996	0	0	2,272,727	2,500,000
1997	0	0	2,272,727	2,500,000
1998	0	0	2,272,727	2,500,000

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	(short tons/year)	(Mg)	(short tons)
1999	0	0	2,272,727	2,500,000
2000	0	0	2,272,727	2,500,000
2001	0	0	2,272,727	2,500,000
2002	0	0	2,272,727	2,500,000
2003	0	0	2,272,727	2,500,000
2004	0	0	2,272,727	2,500,000
2005	0	0	2,272,727	2,500,000
2006	0	0	2,272,727	2,500,000
2007	0	0	2,272,727	2,500,000
2008	0	0	2,272,727	2,500,000
2009	0	0	2,272,727	2,500,000
2010	0	0	2,272,727	2,500,000
2011	0	0	2,272,727	2,500,000
2012	0	0	2,272,727	2,500,000
2013	0	0	2,272,727	2,500,000
2014	0	0	2,272,727	2,500,000
2015	0	0	2,272,727	2,500,000
2016	0	0	2,272,727	2,500,000
2017	0	0	2,272,727	2,500,000
2018	0	0	2,272,727	2,500,000
2019	0	0	2,272,727	2,500,000
2020	0	0	2,272,727	2,500,000
2021	0	0	2,272,727	2,500,000
2022	0	0	2,272,727	2,500,000
2023	0	0	2,272,727	2,500,000
2024	0	0	2,272,727	2,500,000
2025	0	0	2,272,727	2,500,000
2026	0	0	2,272,727	2,500,000
2027	0	0	2,272,727	2,500,000
2028	0	0	2,272,727	2,500,000
2029	0	0	2,272,727	2,500,000
2030	0	0	2,272,727	2,500,000
2031	0	0	2,272,727	2,500,000
2032	0	0	2,272,727	2,500,000
2033	0	0	2,272,727	2,500,000
2034	0	0	2,272,727	2,500,000
2035	0	0	2,272,727	2,500,000
2036	0	0	2,272,727	2,500,000
2037	0	0	2,272,727	2,500,000
2038	0	0	2,272,727	2,500,000

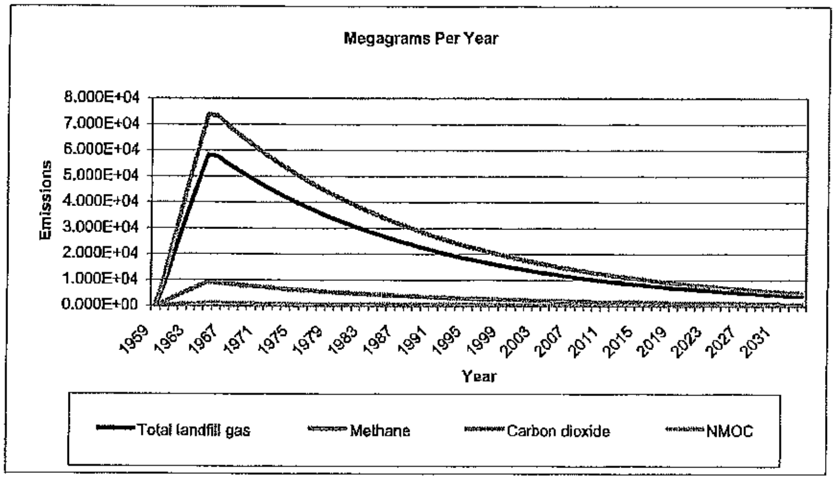
Pollutant Parameters

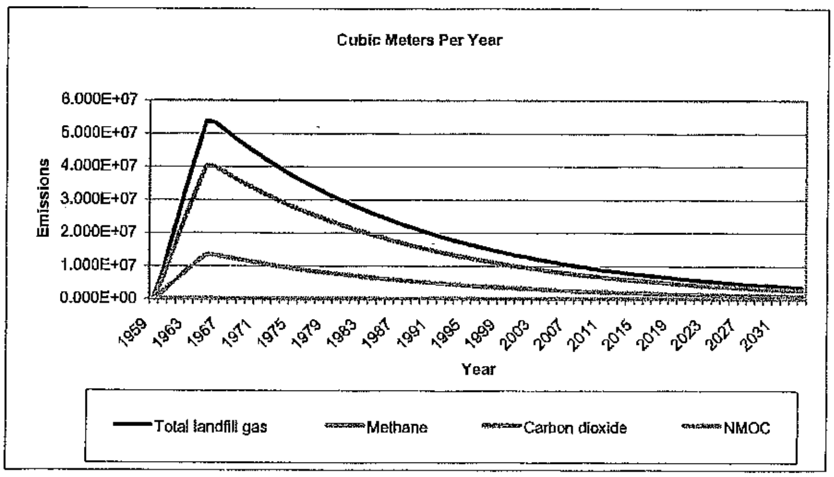
	Compound	Gas / Pollutant Default Parameters: Concentration (*ppmv*)	Molecular Weight	User-specified Pollutant Parameters: Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

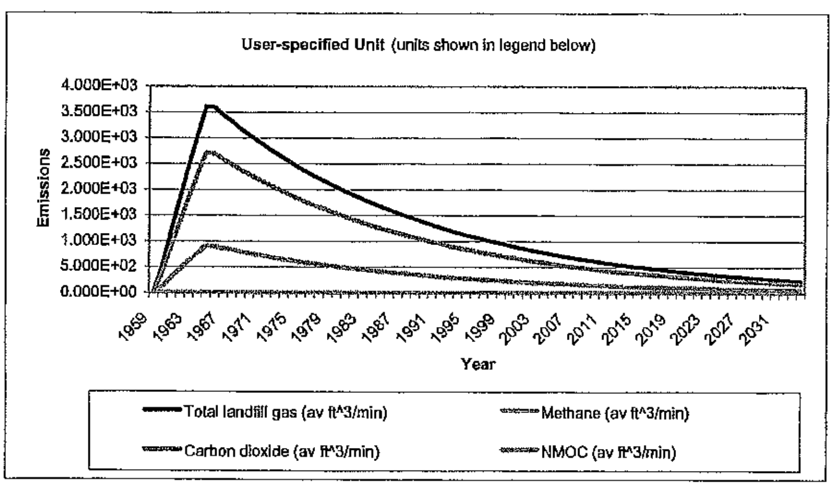
Pollutant Parameters (Continued)

	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

Graphs


Megagrams Per Year
8.000E+04
7.000E+04
6.000E+04
5.000E+04
4.000E+04
3.000E+04
2.000E+04
1.000E+04
0.000E+00
Emissions
1959 1963 1967 1971 1975 1979 1983 1987 1991 1995 1999 2003 2007 2011 2015 2019 2023 2027 2031
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
6.000E+07
5.000E+07
4.000E+07
3.000E+07
2.000E+07
1.000E+07
0.000E+00
Emissions
1959 1963 1967 1971 1975 1979 1983 1987 1991 1995 1999 2003 2007 2011 2015 2019 2023 2027 2031
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
4.000E+03
3.500E+03
3.000E+03
2.500E+03
2.000E+03
1.500E+03
1.000E+03
5.000E+02
0.000E+00
Emissions
1959 1963 1967 1971 1975 1979 1983 1987 1991 1995 1999 2003 2007 2011 2015 2019 2023 2027 2031
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
1959	0	0	0	0	0	0
1960	8.328E+03	7.697E+06	5.171E+02	1.284E+03	1.924E+06	1.293E+02
1961	1.911E+04	1.766E+07	1.186E+03	2.945E+03	4.414E+06	2.966E+02
1962	2.946E+04	2.723E+07	1.829E+03	4.541E+03	6.807E+06	4.574E+02
1963	3.941E+04	3.642E+07	2.447E+03	6.075E+03	9.106E+06	6.118E+02
1964	4.897E+04	4.526E+07	3.041E+03	7.548E+03	1.131E+07	7.602E+02
1965	5.815E+04	5.374E+07	3.611E+03	8.964E+03	1.344E+07	9.028E+02
1966	5.772E+04	5.335E+07	3.584E+03	8.898E+03	1.334E+07	8.961E+02
1967	5.546E+04	5.126E+07	3.444E+03	8.549E+03	1.281E+07	8.610E+02
1968	5.329E+04	4.925E+07	3.309E+03	8.214E+03	1.231E+07	8.272E+02
1969	5.120E+04	4.732E+07	3.179E+03	7.892E+03	1.183E+07	7.948E+02
1970	4.919E+04	4.546E+07	3.054E+03	7.582E+03	1.136E+07	7.636E+02
1971	4.726E+04	4.368E+07	2.935E+03	7.285E+03	1.092E+07	7.337E+02
1972	4.541E+04	4.196E+07	2.820E+03	6.999E+03	1.049E+07	7.049E+02
1973	4.363E+04	4.032E+07	2.709E+03	6.725E+03	1.008E+07	6.773E+02
1974	4.192E+04	3.874E+07	2.603E+03	6.461E+03	9.685E+06	6.507E+02
1975	4.027E+04	3.722E+07	2.501E+03	6.208E+03	9.305E+06	6.252E+02
1976	3.869E+04	3.576E+07	2.403E+03	5.964E+03	8.940E+06	6.007E+02
1977	3.718E+04	3.436E+07	2.308E+03	5.730E+03	8.589E+06	5.771E+02
1978	3.572E+04	3.301E+07	2.218E+03	5.506E+03	8.253E+06	5.545E+02
1979	3.432E+04	3.172E+07	2.131E+03	5.290E+03	7.929E+06	5.328E+02
1980	3.297E+04	3.047E+07	2.047E+03	5.082E+03	7.618E+06	5.119E+02
1981	3.168E+04	2.928E+07	1.967E+03	4.883E+03	7.319E+06	4.918E+02
1982	3.044E+04	2.813E+07	1.890E+03	4.692E+03	7.032E+06	4.725E+02
1983	2.924E+04	2.703E+07	1.816E+03	4.508E+03	6.757E+06	4.540E+02
1984	2.810E+04	2.597E+07	1.745E+03	4.331E+03	6.492E+06	4.362E+02
1985	2.700E+04	2.495E+07	1.676E+03	4.161E+03	6.237E+06	4.191E+02
1986	2.594E+04	2.397E+07	1.611E+03	3.998E+03	5.993E+06	4.026E+02
1987	2.492E+04	2.303E+07	1.547E+03	3.841E+03	5.758E+06	3.869E+02
1988	2.394E+04	2.213E+07	1.487E+03	3.691E+03	5.532E+06	3.717E+02
1989	2.300E+04	2.126E+07	1.428E+03	3.546E+03	5.315E+06	3.571E+02
1990	2.210E+04	2.043E+07	1.372E+03	3.407E+03	5.107E+06	3.431E+02
1991	2.124E+04	1.963E+07	1.319E+03	3.273E+03	4.906E+06	3.297E+02
1992	2.040E+04	1.886E+07	1.267E+03	3.145E+03	4.714E+06	3.167E+02
1993	1.960E+04	1.812E+07	1.217E+03	3.022E+03	4.529E+06	3.043E+02
1994	1.883E+04	1.741E+07	1.170E+03	2.903E+03	4.352E+06	2.924E+02
1995	1.810E+04	1.672E+07	1.124E+03	2.789E+03	4.181E+06	2.809E+02
1996	1.739E+04	1.607E+07	1.080E+03	2.680E+03	4.017E+06	2.699E+02
1997	1.670E+04	1.544E+07	1.037E+03	2.575E+03	3.859E+06	2.593E+02
1998	1.605E+04	1.483E+07	9.966E+02	2.474E+03	3.708E+06	2.492E+02
1999	1.542E+04	1.425E+07	9.575E+02	2.377E+03	3.563E+06	2.394E+02
2000	1.482E+04	1.369E+07	9.200E+02	2.284E+03	3.423E+06	2.300E+02
2001	1.423E+04	1.316E+07	8.839E+02	2.194E+03	3.289E+06	2.210E+02
2002	1.368E+04	1.264E+07	8.492E+02	2.108E+03	3.160E+06	2.123E+02
2003	1.314E+04	1.214E+07	8.159E+02	2.025E+03	3.036E+06	2.040E+02
2004	1.262E+04	1.167E+07	7.840E+02	1.946E+03	2.917E+06	1.960E+02
2005	1.213E+04	1.121E+07	7.532E+02	1.870E+03	2.803E+06	1.883E+02
2006	1.165E+04	1.077E+07	7.237E+02	1.796E+03	2.693E+06	1.809E+02
2007	1.120E+04	1.035E+07	6.953E+02	1.726E+03	2.587E+06	1.738E+02
2008	1.076E+04	9.943E+06	6.680E+02	1.658E+03	2.486E+06	1.670E+02

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2009	1.034E+04	9.553E+06	6.418E+02	1.593E+03	2.388E+06	1.605E+02
2010	9.931E+03	9.178E+06	6.167E+02	1.531E+03	2.295E+06	1.542E+02
2011	9.542E+03	8.818E+06	5.925E+02	1.471E+03	2.205E+06	1.481E+02
2012	9.168E+03	8.473E+06	5.693E+02	1.413E+03	2.118E+06	1.423E+02
2013	8.808E+03	8.140E+06	5.469E+02	1.358E+03	2.035E+06	1.367E+02
2014	8.463E+03	7.821E+06	5.255E+02	1.304E+03	1.955E+06	1.314E+02
2015	8.131E+03	7.514E+06	5.049E+02	1.253E+03	1.879E+06	1.262E+02
2016	7.812E+03	7.220E+06	4.851E+02	1.204E+03	1.805E+06	1.213E+02
2017	7.506E+03	6.937E+06	4.661E+02	1.157E+03	1.734E+06	1.165E+02
2018	7.211E+03	6.665E+06	4.478E+02	1.112E+03	1.666E+06	1.120E+02
2019	6.929E+03	6.403E+06	4.302E+02	1.068E+03	1.601E+06	1.076E+02
2020	6.657E+03	6.152E+06	4.134E+02	1.026E+03	1.538E+06	1.033E+02
2021	6.396E+03	5.911E+06	3.972E+02	9.859E+02	1.478E+06	9.929E+01
2022	6.145E+03	5.679E+06	3.816E+02	9.472E+02	1.420E+06	9.540E+01
2023	5.904E+03	5.457E+06	3.666E+02	9.101E+02	1.364E+06	9.166E+01
2024	5.673E+03	5.243E+06	3.523E+02	8.744E+02	1.311E+06	8.806E+01
2025	5.450E+03	5.037E+06	3.384E+02	8.401E+02	1.259E+06	8.461E+01
2026	5.237E+03	4.840E+06	3.252E+02	8.072E+02	1.210E+06	8.129E+01
2027	5.031E+03	4.650E+06	3.124E+02	7.755E+02	1.162E+06	7.811E+01
2028	4.834E+03	4.468E+06	3.002E+02	7.451E+02	1.117E+06	7.504E+01
2029	4.644E+03	4.292E+06	2.884E+02	7.159E+02	1.073E+06	7.210E+01
2030	4.462E+03	4.124E+06	2.771E+02	6.878E+02	1.031E+06	6.927E+01
2031	4.287E+03	3.962E+06	2.662E+02	6.609E+02	9.906E+05	6.656E+01
2032	4.119E+03	3.807E+06	2.558E+02	6.350E+02	9.517E+05	6.395E+01
2033	3.958E+03	3.658E+06	2.458E+02	6.101E+02	9.144E+05	6.144E+01
2034	3.803E+03	3.514E+06	2.361E+02	5.861E+02	8.786E+05	5.903E+01
2035	3.653E+03	3.376E+06	2.269E+02	5.632E+02	8.441E+05	5.672E+01
2036	3.510E+03	3.244E+06	2.180E+02	5.411E+02	8.110E+05	5.449E+01
2037	3.373E+03	3.117E+06	2.094E+02	5.199E+02	7.792E+05	5.236E+01
2038	3.240E+03	2.995E+06	2.012E+02	4.995E+02	7.487E+05	5.030E+01
2039	3.113E+03	2.877E+06	1.933E+02	4.799E+02	7.193E+05	4.833E+01
2040	2.991E+03	2.764E+06	1.857E+02	4.611E+02	6.911E+05	4.644E+01
2041	2.874E+03	2.656E+06	1.785E+02	4.430E+02	6.640E+05	4.461E+01
2042	2.761E+03	2.552E+06	1.715E+02	4.256E+02	6.380E+05	4.287E+01
2043	2.653E+03	2.452E+06	1.647E+02	4.089E+02	6.130E+05	4.118E+01
2044	2.549E+03	2.356E+06	1.583E+02	3.929E+02	5.889E+05	3.957E+01
2045	2.449E+03	2.263E+06	1.521E+02	3.775E+02	5.658E+05	3.802E+01
2046	2.353E+03	2.175E+06	1.461E+02	3.627E+02	5.436E+05	3.653E+01
2047	2.261E+03	2.089E+06	1.404E+02	3.485E+02	5.223E+05	3.509E+01
2048	2.172E+03	2.007E+06	1.349E+02	3.348E+02	5.018E+05	3.372E+01
2049	2.087E+03	1.929E+06	1.296E+02	3.217E+02	4.822E+05	3.240E+01
2050	2.005E+03	1.853E+06	1.245E+02	3.091E+02	4.633E+05	3.113E+01
2051	1.926E+03	1.780E+06	1.196E+02	2.969E+02	4.451E+05	2.991E+01
2052	1.851E+03	1.711E+06	1.149E+02	2.853E+02	4.276E+05	2.873E+01
2053	1.778E+03	1.644E+06	1.104E+02	2.741E+02	4.109E+05	2.761E+01
2054	1.709E+03	1.579E+06	1.061E+02	2.634E+02	3.948E+05	2.652E+01
2055	1.642E+03	1.517E+06	1.019E+02	2.530E+02	3.793E+05	2.548E+01
2056	1.577E+03	1.458E+06	9.794E+01	2.431E+02	3.644E+05	2.448E+01
2057	1.515E+03	1.401E+06	9.410E+01	2.336E+02	3.501E+05	2.352E+01
2058	1.456E+03	1.346E+06	9.041E+01	2.244E+02	3.364E+05	2.260E+01
2059	1.399E+03	1.293E+06	8.686E+01	2.156E+02	3.232E+05	2.172E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2060	1.344E+03	1.242E+06	8.346E+01	2.072E+02	3.105E+05	2.086E+01
2061	1.291E+03	1.193E+06	8.019E+01	1.990E+02	2.984E+05	2.005E+01
2062	1.241E+03	1.147E+06	7.704E+01	1.912E+02	2.867E+05	1.926E+01
2063	1.192E+03	1.102E+06	7.402E+01	1.837E+02	2.754E+05	1.851E+01
2064	1.145E+03	1.058E+06	7.112E+01	1.765E+02	2.646E+05	1.778E+01
2065	1.100E+03	1.017E+06	6.833E+01	1.696E+02	2.542E+05	1.708E+01
2066	1.057E+03	9.771E+05	6.565E+01	1.630E+02	2.443E+05	1.641E+01
2067	1.016E+03	9.388E+05	6.308E+01	1.566E+02	2.347E+05	1.577E+01
2068	9.760E+02	9.020E+05	6.060E+01	1.504E+02	2.255E+05	1.515E+01
2069	9.377E+02	8.666E+05	5.823E+01	1.445E+02	2.167E+05	1.456E+01
2070	9.009E+02	8.326E+05	5.594E+01	1.389E+02	2.082E+05	1.399E+01
2071	8.656E+02	8.000E+05	5.375E+01	1.334E+02	2.000E+05	1.344E+01
2072	8.317E+02	7.686E+05	5.164E+01	1.282E+02	1.922E+05	1.291E+01
2073	7.991E+02	7.385E+05	4.962E+01	1.232E+02	1.846E+05	1.240E+01
2074	7.677E+02	7.095E+05	4.767E+01	1.183E+02	1.774E+05	1.192E+01
2075	7.376E+02	6.817E+05	4.580E+01	1.137E+02	1.704E+05	1.145E+01
2076	7.087E+02	6.550E+05	4.401E+01	1.092E+02	1.637E+05	1.100E+01
2077	6.809E+02	6.293E+05	4.228E+01	1.050E+02	1.573E+05	1.057E+01
2078	6.542E+02	6.046E+05	4.062E+01	1.008E+02	1.512E+05	1.016E+01
2079	6.286E+02	5.809E+05	3.903E+01	9.689E+01	1.452E+05	9.758E+00
2080	6.039E+02	5.581E+05	3.750E+01	9.309E+01	1.395E+05	9.375E+00
2081	5.802E+02	5.362E+05	3.603E+01	8.944E+01	1.341E+05	9.008E+00
2082	5.575E+02	5.152E+05	3.462E+01	8.593E+01	1.288E+05	8.654E+00
2083	5.356E+02	4.950E+05	3.326E+01	8.256E+01	1.238E+05	8.315E+00
2084	5.146E+02	4.756E+05	3.196E+01	7.932E+01	1.189E+05	7.989E+00
2085	4.944E+02	4.570E+05	3.070E+01	7.621E+01	1.142E+05	7.676E+00
2086	4.751E+02	4.390E+05	2.950E+01	7.323E+01	1.098E+05	7.375E+00
2087	4.564E+02	4.218E+05	2.834E+01	7.035E+01	1.055E+05	7.086E+00
2088	4.385E+02	4.053E+05	2.723E+01	6.760E+01	1.013E+05	6.808E+00
2089	4.213E+02	3.894E+05	2.616E+01	6.495E+01	9.735E+04	6.541E+00
2090	4.048E+02	3.741E+05	2.514E+01	6.240E+01	9.353E+04	6.284E+00
2091	3.889E+02	3.595E+05	2.415E+01	5.995E+01	8.986E+04	6.038E+00
2092	3.737E+02	3.454E+05	2.320E+01	5.760E+01	8.634E+04	5.801E+00
2093	3.590E+02	3.318E+05	2.229E+01	5.534E+01	8.295E+04	5.574E+00
2094	3.450E+02	3.188E+05	2.142E+01	5.317E+01	7.970E+04	5.355E+00
2095	3.314E+02	3.063E+05	2.058E+01	5.109E+01	7.658E+04	5.145E+00
2096	3.184E+02	2.943E+05	1.977E+01	4.908E+01	7.357E+04	4.943E+00
2097	3.060E+02	2.828E+05	1.900E+01	4.716E+01	7.069E+04	4.750E+00
2098	2.940E+02	2.717E+05	1.825E+01	4.531E+01	6.792E+04	4.563E+00
2099	2.824E+02	2.610E+05	1.754E+01	4.353E+01	6.525E+04	4.384E+00

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1959	0	0	0	0	0	0
1960	1.057E+04	5.773E+06	3.879E+02	1.104E+02	3.079E+04	2.069E+00
1961	2.424E+04	1.324E+07	8.898E+02	2.532E+02	7.063E+04	4.746E+00
1962	3.738E+04	2.042E+07	1.372E+03	3.904E+02	1.089E+05	7.318E+00
1963	5.000E+04	2.732E+07	1.835E+03	5.222E+02	1.457E+05	9.789E+00
1964	6.213E+04	3.394E+07	2.281E+03	6.489E+02	1.810E+05	1.216E+01
1965	7.378E+04	4.031E+07	2.708E+03	7.706E+02	2.150E+05	1.444E+01
1966	7.324E+04	4.001E+07	2.688E+03	7.649E+02	2.134E+05	1.434E+01
1967	7.037E+04	3.844E+07	2.583E+03	7.349E+02	2.050E+05	1.378E+01
1968	6.761E+04	3.693E+07	2.482E+03	7.061E+02	1.970E+05	1.324E+01
1969	6.496E+04	3.549E+07	2.384E+03	6.784E+02	1.893E+05	1.272E+01
1970	6.241E+04	3.409E+07	2.291E+03	6.518E+02	1.818E+05	1.222E+01
1971	5.996E+04	3.276E+07	2.201E+03	6.262E+02	1.747E+05	1.174E+01
1972	5.761E+04	3.147E+07	2.115E+03	6.017E+02	1.679E+05	1.128E+01
1973	5.535E+04	3.024E+07	2.032E+03	5.781E+02	1.613E+05	1.084E+01
1974	5.318E+04	2.905E+07	1.952E+03	5.554E+02	1.550E+05	1.041E+01
1975	5.110E+04	2.791E+07	1.876E+03	5.336E+02	1.489E+05	1.000E+01
1976	4.909E+04	2.682E+07	1.802E+03	5.127E+02	1.430E+05	9.611E+00
1977	4.717E+04	2.577E+07	1.731E+03	4.926E+02	1.374E+05	9.234E+00
1978	4.532E+04	2.476E+07	1.663E+03	4.733E+02	1.320E+05	8.872E+00
1979	4.354E+04	2.379E+07	1.598E+03	4.547E+02	1.269E+05	8.524E+00
1980	4.184E+04	2.285E+07	1.536E+03	4.369E+02	1.219E+05	8.190E+00
1981	4.019E+04	2.196E+07	1.475E+03	4.198E+02	1.171E+05	7.869E+00
1982	3.862E+04	2.110E+07	1.418E+03	4.033E+02	1.125E+05	7.560E+00
1983	3.710E+04	2.027E+07	1.362E+03	3.875E+02	1.081E+05	7.264E+00
1984	3.565E+04	1.948E+07	1.309E+03	3.723E+02	1.039E+05	6.979E+00
1985	3.425E+04	1.871E+07	1.257E+03	3.577E+02	9.980E+04	6.705E+00
1986	3.291E+04	1.798E+07	1.208E+03	3.437E+02	9.588E+04	6.442E+00
1987	3.162E+04	1.727E+07	1.161E+03	3.302E+02	9.212E+04	6.190E+00
1988	3.038E+04	1.660E+07	1.115E+03	3.173E+02	8.851E+04	5.947E+00
1989	2.919E+04	1.595E+07	1.071E+03	3.048E+02	8.504E+04	5.714E+00
1990	2.804E+04	1.532E+07	1.029E+03	2.929E+02	8.171E+04	5.490E+00
1991	2.694E+04	1.472E+07	9.890E+02	2.814E+02	7.850E+04	5.275E+00
1992	2.589E+04	1.414E+07	9.502E+02	2.704E+02	7.542E+04	5.068E+00
1993	2.487E+04	1.359E+07	9.129E+02	2.598E+02	7.247E+04	4.869E+00
1994	2.390E+04	1.305E+07	8.771E+02	2.496E+02	6.963E+04	4.678E+00
1995	2.296E+04	1.254E+07	8.427E+02	2.398E+02	6.689E+04	4.495E+00
1996	2.206E+04	1.205E+07	8.097E+02	2.304E+02	6.427E+04	4.318E+00
1997	2.119E+04	1.158E+07	7.780E+02	2.213E+02	6.175E+04	4.149E+00
1998	2.036E+04	1.112E+07	7.475E+02	2.127E+02	5.933E+04	3.986E+00
1999	1.956E+04	1.069E+07	7.181E+02	2.043E+02	5.700E+04	3.830E+00
2000	1.880E+04	1.027E+07	6.900E+02	1.963E+02	5.477E+04	3.680E+00
2001	1.806E+04	9.867E+06	6.629E+02	1.886E+02	5.262E+04	3.536E+00
2002	1.735E+04	9.480E+06	6.369E+02	1.812E+02	5.056E+04	3.397E+00
2003	1.667E+04	9.108E+06	6.120E+02	1.741E+02	4.858E+04	3.264E+00
2004	1.602E+04	8.751E+06	5.880E+02	1.673E+02	4.667E+04	3.136E+00
2005	1.539E+04	8.408E+06	5.649E+02	1.607E+02	4.484E+04	3.013E+00
2006	1.479E+04	8.078E+06	5.428E+02	1.544E+02	4.308E+04	2.895E+00
2007	1.421E+04	7.761E+06	5.215E+02	1.484E+02	4.139E+04	2.781E+00
2008	1.365E+04	7.457E+06	5.010E+02	1.426E+02	3.977E+04	2.672E+00

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2009	1.311E+04	7.165E+06	4.814E+02	1.370E+02	3.821E+04	2.567E+00
2010	1.260E+04	6.884E+06	4.625E+02	1.316E+02	3.671E+04	2.467E+00
2011	1.211E+04	6.614E+06	4.444E+02	1.264E+02	3.527E+04	2.370E+00
2012	1.163E+04	6.354E+06	4.270E+02	1.215E+02	3.389E+04	2.277E+00
2013	1.118E+04	6.105E+06	4.102E+02	1.167E+02	3.256E+04	2.188E+00
2014	1.074E+04	5.866E+06	3.941E+02	1.121E+02	3.128E+04	2.102E+00
2015	1.032E+04	5.636E+06	3.787E+02	1.077E+02	3.006E+04	2.020E+00
2016	9.912E+03	5.415E+06	3.638E+02	1.035E+02	2.888E+04	1.940E+00
2017	9.523E+03	5.203E+06	3.496E+02	9.946E+01	2.775E+04	1.864E+00
2018	9.150E+03	4.999E+06	3.359E+02	9.556E+01	2.666E+04	1.791E+00
2019	8.791E+03	4.803E+06	3.227E+02	9.181E+01	2.561E+04	1.721E+00
2020	8.446E+03	4.614E+06	3.100E+02	8.821E+01	2.461E+04	1.653E+00
2021	8.115E+03	4.433E+06	2.979E+02	8.475E+01	2.364E+04	1.589E+00
2022	7.797E+03	4.259E+06	2.862E+02	8.143E+01	2.272E+04	1.526E+00
2023	7.491E+03	4.092E+06	2.750E+02	7.824E+01	2.183E+04	1.467E+00
2024	7.198E+03	3.932E+06	2.642E+02	7.517E+01	2.097E+04	1.409E+00
2025	6.915E+03	3.778E+06	2.538E+02	7.222E+01	2.015E+04	1.354E+00
2026	6.644E+03	3.630E+06	2.439E+02	6.939E+01	1.936E+04	1.301E+00
2027	6.384E+03	3.487E+06	2.343E+02	6.667E+01	1.860E+04	1.250E+00
2028	6.133E+03	3.351E+06	2.251E+02	6.405E+01	1.787E+04	1.201E+00
2029	5.893E+03	3.219E+06	2.163E+02	6.154E+01	1.717E+04	1.154E+00
2030	5.662E+03	3.093E+06	2.078E+02	5.913E+01	1.650E+04	1.108E+00
2031	5.440E+03	2.972E+06	1.997E+02	5.681E+01	1.585E+04	1.065E+00
2032	5.226E+03	2.855E+06	1.918E+02	5.458E+01	1.523E+04	1.023E+00
2033	5.022E+03	2.743E+06	1.843E+02	5.244E+01	1.463E+04	9.830E-01
2034	4.825E+03	2.636E+06	1.771E+02	5.039E+01	1.406E+04	9.445E-01
2035	4.635E+03	2.532E+06	1.701E+02	4.841E+01	1.351E+04	9.075E-01
2036	4.454E+03	2.433E+06	1.635E+02	4.651E+01	1.298E+04	8.719E-01
2037	4.279E+03	2.338E+06	1.571E+02	4.469E+01	1.247E+04	8.377E-01
2038	4.111E+03	2.246E+06	1.509E+02	4.294E+01	1.198E+04	8.048E-01
2039	3.950E+03	2.158E+06	1.450E+02	4.125E+01	1.151E+04	7.733E-01
2040	3.795E+03	2.073E+06	1.393E+02	3.964E+01	1.106E+04	7.430E-01
2041	3.646E+03	1.992E+06	1.338E+02	3.808E+01	1.062E+04	7.138E-01
2042	3.503E+03	1.914E+06	1.286E+02	3.659E+01	1.021E+04	6.858E-01
2043	3.366E+03	1.839E+06	1.236E+02	3.515E+01	9.807E+03	6.589E-01
2044	3.234E+03	1.767E+06	1.187E+02	3.378E+01	9.423E+03	6.331E-01
2045	3.107E+03	1.697E+06	1.141E+02	3.245E+01	9.053E+03	6.083E-01
2046	2.985E+03	1.631E+06	1.096E+02	3.118E+01	8.698E+03	5.844E-01
2047	2.868E+03	1.567E+06	1.053E+02	2.996E+01	8.357E+03	5.615E-01
2048	2.756E+03	1.506E+06	1.012E+02	2.878E+01	8.030E+03	5.395E-01
2049	2.648E+03	1.447E+06	9.719E+01	2.765E+01	7.715E+03	5.183E-01
2050	2.544E+03	1.390E+06	9.338E+01	2.657E+01	7.412E+03	4.980E-01
2051	2.444E+03	1.335E+06	8.972E+01	2.553E+01	7.122E+03	4.785E-01
2052	2.348E+03	1.283E+06	8.620E+01	2.453E+01	6.842E+03	4.597E-01
2053	2.256E+03	1.233E+06	8.282E+01	2.356E+01	6.574E+03	4.417E-01
2054	2.168E+03	1.184E+06	7.957E+01	2.264E+01	6.316E+03	4.244E-01
2055	2.083E+03	1.138E+06	7.645E+01	2.175E+01	6.069E+03	4.077E-01
2056	2.001E+03	1.093E+06	7.345E+01	2.090E+01	5.831E+03	3.918E-01
2057	1.923E+03	1.050E+06	7.057E+01	2.008E+01	5.602E+03	3.764E-01
2058	1.847E+03	1.009E+06	6.781E+01	1.929E+01	5.382E+03	3.616E-01
2059	1.775E+03	9.696E+05	6.515E+01	1.854E+01	5.171E+03	3.475E-01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2060	1.705E+03	9.316E+05	6.259E+01	1.781E+01	4.969E+03	3.338E-01
2061	1.638E+03	8.951E+05	6.014E+01	1.711E+01	4.774E+03	3.207E-01
2062	1.574E+03	8.600E+05	5.778E+01	1.644E+01	4.587E+03	3.082E-01
2063	1.512E+03	8.263E+05	5.552E+01	1.580E+01	4.407E+03	2.961E-01
2064	1.453E+03	7.939E+05	5.334E+01	1.518E+01	4.234E+03	2.845E-01
2065	1.396E+03	7.627E+05	5.125E+01	1.458E+01	4.068E+03	2.733E-01
2066	1.341E+03	7.328E+05	4.924E+01	1.401E+01	3.908E+03	2.626E-01
2067	1.289E+03	7.041E+05	4.731E+01	1.346E+01	3.755E+03	2.523E-01
2068	1.238E+03	6.765E+05	4.545E+01	1.293E+01	3.608E+03	2.424E-01
2069	1.190E+03	6.500E+05	4.367E+01	1.243E+01	3.466E+03	2.329E-01
2070	1.143E+03	6.245E+05	4.196E+01	1.194E+01	3.331E+03	2.238E-01
2071	1.098E+03	6.000E+05	4.031E+01	1.147E+01	3.200E+03	2.150E-01
2072	1.055E+03	5.765E+05	3.873E+01	1.102E+01	3.074E+03	2.066E-01
2073	1.014E+03	5.539E+05	3.721E+01	1.059E+01	2.954E+03	1.985E-01
2074	9.741E+02	5.321E+05	3.575E+01	1.017E+01	2.838E+03	1.907E-01
2075	9.359E+02	5.113E+05	3.435E+01	9.774E+00	2.727E+03	1.832E-01
2076	8.992E+02	4.912E+05	3.301E+01	9.391E+00	2.620E+03	1.760E-01
2077	8.639E+02	4.720E+05	3.171E+01	9.023E+00	2.517E+03	1.691E-01
2078	8.301E+02	4.535E+05	3.047E+01	8.669E+00	2.418E+03	1.625E-01
2079	7.975E+02	4.357E+05	2.927E+01	8.329E+00	2.324E+03	1.561E-01
2080	7.662E+02	4.186E+05	2.813E+01	8.002E+00	2.233E+03	1.500E-01
2081	7.362E+02	4.022E+05	2.702E+01	7.689E+00	2.145E+03	1.441E-01
2082	7.073E+02	3.864E+05	2.596E+01	7.387E+00	2.061E+03	1.385E-01
2083	6.796E+02	3.713E+05	2.494E+01	7.097E+00	1.980E+03	1.330E-01
2084	6.529E+02	3.567E+05	2.397E+01	6.819E+00	1.902E+03	1.278E-01
2085	6.273E+02	3.427E+05	2.303E+01	6.552E+00	1.828E+03	1.228E-01
2086	6.027E+02	3.293E+05	2.212E+01	6.295E+00	1.756E+03	1.180E-01
2087	5.791E+02	3.164E+05	2.126E+01	6.048E+00	1.687E+03	1.134E-01
2088	5.564E+02	3.040E+05	2.042E+01	5.811E+00	1.621E+03	1.089E-01
2089	5.346E+02	2.920E+05	1.962E+01	5.583E+00	1.558E+03	1.047E-01
2090	5.136E+02	2.806E+05	1.885E+01	5.364E+00	1.496E+03	1.005E-01
2091	4.935E+02	2.696E+05	1.811E+01	5.154E+00	1.438E+03	9.661E-02
2092	4.741E+02	2.590E+05	1.740E+01	4.952E+00	1.381E+03	9.282E-02
2093	4.555E+02	2.489E+05	1.672E+01	4.758E+00	1.327E+03	8.918E-02
2094	4.377E+02	2.391E+05	1.607E+01	4.571E+00	1.275E+03	8.568E-02
2095	4.205E+02	2.297E+05	1.544E+01	4.392E+00	1.225E+03	8.232E-02
2096	4.040E+02	2.207E+05	1.483E+01	4.220E+00	1.177E+03	7.909E-02
2097	3.882E+02	2.121E+05	1.425E+01	4.054E+00	1.131E+03	7.599E-02
2098	3.730E+02	2.038E+05	1.369E+01	3.895E+00	1.087E+03	7.301E-02
2099	3.583E+02	1.958E+05	1.315E+01	3.742E+00	1.044E+03	7.015E-02

Summary Report

Landfill Name or Identifier: AVALON AT SOUTH BAY-LOW END

Date: Wednesday, July 30, 2008

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

Where,

Q_{CH4} = annual methane generation in the year of the calculation (m^3/*year*)
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate ($year^{-1}$)
L_o = potential methane generation capacity (m^3/Mg)

M_i = mass of waste accepted in the i^{th} year (*Mg*)
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1959**	
Landfill Closure Year (with 80-year limit)	**1965**	
Actual Closure Year (without limit)	***1965***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity	**2,000,000**	*short tons*

MODEL PARAMETERS

Methane Generation Rate, k	**0.040**	*year^{-1}*
Potential Methane Generation Capacity, L_o	**170**	*m^3/Mg*
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**25**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1959	230,474	253,521	0	0
1960	307,298	338,028	230,474	253,521
1961	307,298	338,028	537,772	591,549
1962	307,298	338,028	845,070	929,577
1963	307,298	338,028	1,152,368	1,267,605
1964	307,298	338,028	1,459,666	1,605,633
1965	51,218	56,340	1,766,965	1,943,661
1966	0	0	1,818,183	2,000,001
1967	0	0	1,818,183	2,000,001
1968	0	0	1,818,183	2,000,001
1969	0	0	1,818,183	2,000,001
1970	0	0	1,818,183	2,000,001
1971	0	0	1,818,183	2,000,001
1972	0	0	1,818,183	2,000,001
1973	0	0	1,818,183	2,000,001
1974	0	0	1,818,183	2,000,001
1975	0	0	1,818,183	2,000,001
1976	0	0	1,818,183	2,000,001
1977	0	0	1,818,183	2,000,001
1978	0	0	1,818,183	2,000,001
1979	0	0	1,818,183	2,000,001
1980	0	0	1,818,183	2,000,001
1981	0	0	1,818,183	2,000,001
1982	0	0	1,818,183	2,000,001
1983	0	0	1,818,183	2,000,001
1984	0	0	1,818,183	2,000,001
1985	0	0	1,818,183	2,000,001
1986	0	0	1,818,183	2,000,001
1987	0	0	1,818,183	2,000,001
1988	0	0	1,818,183	2,000,001
1989	0	0	1,818,183	2,000,001
1990	0	0	1,818,183	2,000,001
1991	0	0	1,818,183	2,000,001
1992	0	0	1,818,183	2,000,001
1993	0	0	1,818,183	2,000,001
1994	0	0	1,818,183	2,000,001
1995	0	0	1,818,183	2,000,001
1996	0	0	1,818,183	2,000,001
1997	0	0	1,818,183	2,000,001
1998	0	0	1,818,183	2,000,001

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	(short tons/year)	(Mg)	(short tons)
1999	0	0	1,818,183	2,000,001
2000	0	0	1,818,183	2,000,001
2001	0	0	1,818,183	2,000,001
2002	0	0	1,818,183	2,000,001
2003	0	0	1,818,183	2,000,001
2004	0	0	1,818,183	2,000,001
2005	0	0	1,818,183	2,000,001
2006	0	0	1,818,183	2,000,001
2007	0	0	1,818,183	2,000,001
2008	0	0	1,818,183	2,000,001
2009	0	0	1,818,183	2,000,001
2010	0	0	1,818,183	2,000,001
2011	0	0	1,818,183	2,000,001
2012	0	0	1,818,183	2,000,001
2013	0	0	1,818,183	2,000,001
2014	0	0	1,818,183	2,000,001
2015	0	0	1,818,183	2,000,001
2016	0	0	1,818,183	2,000,001
2017	0	0	1,818,183	2,000,001
2018	0	0	1,818,183	2,000,001
2019	0	0	1,818,183	2,000,001
2020	0	0	1,818,183	2,000,001
2021	0	0	1,818,183	2,000,001
2022	0	0	1,818,183	2,000,001
2023	0	0	1,818,183	2,000,001
2024	0	0	1,818,183	2,000,001
2025	0	0	1,818,183	2,000,001
2026	0	0	1,818,183	2,000,001
2027	0	0	1,818,183	2,000,001
2028	0	0	1,818,183	2,000,001
2029	0	0	1,818,183	2,000,001
2030	0	0	1,818,183	2,000,001
2031	0	0	1,818,183	2,000,001
2032	0	0	1,818,183	2,000,001
2033	0	0	1,818,183	2,000,001
2034	0	0	1,818,183	2,000,001
2035	0	0	1,818,183	2,000,001
2036	0	0	1,818,183	2,000,001
2037	0	0	1,818,183	2,000,001
2038	0	0	1,818,183	2,000,001

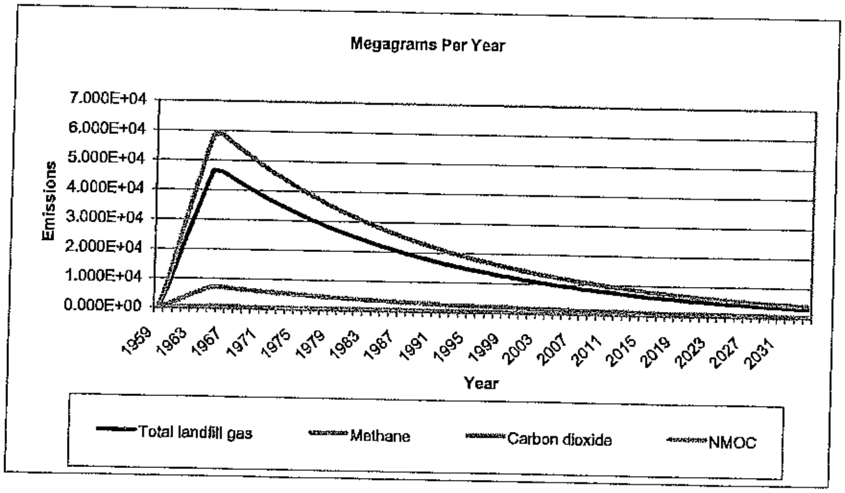
Pollutant Parameters

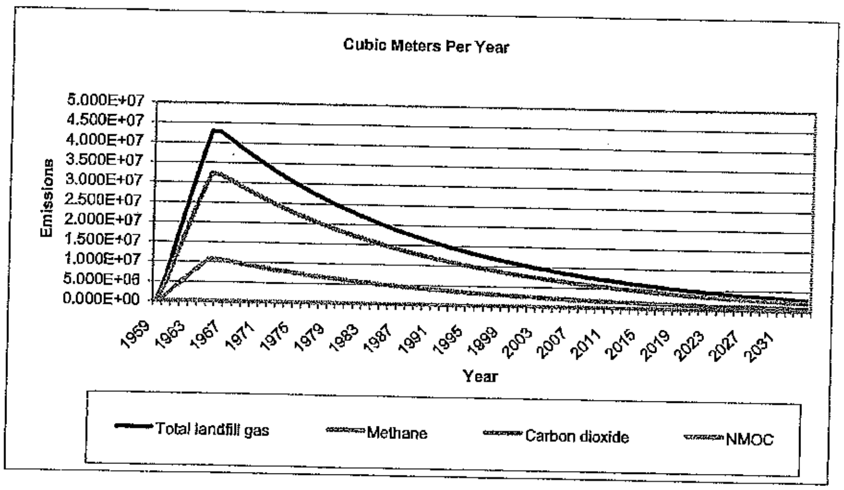
	Compound	Gas / Pollutant Default Parameters: Concentration (*ppmv*)	Molecular Weight	User-specified Pollutant Parameters: Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

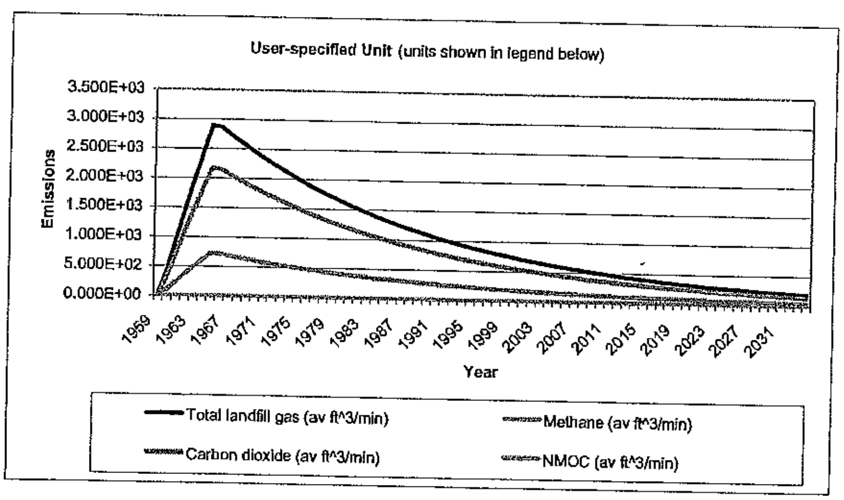
Pollutant Parameters (Continued)

	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

Graphs


Megagrams Per Year
7.000E+04
6.000E+04
5.000E+04
4.000E+04
3.000E+04
2.000E+04
1.000E+04
0.000E+00
Emissions
1959
1963
1967
1971
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
2015
2019
2023
2027
2031
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
5.000E+07
4.500E+07
4.000E+07
3.500E+07
3.000E+07
2.500E+07
2.000E+07
1.500E+07
1.000E+07
5.000E+06
0.000E+00
Emissions
1959
1963
1967
1971
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
2015
2019
2023
2027
2031
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
3.500E+03
3.000E+03
2.500E+03
2.000E+03
1.500E+03
1.000E+03
5.000E+02
0.000E+00
Emissions
1959
1963
1967
1971
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
2015
2019
2023
2027
2031
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
1959	0	0	0	0	0	0
1960	6.663E+03	6.157E+06	4.137E+02	1.027E+03	1.539E+06	1.034E+02
1961	1.528E+04	1.413E+07	9.491E+02	2.356E+03	3.531E+06	2.373E+02
1962	2.357E+04	2.178E+07	1.464E+03	3.633E+03	5.446E+06	3.659E+02
1963	3.153E+04	2.914E+07	1.958E+03	4.860E+03	7.284E+06	4.894E+02
1964	3.918E+04	3.621E+07	2.433E+03	6.039E+03	9.051E+06	6.082E+02
1965	4.652E+04	4.300E+07	2.889E+03	7.171E+03	1.075E+07	7.222E+02
1966	4.618E+04	4.268E+07	2.868E+03	7.118E+03	1.067E+07	7.169E+02
1967	4.437E+04	4.100E+07	2.755E+03	6.839E+03	1.025E+07	6.888E+02
1968	4.263E+04	3.940E+07	2.647E+03	6.571E+03	9.849E+06	6.618E+02
1969	4.096E+04	3.785E+07	2.543E+03	6.313E+03	9.463E+06	6.358E+02
1970	3.935E+04	3.637E+07	2.444E+03	6.066E+03	9.092E+06	6.109E+02
1971	3.781E+04	3.494E+07	2.348E+03	5.828E+03	8.735E+06	5.869E+02
1972	3.633E+04	3.357E+07	2.256E+03	5.599E+03	8.393E+06	5.639E+02
1973	3.490E+04	3.226E+07	2.167E+03	5.380E+03	8.064E+06	5.418E+02
1974	3.353E+04	3.099E+07	2.082E+03	5.169E+03	7.748E+06	5.206E+02
1975	3.222E+04	2.978E+07	2.001E+03	4.966E+03	7.444E+06	5.002E+02
1976	3.095E+04	2.861E+07	1.922E+03	4.771E+03	7.152E+06	4.805E+02
1977	2.974E+04	2.749E+07	1.847E+03	4.584E+03	6.872E+06	4.617E+02
1978	2.857E+04	2.641E+07	1.774E+03	4.405E+03	6.602E+06	4.436E+02
1979	2.745E+04	2.537E+07	1.705E+03	4.232E+03	6.343E+06	4.262E+02
1980	2.638E+04	2.438E+07	1.638E+03	4.066E+03	6.095E+06	4.095E+02
1981	2.534E+04	2.342E+07	1.574E+03	3.907E+03	5.856E+06	3.934E+02
1982	2.435E+04	2.250E+07	1.512E+03	3.753E+03	5.626E+06	3.780E+02
1983	2.340E+04	2.162E+07	1.453E+03	3.606E+03	5.405E+06	3.632E+02
1984	2.248E+04	2.077E+07	1.396E+03	3.465E+03	5.193E+06	3.489E+02
1985	2.160E+04	1.996E+07	1.341E+03	3.329E+03	4.990E+06	3.353E+02
1986	2.075E+04	1.918E+07	1.288E+03	3.198E+03	4.794E+06	3.221E+02
1987	1.994E+04	1.842E+07	1.238E+03	3.073E+03	4.606E+06	3.095E+02
1988	1.915E+04	1.770E+07	1.189E+03	2.952E+03	4.426E+06	2.974E+02
1989	1.840E+04	1.701E+07	1.143E+03	2.837E+03	4.252E+06	2.857E+02
1990	1.768E+04	1.634E+07	1.098E+03	2.725E+03	4.085E+06	2.745E+02
1991	1.699E+04	1.570E+07	1.055E+03	2.619E+03	3.925E+06	2.637E+02
1992	1.632E+04	1.508E+07	1.014E+03	2.516E+03	3.771E+06	2.534E+02
1993	1.568E+04	1.449E+07	9.738E+02	2.417E+03	3.623E+06	2.435E+02
1994	1.507E+04	1.393E+07	9.356E+02	2.323E+03	3.481E+06	2.339E+02
1995	1.448E+04	1.338E+07	8.989E+02	2.231E+03	3.345E+06	2.247E+02
1996	1.391E+04	1.285E+07	8.637E+02	2.144E+03	3.214E+06	2.159E+02
1997	1.336E+04	1.235E+07	8.298E+02	2.060E+03	3.088E+06	2.075E+02
1998	1.284E+04	1.187E+07	7.973E+02	1.979E+03	2.967E+06	1.993E+02
1999	1.234E+04	1.140E+07	7.660E+02	1.902E+03	2.850E+06	1.915E+02
2000	1.185E+04	1.095E+07	7.360E+02	1.827E+03	2.738E+06	1.840E+02
2001	1.139E+04	1.052E+07	7.071E+02	1.755E+03	2.631E+06	1.768E+02
2002	1.094E+04	1.011E+07	6.794E+02	1.686E+03	2.528E+06	1.698E+02
2003	1.051E+04	9.715E+06	6.528E+02	1.620E+03	2.429E+06	1.632E+02
2004	1.010E+04	9.334E+06	6.272E+02	1.557E+03	2.334E+06	1.568E+02
2005	9.704E+03	8.968E+06	6.026E+02	1.496E+03	2.242E+06	1.506E+02
2006	9.323E+03	8.617E+06	5.789E+02	1.437E+03	2.154E+06	1.447E+02
2007	8.958E+03	8.279E+06	5.562E+02	1.381E+03	2.070E+06	1.391E+02
2008	8.607E+03	7.954E+06	5.344E+02	1.327E+03	1.989E+06	1.336E+02

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2009	8.269E+03	7.642E+06	5.135E+02	1.275E+03	1.911E+06	1.284E+02
2010	7.945E+03	7.343E+06	4.933E+02	1.225E+03	1.836E+06	1.233E+02
2011	7.633E+03	7.055E+06	4.740E+02	1.177E+03	1.764E+06	1.185E+02
2012	7.334E+03	6.778E+06	4.554E+02	1.130E+03	1.695E+06	1.139E+02
2013	7.047E+03	6.512E+06	4.376E+02	1.086E+03	1.628E+06	1.094E+02
2014	6.770E+03	6.257E+06	4.204E+02	1.044E+03	1.564E+06	1.051E+02
2015	6.505E+03	6.012E+06	4.039E+02	1.003E+03	1.503E+06	1.010E+02
2016	6.250E+03	5.776E+06	3.881E+02	9.633E+02	1.444E+06	9.702E+01
2017	6.005E+03	5.549E+06	3.729E+02	9.256E+02	1.387E+06	9.322E+01
2018	5.769E+03	5.332E+06	3.582E+02	8.893E+02	1.333E+06	8.956E+01
2019	5.543E+03	5.123E+06	3.442E+02	8.544E+02	1.281E+06	8.605E+01
2020	5.326E+03	4.922E+06	3.307E+02	8.209E+02	1.230E+06	8.267E+01
2021	5.117E+03	4.729E+06	3.177E+02	7.887E+02	1.182E+06	7.943E+01
2022	4.916E+03	4.543E+06	3.053E+02	7.578E+02	1.136E+06	7.632E+01
2023	4.723E+03	4.365E+06	2.933E+02	7.281E+02	1.091E+06	7.333E+01
2024	4.538E+03	4.194E+06	2.818E+02	6.995E+02	1.049E+06	7.045E+01
2025	4.360E+03	4.030E+06	2.708E+02	6.721E+02	1.007E+06	6.769E+01
2026	4.189E+03	3.872E+06	2.601E+02	6.457E+02	9.679E+05	6.503E+01
2027	4.025E+03	3.720E+06	2.499E+02	6.204E+02	9.300E+05	6.248E+01
2028	3.867E+03	3.574E+06	2.401E+02	5.961E+02	8.935E+05	6.003E+01
2029	3.716E+03	3.434E+06	2.307E+02	5.727E+02	8.585E+05	5.768E+01
2030	3.570E+03	3.299E+06	2.217E+02	5.503E+02	8.248E+05	5.542E+01
2031	3.430E+03	3.170E+06	2.130E+02	5.287E+02	7.925E+05	5.325E+01
2032	3.295E+03	3.046E+06	2.046E+02	5.080E+02	7.614E+05	5.116E+01
2033	3.166E+03	2.926E+06	1.966E+02	4.880E+02	7.315E+05	4.915E+01
2034	3.042E+03	2.811E+06	1.889E+02	4.689E+02	7.029E+05	4.722E+01
2035	2.923E+03	2.701E+06	1.815E+02	4.505E+02	6.753E+05	4.537E+01
2036	2.808E+03	2.595E+06	1.744E+02	4.329E+02	6.488E+05	4.359E+01
2037	2.698E+03	2.493E+06	1.675E+02	4.159E+02	6.234E+05	4.188E+01
2038	2.592E+03	2.396E+06	1.610E+02	3.996E+02	5.989E+05	4.024E+01
2039	2.491E+03	2.302E+06	1.547E+02	3.839E+02	5.754E+05	3.866E+01
2040	2.393E+03	2.212E+06	1.486E+02	3.689E+02	5.529E+05	3.715E+01
2041	2.299E+03	2.125E+06	1.428E+02	3.544E+02	5.312E+05	3.569E+01
2042	2.209E+03	2.042E+06	1.372E+02	3.405E+02	5.104E+05	3.429E+01
2043	2.122E+03	1.961E+06	1.318E+02	3.271E+02	4.904E+05	3.295E+01
2044	2.039E+03	1.885E+06	1.266E+02	3.143E+02	4.711E+05	3.166E+01
2045	1.959E+03	1.811E+06	1.217E+02	3.020E+02	4.527E+05	3.041E+01
2046	1.882E+03	1.740E+06	1.169E+02	2.902E+02	4.349E+05	2.922E+01
2047	1.809E+03	1.671E+06	1.123E+02	2.788E+02	4.179E+05	2.808E+01
2048	1.738E+03	1.606E+06	1.079E+02	2.678E+02	4.015E+05	2.698E+01
2049	1.670E+03	1.543E+06	1.037E+02	2.573E+02	3.857E+05	2.592E+01
2050	1.604E+03	1.482E+06	9.960E+01	2.473E+02	3.706E+05	2.490E+01
2051	1.541E+03	1.424E+06	9.570E+01	2.376E+02	3.561E+05	2.392E+01
2052	1.481E+03	1.368E+06	9.195E+01	2.282E+02	3.421E+05	2.299E+01
2053	1.423E+03	1.315E+06	8.834E+01	2.193E+02	3.287E+05	2.209E+01
2054	1.367E+03	1.263E+06	8.488E+01	2.107E+02	3.158E+05	2.122E+01
2055	1.313E+03	1.214E+06	8.155E+01	2.024E+02	3.034E+05	2.039E+01
2056	1.262E+03	1.166E+06	7.835E+01	1.945E+02	2.915E+05	1.959E+01
2057	1.212E+03	1.120E+06	7.528E+01	1.869E+02	2.801E+05	1.882E+01
2058	1.165E+03	1.076E+06	7.233E+01	1.795E+02	2.691E+05	1.808E+01
2059	1.119E+03	1.034E+06	6.949E+01	1.725E+02	2.586E+05	1.737E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2060	1.075E+03	9.937E+05	6.677E+01	1.657E+02	2.484E+05	1.669E+01
2061	1.033E+03	9.547E+05	6.415E+01	1.592E+02	2.387E+05	1.604E+01
2062	9.926E+02	9.173E+05	6.163E+01	1.530E+02	2.293E+05	1.541E+01
2063	9.536E+02	8.813E+05	5.922E+01	1.470E+02	2.203E+05	1.480E+01
2064	9.162E+02	8.468E+05	5.690E+01	1.412E+02	2.117E+05	1.422E+01
2065	8.803E+02	8.136E+05	5.466E+01	1.357E+02	2.034E+05	1.367E+01
2066	8.458E+02	7.817E+05	5.252E+01	1.304E+02	1.954E+05	1.313E+01
2067	8.126E+02	7.510E+05	5.046E+01	1.253E+02	1.878E+05	1.262E+01
2068	7.808E+02	7.216E+05	4.848E+01	1.204E+02	1.804E+05	1.212E+01
2069	7.502E+02	6.933E+05	4.658E+01	1.156E+02	1.733E+05	1.165E+01
2070	7.207E+02	6.661E+05	4.476E+01	1.111E+02	1.665E+05	1.119E+01
2071	6.925E+02	6.400E+05	4.300E+01	1.067E+02	1.600E+05	1.075E+01
2072	6.653E+02	6.149E+05	4.131E+01	1.026E+02	1.537E+05	1.033E+01
2073	6.392E+02	5.908E+05	3.969E+01	9.853E+01	1.477E+05	9.924E+00
2074	6.142E+02	5.676E+05	3.814E+01	9.467E+01	1.419E+05	9.534E+00
2075	5.901E+02	5.454E+05	3.664E+01	9.096E+01	1.363E+05	9.161E+00
2076	5.670E+02	5.240E+05	3.521E+01	8.739E+01	1.310E+05	8.801E+00
2077	5.447E+02	5.034E+05	3.383E+01	8.397E+01	1.259E+05	8.456E+00
2078	5.234E+02	4.837E+05	3.250E+01	8.067E+01	1.209E+05	8.125E+00
2079	5.028E+02	4.647E+05	3.122E+01	7.751E+01	1.162E+05	7.806E+00
2080	4.831E+02	4.465E+05	3.000E+01	7.447E+01	1.116E+05	7.500E+00
2081	4.642E+02	4.290E+05	2.882E+01	7.155E+01	1.072E+05	7.206E+00
2082	4.460E+02	4.122E+05	2.769E+01	6.875E+01	1.030E+05	6.923E+00
2083	4.285E+02	3.960E+05	2.661E+01	6.605E+01	9.900E+04	6.652E+00
2084	4.117E+02	3.805E+05	2.556E+01	6.346E+01	9.512E+04	6.391E+00
2085	3.956E+02	3.656E+05	2.456E+01	6.097E+01	9.139E+04	6.141E+00
2086	3.800E+02	3.512E+05	2.360E+01	5.858E+01	8.781E+04	5.900E+00
2087	3.651E+02	3.375E+05	2.267E+01	5.628E+01	8.436E+04	5.668E+00
2088	3.508E+02	3.242E+05	2.178E+01	5.408E+01	8.106E+04	5.446E+00
2089	3.371E+02	3.115E+05	2.093E+01	5.196E+01	7.788E+04	5.233E+00
2090	3.239E+02	2.993E+05	2.011E+01	4.992E+01	7.482E+04	5.027E+00
2091	3.112E+02	2.876E+05	1.932E+01	4.796E+01	7.189E+04	4.830E+00
2092	2.990E+02	2.763E+05	1.856E+01	4.608E+01	6.907E+04	4.641E+00
2093	2.872E+02	2.655E+05	1.784E+01	4.427E+01	6.636E+04	4.459E+00
2094	2.760E+02	2.550E+05	1.714E+01	4.254E+01	6.376E+04	4.284E+00
2095	2.651E+02	2.450E+05	1.646E+01	4.087E+01	6.126E+04	4.116E+00
2096	2.548E+02	2.354E+05	1.582E+01	3.927E+01	5.886E+04	3.955E+00
2097	2.448E+02	2.262E+05	1.520E+01	3.773E+01	5.655E+04	3.800E+00
2098	2.352E+02	2.173E+05	1.460E+01	3.625E+01	5.433E+04	3.651E+00
2099	2.259E+02	2.088E+05	1.403E+01	3.483E+01	5.220E+04	3.508E+00

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
1959	0	0	0	0	0	0
1960	8.453E+03	4.618E+06	3.103E+02	8.828E+01	2.463E+04	1.655E+00
1961	1.939E+04	1.059E+07	7.118E+02	2.025E+02	5.650E+04	3.796E+00
1962	2.990E+04	1.634E+07	1.098E+03	3.123E+02	8.713E+04	5.854E+00
1963	4.000E+04	2.185E+07	1.468E+03	4.178E+02	1.166E+05	7.831E+00
1964	4.971E+04	2.715E+07	1.824E+03	5.191E+02	1.448E+05	9.731E+00
1965	5.903E+04	3.225E+07	2.167E+03	6.165E+02	1.720E+05	1.156E+01
1966	5.859E+04	3.201E+07	2.151E+03	6.119E+02	1.707E+05	1.147E+01
1967	5.629E+04	3.075E+07	2.066E+03	5.879E+02	1.640E+05	1.102E+01
1968	5.409E+04	2.955E+07	1.985E+03	5.649E+02	1.576E+05	1.059E+01
1969	5.197E+04	2.839E+07	1.907E+03	5.427E+02	1.514E+05	1.017E+01
1970	4.993E+04	2.728E+07	1.833E+03	5.214E+02	1.455E+05	9.774E+00
1971	4.797E+04	2.621E+07	1.761E+03	5.010E+02	1.398E+05	9.391E+00
1972	4.609E+04	2.518E+07	1.692E+03	4.813E+02	1.343E+05	9.023E+00
1973	4.428E+04	2.419E+07	1.625E+03	4.625E+02	1.290E+05	8.669E+00
1974	4.255E+04	2.324E+07	1.562E+03	4.443E+02	1.240E+05	8.329E+00
1975	4.088E+04	2.233E+07	1.500E+03	4.269E+02	1.191E+05	8.002E+00
1976	3.928E+04	2.146E+07	1.442E+03	4.102E+02	1.144E+05	7.689E+00
1977	3.774E+04	2.061E+07	1.385E+03	3.941E+02	1.099E+05	7.387E+00
1978	3.626E+04	1.981E+07	1.331E+03	3.786E+02	1.056E+05	7.098E+00
1979	3.483E+04	1.903E+07	1.279E+03	3.638E+02	1.015E+05	6.819E+00
1980	3.347E+04	1.828E+07	1.228E+03	3.495E+02	9.751E+04	6.552E+00
1981	3.216E+04	1.757E+07	1.180E+03	3.358E+02	9.369E+04	6.295E+00
1982	3.089E+04	1.688E+07	1.134E+03	3.227E+02	9.002E+04	6.048E+00
1983	2.968E+04	1.622E+07	1.090E+03	3.100E+02	8.649E+04	5.811E+00
1984	2.852E+04	1.558E+07	1.047E+03	2.979E+02	8.309E+04	5.583E+00
1985	2.740E+04	1.497E+07	1.006E+03	2.862E+02	7.984E+04	5.364E+00
1986	2.633E+04	1.438E+07	9.664E+02	2.750E+02	7.671E+04	5.154E+00
1987	2.529E+04	1.382E+07	9.285E+02	2.642E+02	7.370E+04	4.952E+00
1988	2.430E+04	1.328E+07	8.921E+02	2.538E+02	7.081E+04	4.758E+00
1989	2.335E+04	1.276E+07	8.571E+02	2.439E+02	6.803E+04	4.571E+00
1990	2.243E+04	1.226E+07	8.235E+02	2.343E+02	6.536E+04	4.392E+00
1991	2.155E+04	1.178E+07	7.912E+02	2.251E+02	6.280E+04	4.220E+00
1992	2.071E+04	1.131E+07	7.602E+02	2.163E+02	6.034E+04	4.054E+00
1993	1.990E+04	1.087E+07	7.304E+02	2.078E+02	5.797E+04	3.895E+00
1994	1.912E+04	1.044E+07	7.017E+02	1.997E+02	5.570E+04	3.742E+00
1995	1.837E+04	1.003E+07	6.742E+02	1.918E+02	5.352E+04	3.596E+00
1996	1.765E+04	9.641E+06	6.478E+02	1.843E+02	5.142E+04	3.455E+00
1997	1.696E+04	9.263E+06	6.224E+02	1.771E+02	4.940E+04	3.319E+00
1998	1.629E+04	8.900E+06	5.980E+02	1.701E+02	4.746E+04	3.189E+00
1999	1.565E+04	8.551E+06	5.745E+02	1.635E+02	4.560E+04	3.064E+00
2000	1.504E+04	8.215E+06	5.520E+02	1.571E+02	4.382E+04	2.944E+00
2001	1.445E+04	7.893E+06	5.303E+02	1.509E+02	4.210E+04	2.829E+00
2002	1.388E+04	7.584E+06	5.095E+02	1.450E+02	4.045E+04	2.718E+00
2003	1.334E+04	7.286E+06	4.896E+02	1.393E+02	3.886E+04	2.611E+00
2004	1.281E+04	7.001E+06	4.704E+02	1.338E+02	3.734E+04	2.509E+00
2005	1.231E+04	6.726E+06	4.519E+02	1.286E+02	3.587E+04	2.410E+00
2006	1.183E+04	6.462E+06	4.342E+02	1.235E+02	3.447E+04	2.316E+00
2007	1.137E+04	6.209E+06	4.172E+02	1.187E+02	3.311E+04	2.225E+00
2008	1.092E+04	5.966E+06	4.008E+02	1.140E+02	3.182E+04	2.138E+00

Results (Continued)

Year	Carbon dioxide (Mg/year)	Carbon dioxide (m^3/year)	Carbon dioxide (av ft^3/min)	NMOC (Mg/year)	NMOC (m^3/year)	NMOC (av ft^3/min)
2009	1.049E+04	5.732E+06	3.851E+02	1.096E+02	3.057E+04	2.054E+00
2010	1.008E+04	5.507E+06	3.700E+02	1.053E+02	2.937E+04	1.973E+00
2011	9.685E+03	5.291E+06	3.555E+02	1.011E+02	2.822E+04	1.896E+00
2012	9.305E+03	5.084E+06	3.416E+02	9.718E+01	2.711E+04	1.822E+00
2013	8.941E+03	4.884E+06	3.282E+02	9.337E+01	2.605E+04	1.750E+00
2014	8.590E+03	4.693E+06	3.153E+02	8.971E+01	2.503E+04	1.682E+00
2015	8.253E+03	4.509E+06	3.029E+02	8.619E+01	2.405E+04	1.616E+00
2016	7.930E+03	4.332E+06	2.911E+02	8.281E+01	2.310E+04	1.552E+00
2017	7.619E+03	4.162E+06	2.796E+02	7.957E+01	2.220E+04	1.491E+00
2018	7.320E+03	3.999E+06	2.687E+02	7.645E+01	2.133E+04	1.433E+00
2019	7.033E+03	3.842E+06	2.581E+02	7.345E+01	2.049E+04	1.377E+00
2020	6.757E+03	3.691E+06	2.480E+02	7.057E+01	1.969E+04	1.323E+00
2021	6.492E+03	3.547E+06	2.383E+02	6.780E+01	1.892E+04	1.271E+00
2022	6.238E+03	3.408E+06	2.290E+02	6.514E+01	1.817E+04	1.221E+00
2023	5.993E+03	3.274E+06	2.200E+02	6.259E+01	1.746E+04	1.173E+00
2024	5.758E+03	3.146E+06	2.114E+02	6.013E+01	1.678E+04	1.127E+00
2025	5.532E+03	3.022E+06	2.031E+02	5.778E+01	1.612E+04	1.083E+00
2026	5.315E+03	2.904E+06	1.951E+02	5.551E+01	1.549E+04	1.041E+00
2027	5.107E+03	2.790E+06	1.875E+02	5.333E+01	1.488E+04	9.997E-01
2028	4.907E+03	2.681E+06	1.801E+02	5.124E+01	1.430E+04	9.605E-01
2029	4.714E+03	2.575E+06	1.730E+02	4.923E+01	1.374E+04	9.229E-01
2030	4.529E+03	2.474E+06	1.663E+02	4.730E+01	1.320E+04	8.867E-01
2031	4.352E+03	2.377E+06	1.597E+02	4.545E+01	1.268E+04	8.519E-01
2032	4.181E+03	2.284E+06	1.535E+02	4.367E+01	1.218E+04	8.185E-01
2033	4.017E+03	2.195E+06	1.475E+02	4.195E+01	1.170E+04	7.864E-01
2034	3.860E+03	2.109E+06	1.417E+02	4.031E+01	1.125E+04	7.556E-01
2035	3.708E+03	2.026E+06	1.361E+02	3.873E+01	1.080E+04	7.260E-01
2036	3.563E+03	1.946E+06	1.308E+02	3.721E+01	1.038E+04	6.975E-01
2037	3.423E+03	1.870E+06	1.257E+02	3.575E+01	9.974E+03	6.702E-01
2038	3.289E+03	1.797E+06	1.207E+02	3.435E+01	9.583E+03	6.439E-01
2039	3.160E+03	1.726E+06	1.160E+02	3.300E+01	9.207E+03	6.186E-01
2040	3.036E+03	1.659E+06	1.114E+02	3.171E+01	8.846E+03	5.944E-01
2041	2.917E+03	1.594E+06	1.071E+02	3.047E+01	8.499E+03	5.711E-01
2042	2.803E+03	1.531E+06	1.029E+02	2.927E+01	8.166E+03	5.487E-01
2043	2.693E+03	1.471E+06	9.884E+01	2.812E+01	7.846E+03	5.272E-01
2044	2.587E+03	1.413E+06	9.497E+01	2.702E+01	7.538E+03	5.065E-01
2045	2.486E+03	1.358E+06	9.124E+01	2.596E+01	7.243E+03	4.866E-01
2046	2.388E+03	1.305E+06	8.767E+01	2.494E+01	6.959E+03	4.675E-01
2047	2.295E+03	1.254E+06	8.423E+01	2.396E+01	6.686E+03	4.492E-01
2048	2.205E+03	1.204E+06	8.093E+01	2.303E+01	6.424E+03	4.316E-01
2049	2.118E+03	1.157E+06	7.775E+01	2.212E+01	6.172E+03	4.147E-01
2050	2.035E+03	1.112E+06	7.470E+01	2.125E+01	5.930E+03	3.984E-01
2051	1.955E+03	1.068E+06	7.177E+01	2.042E+01	5.697E+03	3.828E-01
2052	1.879E+03	1.026E+06	6.896E+01	1.962E+01	5.474E+03	3.678E-01
2053	1.805E+03	9.861E+05	6.626E+01	1.885E+01	5.259E+03	3.534E-01
2054	1.734E+03	9.474E+05	6.366E+01	1.811E+01	5.053E+03	3.395E-01
2055	1.666E+03	9.103E+05	6.116E+01	1.740E+01	4.855E+03	3.262E-01
2056	1.601E+03	8.746E+05	5.876E+01	1.672E+01	4.665E+03	3.134E-01
2057	1.538E+03	8.403E+05	5.646E+01	1.606E+01	4.482E+03	3.011E-01
2058	1.478E+03	8.074E+05	5.425E+01	1.543E+01	4.306E+03	2.893E-01
2059	1.420E+03	7.757E+05	5.212E+01	1.483E+01	4.137E+03	2.780E-01

Results (Continued)

Year	Carbon dioxide (Mg/year)	Carbon dioxide (m^3/year)	Carbon dioxide (av ft^3/min)	NMOC (Mg/year)	NMOC (m^3/year)	NMOC (av ft^3/min)
2060	1.364E+03	7.453E+05	5.008E+01	1.425E+01	3.975E+03	2.671E-01
2061	1.311E+03	7.161E+05	4.811E+01	1.369E+01	3.819E+03	2.566E-01
2062	1.259E+03	6.880E+05	4.623E+01	1.315E+01	3.669E+03	2.465E-01
2063	1.210E+03	6.610E+05	4.441E+01	1.264E+01	3.525E+03	2.369E-01
2064	1.163E+03	6.351E+05	4.267E+01	1.214E+01	3.387E+03	2.276E-01
2065	1.117E+03	6.102E+05	4.100E+01	1.166E+01	3.254E+03	2.187E-01
2066	1.073E+03	5.863E+05	3.939E+01	1.121E+01	3.127E+03	2.101E-01
2067	1.031E+03	5.633E+05	3.785E+01	1.077E+01	3.004E+03	2.018E-01
2068	9.906E+02	5.412E+05	3.636E+01	1.035E+01	2.886E+03	1.939E-01
2069	9.518E+02	5.200E+05	3.494E+01	9.940E+00	2.773E+03	1.863E-01
2070	9.145E+02	4.996E+05	3.357E+01	9.550E+00	2.664E+03	1.790E-01
2071	8.786E+02	4.800E+05	3.225E+01	9.176E+00	2.560E+03	1.720E-01
2072	8.442E+02	4.612E+05	3.099E+01	8.816E+00	2.460E+03	1.653E-01
2073	8.111E+02	4.431E+05	2.977E+01	8.471E+00	2.363E+03	1.588E-01
2074	7.793E+02	4.257E+05	2.860E+01	8.138E+00	2.270E+03	1.526E-01
2075	7.487E+02	4.090E+05	2.748E+01	7.819E+00	2.181E+03	1.466E-01
2076	7.194E+02	3.930E+05	2.640E+01	7.513E+00	2.096E+03	1.408E-01
2077	6.911E+02	3.776E+05	2.537E+01	7.218E+00	2.014E+03	1.353E-01
2078	6.640E+02	3.628E+05	2.437E+01	6.935E+00	1.935E+03	1.300E-01
2079	6.380E+02	3.485E+05	2.342E+01	6.663E+00	1.859E+03	1.249E-01
2080	6.130E+02	3.349E+05	2.250E+01	6.402E+00	1.786E+03	1.200E-01
2081	5.890E+02	3.217E+05	2.162E+01	6.151E+00	1.716E+03	1.153E-01
2082	5.659E+02	3.091E+05	2.077E+01	5.910E+00	1.649E+03	1.108E-01
2083	5.437E+02	2.970E+05	1.996E+01	5.678E+00	1.584E+03	1.064E-01
2084	5.224E+02	2.854E+05	1.917E+01	5.455E+00	1.522E+03	1.023E-01
2085	5.019E+02	2.742E+05	1.842E+01	5.241E+00	1.462E+03	9.825E-02
2086	4.822E+02	2.634E+05	1.770E+01	5.036E+00	1.405E+03	9.440E-02
2087	4.633E+02	2.531E+05	1.701E+01	4.838E+00	1.350E+03	9.070E-02
2088	4.451E+02	2.432E+05	1.634E+01	4.649E+00	1.297E+03	8.714E-02
2089	4.277E+02	2.336E+05	1.570E+01	4.466E+00	1.246E+03	8.372E-02
2090	4.109E+02	2.245E+05	1.508E+01	4.291E+00	1.197E+03	8.044E-02
2091	3.948E+02	2.157E+05	1.449E+01	4.123E+00	1.150E+03	7.729E-02
2092	3.793E+02	2.072E+05	1.392E+01	3.961E+00	1.105E+03	7.425E-02
2093	3.644E+02	1.991E+05	1.338E+01	3.806E+00	1.062E+03	7.134E-02
2094	3.501E+02	1.913E+05	1.285E+01	3.657E+00	1.020E+03	6.855E-02
2095	3.364E+02	1.838E+05	1.235E+01	3.513E+00	9.802E+02	6.586E-02
2096	3.232E+02	1.766E+05	1.186E+01	3.376E+00	9.417E+02	6.328E-02
2097	3.106E+02	1.697E+05	1.140E+01	3.243E+00	9.048E+02	6.079E-02
2098	2.984E+02	1.630E+05	1.095E+01	3.116E+00	8.693E+02	5.841E-02
2099	2.867E+02	1.566E+05	1.052E+01	2.994E+00	8.353E+02	5.612E-02

Waste Volume and Tonnage Overview for LFG Modeling

MCz, 16 Feb 06

Table 1	Cell Volume (cy)		
Cell	Bottom of waste to elev +0.5 ft msl	Above +0.5 ft msl to top of waste	Total
1	319,842	406,761	726,603
2	695,340	1,616,661	2,312,001
3	604,021	775,571	1,379,592
4	749,366	1,208,811	1,958,177
5	35,442	237,255	272,697
Total	2,404,011	4,245,059	6,649,070

From BAS Expert Witness Report, 2003

Table 2	Waste Volume (cy)		
Cell	Inert waste volume at 85% of above	Decomposable waste volume at 100% of above + 15% of volume below elev +0.5 msl	Total
1	271,866	454,737	726,603
2	591,039	1,720,962	2,312,001
3	513,418	866,174	1,379,592
4	636,961	1,321,216	1,958,177
5	30,126	242,571	272,697
Total	2,043,409	4,605,661	6,649,070

Table 3	Proportional Total Waste Volume (each sub-volume above to total)		
Cell			
1	4.1%	6.8%	10.9%
2	8.9%	25.9%	34.8%
3	7.7%	13.0%	20.7%
4	9.6%	19.9%	29.5%
5	0.5%	3.6%	4.1%
Total	30.7%	69.3%	100.0%

Table 4	Proportional Decomposible Waste Volume		
Cell			
1		9.9%	
2		37.4%	
3		18.8%	
4		28.7%	
5		5.3%	
Total		100.0%	

The volumes above are based on borings and drawings done many years after waste was placed. It is logical that waste would have settled from the time it was placed to the time it was defined by the boreholes and drawings. Therefore, to find the begining point of waste volume that would correspond to the start of LFG generation modeling, we should attempt to estimate the larger volume occupied by the waste in 1965. For the purposes here, assume 30 years duration between completion of waste placement and the definition of its volume by boreholes and drawings.

Landfill settlement is hard to predict, but it is likely to have lost at least 25% of its original waste thickness at each point on the landfill surface. However, for our purposes, let's assume that this corresponds to an average of 20% volume loss over all waste thicknesses. Therefore, the next set of tables are used to estimate the total waste in place in 1965.

Table 5	Volume of Decomposible Waste in 1965 (add 20%)	
Cell		
1	545,685	9.9%
2	2,065,154	37.4%
3	1,039,409	18.8%
4	1,585,459	28.7%
5	291,086	5.3%
Total	5,526,793	100.0%

Converting volume of airspace consumed to tons of refuse requires an estimate of the in-place density of the refuse achieved and the ratio of soil to waste used. (Note - inplace density does not include weight of the soil)

Practical ranges for Cal Compact are estimated to be:

800 to 1200 lbs/cy for in-place density of refuse

3 parts refuse to 1 part soil (75% refuse)

Total volume (cy) occupied by decomposible waste = 5,526,793

In-place Refuse Density (lb/cy)	Tons of decomposible waste in place, using 3 parts refuse to one part soil
800	1,658,038
900	1,865,293
1000	2,072,547
1100	2,279,802
1200	2,487,057

Therefore - For LFG modeling, it is logical to use a range of decomposible waste in place of 2,000,000 to 2,500,000 tons

Using Table 5 to proportion these totals to the cells in same proportion as volume:

Table 6	Decomposible Tons in Place	
Cell	Low	High
1	197,469	246,836
2	747,325	934,156
3	376,135	470,168
4	573,736	717,170
5	105,336	131,670
Total	2,000,000	2,500,000

BAS (2003) refers to prior reports that indicated that cells were developed from northeast to southwest.

BAS (2003) indicates 71 months of landfill operation from April 1959 to February 1965.

At 2,000,000 tons total, this is an average of 28,169 tons per month, 338,028 tons per year

At 2,500,000 tons total, this is an average of 35,211 tons per month, 422,535 per year.

Therefore, we can assume the following:

Table 7

Tonnage in Place by Cell and Year (low end)

Period	Cell 2	Cell 4	Cell 5	Cell 1	Cell 3
9 mo -1959	253,521				
1960	338,028				
1961	155,776	182,252			
1962		338,028			
1963		53,456	105,336	179,236	
1964				18,233	319,795
2 mo -1965					56,340
Total	747,325	573,736	105,336	197,469	376,135
			2,000,001		
Check					
From Table 6	747,325	573,736	105,336	197,469	376,135
Diff	0	0	0	0	0

Table 8

Tonnage in Place by Cell and Year (high end)

Period	Cell 2	Cell 4	Cell 5	Cell 1	Cell 3
9 mo -1959	316,899				
1960	422,535				
1961	194,722	227,813			
1962		422,535			
1963		66,822	131,670	224,043	
1964				22,793	399,742
2 mo -1965					70,426
Total	934,156	717,170	131,670	246,836	470,168
			2,500,000		
Check					
From Table 6	934,156	717,170	131,670	246,836	470,168
Diff	0	0	0	0	0

CARSON MARKETPLACE, LLC
LANDFILL GAS PILOT TEST
REPORT OF FINDINGS

TABLE OF CONTENTS

CARSON MARKETPLACE, LLC
LANDFILL GAS PILOT TEST
REPORT OF FINDINGS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

EXECUTIVE SUMMARY

Bryan A. Stirrat & Associates (BAS) was retained by ARCADIS (formerly ARCADIS BBL) to implement the Landfill Gas Pilot Test Work Plan (work plan) prepared by Tetra Tech, Inc., dated June 12, 2006. All major tasks of the work plan described in this report were reasonably completed on behalf of the property owner, Carson Marketplace, LLC (Carson Marketplace), at the former Cal Compact Landfill located in Carson, California. The objectives of the Pilot Test were as follows:

- Establish a steady state extraction rate of landfill gas (LFG)
- Determine the size of extraction system equipment
- Determine the type of treatment equipment
- Assist permitting the final system

As an initial first step of the Pilot Test, static LFG samples were collected from each of the five refuse disposal cells at the site, using push probes, to establish a baseline understanding of the LFG composition and static volatile organic compounds (VOCs) to be encountered.

Laboratory testing of the collected samples indicated a relatively high static concentration of VOCs. Based upon Environmental Protection Agency (EPA) Method 25C guidelines these compounds are not speciated, however they are quantified as Total Gaseous Non-Methane, Non-Ethane Organic Compounds (TGNMNEOCs).

After the initial static probe sampling, the Pilot Test extraction and treatment system were installed. The Pilot Test was initiated and continued over a seven week period in an attempt to reach a LFG generation/extraction equilibrium (steady state condition). However, a steady state extraction rate was not determined due to the high volume of LFG resulting from a static "bubble", as well as the continued natural production of LFG from the anaerobic decomposition of refuse.

At the completion of the Pilot Test, the average methane concentration at the blower/treatment facility had dropped to 48.6 percent (%) by volume. Even though a clear reduction in the methane content of the LFG was evident, a steady state extraction of the LFG did not occur within the 7-week duration of the Pilot Test.

Because a steady state LFG extraction rate was not achieved, theoretical methane generation models were used to estimate equipment and pipe size, and to determine a range of anticipated LFG flows (from 14 to 300 standard cubic foot per minute [scfm] at 25% methane by volume). The theoretical methane generation models suggest that diminishing methane production in the near future may fail to sustain combustion of a LFG flare. Inclusion of supplemental fuel will be required in the design phase of this project.

The Pilot Test operation also revealed elevated TGNMNEOCs concentrations. This data, along with the high methane concentrations, supports the proposed conceptual design use of an enclosed ground flare versus the use of granular activated carbon [GAC] system. The function of an enclosed ground flare using the LFG as combustion fuel is an effective method of treatment for the TGNMNEOCs.

The last objective for the Pilot Test was to obtain real field data and laboratory testing results which can be used in the preparation of the South Coast Air Quality Management District (SCAQMD) permit to operate health risk assessment for the permanent system. The data necessary for this task was obtained during the speciated analysis of LFG performed during the pilot test.

1.0 BACKGROUND AND INTRODUCTION

On behalf of Carson Marketplace, LLC (Carson Marketplace), a Pilot Test was completed at the former Cal Compact Landfill property located at 20300 Main Street in Carson, California (Site) by Bryan A. Stirrat & Associates (BAS), who was retained by ARCADIS (formerly ARCADIS BBL). It is anticipated that the Site will be developed in the future and will be called Avalon at South Bay. The future development area is comprised of approximately 168 acres, including 157 acres of the former Cal Compact Landfill, and 11 acres of undeveloped (non-landfill) property north of Del Amo Boulevard. Current proposed redevelopment of the Site includes construction of mixed-use commercial and residential units.

In 1959, Cal Compact, Inc., a California Corporation, was issued an industrial waste disposal permit to operate a Class II landfill on the Site. The facility operated from approximately 1959 to 1964, with an approximate closing date of February 1965. The Cal Compact Landfill was permitted to accept both municipal solid waste and specified industrial liquid wastes.

The landfill accepted approximately 6 million cubic yards of municipal solid waste and 6.3 million gallons of industrial liquid waste. The liquid waste was predominately water and clay mixtures. Other wastes received included solvents, oils, sludges, heavy metals, paint sludges, and inorganic salts. The landfill is comprised of five separate cells, divided by haul roads, and is currently separated by Lenardo Drive and Stamps Drive. A soil cover which varies in thickness overlies all five cells.

The California Environmental Protection Agency, Department of Toxic Substances Control (DTSC) approved a Remedial Action Plan (RAP) in 1995 which permits Site development provided that an engineered landfill cap is installed to protect human health and the environment. In accordance with the approved RAP, remedial action improvements include an engineered clay landfill cap, a landfill gas (LFG) collection and treatment system, and a groundwater containment system. Carson Marketplace has discussed and presented refinements to the currently approved RAP that includes a linear low-density polyethylene (LLDPE) geomembrane in lieu of a clay landfill cap.

In order to design the permanent LFG collection and treatment system, a Pilot Test was conducted to determine site-specific design parameters. The Pilot Test was developed to be a dynamic LFG extraction test over time to establish a steady state extraction rate of LFG. The Pilot Test was based on procedures developed by the Environmental Protection Agency (EPA) Method 2E. This included the installation of vertical extraction wells, shallow pressure probes located adjacent to the extraction well, and deep pressure probes installed to the depth of the well perforations. The Pilot Test would provide design and engineering information necessary to determine the best method of LFG treatment, (i.e., flare or granular activated carbon [GAC]); and to size equipment and piping to maximize performance of the permanent system. (Bryan A. Stirrat & Associates, 2006)

2.0 SITE CONDITIONS AND INVESTIGATION

2.1 METHANE GENERATION MODELING

Methane generation modeling was performed to generate data needed to obtain the temporary permits to operate for the Pilot Test, and for the development of initial conceptual designs. This modeling helped to establish expected baseline flows necessary in determination of Pilot Test equipment sizing and for the development of the human health risk assessment. and the temporary permit to operate.

Based on historical data, approximately 3,450,000 tons of waste was placed in the five distinct landfill cells. It is estimated that approximately 29 percent (%) of the waste mass was non-decomposable materials. The remaining approximate 2,500,000 tons of refuse was used to estimate the methane production from the Site (Bryan A. Stirrat & Associates, 2006). Methane production is a natural process of anaerobic decomposition of organic matter. When conditions are correct, methanogenic bacteria consume organics and produce approximately 50% methane and 50% carbon dioxide. It is this methane that must be collected and controlled to minimize off-site migration and surface emissions due to its flammability / explosivity and air contaminants associated with the LFG.

Using this information, BAS estimated methane production using a proprietary methane generation model (see Figure 2.1). By varying the decomposition rates, distribution of refuse, and moisture content, BAS was able to estimate theoretical methane generation.

For 2008 the estimated methane generation is between 4 and 83 standard cubic foot per minute (scfm) (see Appendix A). Using an assumed extraction efficiency of 90%, the range of methane that can be collected by an extraction system would be between 3.6 and 75 scfm. The assumed extraction efficiency is relatively high due to the fact that a LLDPE geomembrane cap will be installed over the entire landfill as part of the future remedy. Using these methane volumes, the expected LFG flow rate would extrapolate to 14 to 300 scfm at 25% methane by volume.

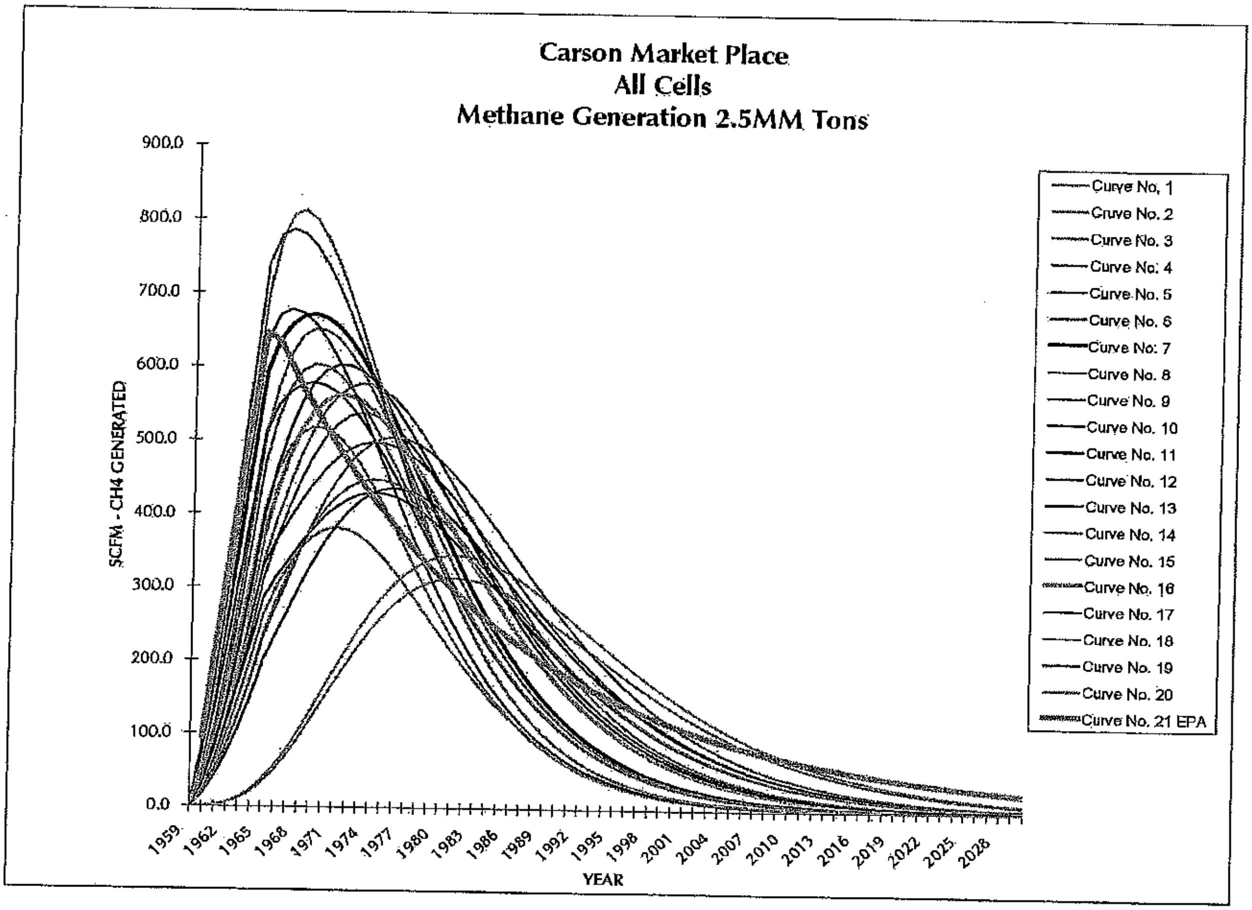


FIGURE 2.1
METHANE GENERATION MODEL

2.2 PUSH PROBES AND STATIC LANDFILL GAS SAMPLING

In an effort to characterize the static LFG for future baseline comparison, BAS installed one static LFG sample probe at specific locations in each of the landfill cells. Each static LFG sample probe was installed using the "direct push" method. The probes were constructed of ½ inch diameter, schedule 80 polyvinyl chloride (PVC). Probe depths are shown in Table 2.1. The pipe casings were connected using a PVC slip coupling and secured with a screw. The annular space between boring and probe casing at the perforations was backfilled with coarse sand and a bentonite seal was placed near the surface. The top of the probe casing was sealed with a pipe cap. To facilitate sampling, a PVC labcock valve was threaded into the cap. All PVC connections were facilitated by slip fit couplings secured with a self tapping screw to prevent any contamination of LFG samples from the PVC glue or primer.

After completion of probe construction, BAS purged each casing and pulled a LFG sample for relative LFG composition and a baseline reference. The initial probe LFG samples were analyzed using a Landtec GEM 2000 hand held LFG instrument. Initial field sampling results are shown in Table 2.1. Before drawing samples for laboratory analysis, each of the probe casings were allowed to stand for 24 hours to diffuse/dilute any residual atmospheric influence caused during construction (i.e., air).

TABLE 2.1
STATIC PUSH PROBES CONSTRUCTION

Construction Characteristics			Initial Static Sample Results			
[illegible] Number	Casing Depth (feet)	Length of Perforations (inches)	Static Pressure (in H_2O)	Percent Methane (CH_4)	Percent Carbon Dioxide (CO_2)	Percent Oxygen (O_2)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	10	12	0.11	57.9	42.1	0.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	7	12	0.37	49.8	29.8	0.2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

To obtain accurate analytical laboratory data, samples were drawn from each probe the following day. Samples were collected by a lung sampler in 10-liter Tedlar bags. The lung sampler was used to obtain non-contaminated samples by installing the sample container (Tedlar bag) in a vacuum chamber with an external connection. The chamber was purged and a vacuum was induced, drawing the sample LFG into the sample container. To protect the LFG samples from ultraviolet (UV) light degradation, each sample was placed in a light-proof container and immediately couriered to a certified laboratory for analyses for LFGs (methane, carbon dioxide, oxygen, and nitrogen), TGNMNEOCs, and speciated TO-15 compounds. Results of the LFG and TGNMNEOCs testing are shown below in Table 2.2. See Appendix B for laboratory analytical reports.

TABLE 2.2
STATIC PUSH PROBES SAMPLING

Probe Gas Number	Percent Methane (CH_4)	Percent Carbon Dioxide (CO_2)	Percent Oxygen (O_2)	Percent Nitrogen (N_2)	TGNMOC (ppmv)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	45.8	25.1	0.54	28.2	1,190
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	51.3	30.9	0.38	14	1,675
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

3.0 PERMITTING

BAS prepared three separate South Coast Air Quality Management District (SCAQMD) permit applications for the Pilot Test. SCAQMD requires a separate permit for the Condensate Management System, LFG extraction system, and Treatment System. This report only addresses the SCAQMD specific permit conditions.

After review of each permit application package, SCAQMD granted and combined all three permits to create one Experimental Research Operations Permit, dated May 18, 2007 (refer to Appendix C for the Permit to Operate). The approved permit conditions allowed the installation of the following components for the Pilot Test.

Landfill Gas Collection System

- Up to 20 vertical extraction wells
- Maximum of 240 LFG monitoring probes
- LFG headers and collection piping as needed

Landfill Gas Treatment System

- Moisture knockout vessel and drain pump
- Condensate day tank, 300-gallon capacity each
- Landfill gas blower, 7.5 horsepower, 300 scfm maximum flow
- Flame arrestor
- Three GAC vessels containing 2,000 pounds each of activated carbon
- One potassium permanganate ($KMNO_4$) vessel with 4,000 pounds of $KMNO_4$ capacity connected in series with the GAC

Condensate Collection and Storage System

- Six 300-gallon day tanks
- One bulk storage tank with a 6,500-gallon capacity, and one drum containing a minimum of 200 pounds of GAC

Monitoring Requirements Summary

Permit requirements for monitoring include the following elements.

- Total volatile organic compound (VOC) concentration shall be measured at the inlet and at the outlet of all four vessels at least once each week of operation, and at least once using an EPA Method 21 approved photo ionization detector (PID) calibrated in parts per million (ppm) by volume as hexane. If other calibrating agent is used, it shall be correlated to and expressed as hexane. Calibration shall be performed with each monitoring visit. The measured concentrations shall be recorded during each monitoring visit.

- Whenever the primary carbon breaks through, the absorbers shall be replaced as follows:

  A. Primary absorber shall be replaced with fresh adsorbent and become the tertiary absorber.
  B. Secondary absorber shall be replaced with fresh adsorbent or become the primary absorber.
  C. Tertiary absorber shall be replaced with fresh adsorbent or become the secondary absorber.

- Samples shall be collected and analyzed one each month of operation for total VOCs and speciated for toxics as follows:

  A. Samples shall be collected at least at the inlet and outlet of the primary carbon vessel and at the inlet and outlet of the $KMNO_4$ vessel.
  B. Sampling and analysis shall be conducted by an independent laboratory per Rule 304.

- At least once each month the LFG at the inlet to the treatment system shall be monitored for methane, carbon dioxide, and oxygen.

During the entire Pilot Test operations, BAS maintained compliance with all SCAQMD permit conditions.

4.0 PILOT TEST COMPONENTS DESIGN AND CONSTRUCTION

In accordance with the DTSC approved work plan, dated June 12, 2006, the Pilot Test included design and construction of an extraction system for Cells 1 through 4 (Appendix D), condensate management system, and LFG treatment system. Construction of the temporary Pilot Test extraction and treatment system began on June 11, 2007, and was completed on July 6, 2007. See Appendix D for the design drawings.

4.1 LANDFILL GAS EXTRACTION SYSTEM

4.1.1 VERTICAL EXTRACTION WELLS

The Pilot Test wells consisted of 13 vertical extraction wells: three wells in Cells 1, four wells in Cell 2, three wells in Cell 3, and three wells in Cell 4. As indicated in the Work Plan, no wells were placed in Cell 5 which is not included in the Pilot Test operations, partially due to the low volume of refuse that was placed in Cell 5. For each Cell, wells were installed in clusters with a 300 foot well to well spacing as specified by EPA Method 2E.

Each of the 13 wells was drilled by a modified air rotary method. A special device was attached to the drill head which assisted in keeping the boring open during drilling and which minimized bore collapse. This device also minimized the amount of drilling spoils generated as compared to an auger type of rig. Refer to Appendix E for well boring logs. Each well was fabricated from 2 inch diameter schedule 80 PVC flush thread pipe, varying in depth from 23 to 48 feet. Due to the Site's shallow refuse depths, BAS provided perforations on the bottom one third of each well's casing. This allowed the wells vacuum to be increased while reducing air infiltration from the surface. Each well's perforated section was backfilled with permeable gravel pack to allow the conveyance of LFG, and was sealed with granular bentonite. Soil was backfilled in the remaining top portion of the well boring. Well construction details are shown in Table 4.1. As indicated in the EPA Method 2E, each well was installed to a minimum depth of 75% of the landfill depth unless water or refusal was encountered (Appendix E).

TABLE 4.1
WELL CONSTRUCTION

Well/Cell Number	Boring Diameter	Boring Depth (feet)	Well Casing Depth (feet)	Perforation Length (feet)	Bentonite Seal (feet)	Backfill Depth (feet)
1a	8"	23	22	7	4	9
1b	8"	31	30	10	4	14
1c	8"	33	32	12	4	14
2a	8"	48	47	16	6	23
2b	8"	42	41	14	6	19
2c	8"	38	37	12.6	6.4	16
2d	8"	38	37	13	6	16
3a	8"	42	41	14	4	21
3b	8"	41	40	14	4	20
3c	8"	39	38	13	3	20
4a	8"	42	41	14	6	19
4b	8"	43	42	14	6	20
4c	8"	45	44	15	6	21

Completion of each vertical well included a "meter run" to facilitate pressure, temperature, and flow monitoring and to allow for required adjustments. Each meter run consisted of a minimum 24-inch length of straight unobstructed 2-inch diameter schedule 40 PVC pipe for LFG velocity measurements. A PVC gate valve with sample ports on each side was installed to allow pressure monitoring on the well and on the extraction system piping. The gate valve facilitates flow adjustment.

4.1.2 DEEP PRESSURE PROBES

Nine deep pressure probes were installed around each extraction well to determine the well's radius of influence in the surrounding refuse. Each deep pressure probe was installed radially at 50-foot, 100-foot and 150-foot spacing as shown in Figure 4.1.

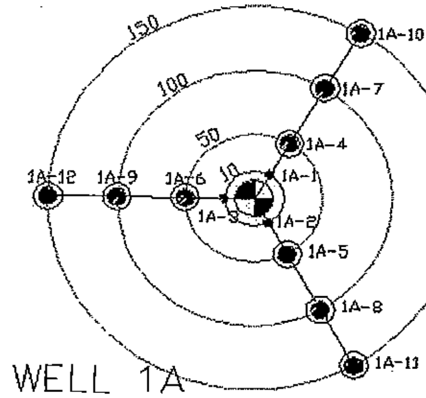


FIGURE 4.1
DEEP PRESSURE PROBES

Each deep pressure probe was fabricated from 1-inch diameter schedule 80 PVC pipe and installed to a depth equal to the associated extraction well depth. The bottom two thirds of each probe was perforated pipe and the top one third was solid pipe. The annular space around the perforated section was backfilled with sand. Granular bentonite was then filled to surface grade and hydrated. Each probe was monitored for pressure and composition throughout the duration of the Pilot Test which is discussed in greater detail later in this document. Probe construction logs are included in Appendix F.

4.1.3 SHALLOW PRESSURE PROBES

Around each vertical extraction well, three shallow pressure probes were installed to monitor air intrusion into each well during the Pilot Test operation. A total of 39 shallow probes were installed. Each probe was placed 120 degrees apart, and offset 10 feet from the well casing. See Table 4.2 for construction details. Daily probe construction logs are provided in Appendix F. The shallow probes were installed to a depth of 50% of the deep pressure probes. They were used for monitoring when atmospheric air was being drawn into the surrounding refuse and soil by the extraction well. Oxygen content in the LFG was measured by a hand-held gas analyzer. In a radial fashion separated 120 degrees apart (in same fashion as the deep pressure probes shown in Figure 4.1), nine pressure probes where installed around each extraction well to establish boundaries of the pressure influence by each of the test wells.

TABLE 4.2
SHALLOW PROBE CONSTRUCTION

Well Number	Probe Number	Well Casing Depth (feet)	Perforation Length (feet)	Well Number	Probe Number	Well Casing Depth (feet)	Perforation Length (feet)
1A	1A-1	12	7	3A	3A-1	14	8
	1A-2	12	7		3A-2	14	8
	1A-3	12	7		3A-3	14	8
1B	1B-1	12	7	3B	3B-1	14	8
	1B-2	12	7		3B-2	14	8
	1B-3	12	7		3B-3	14	8
1C	1C-1	13	8	3C	3C-1	13	8
	1C-2	13	8		3C-2	13	8
	1C-3	13	8		3C-3	13	8
2A	2A-1	16	10	4A	4A-1	16	10
	2A-2	16	10		4A-2	16	10
	2A-3	16	10		4A-3	16	10
2B	2B-1	14	8	4B	4B-1	14	9
	2B-2	14	8		4B-2	14	9
	2B-3	14	8		4B-3	14	9
2C	2C-1	13	8	4C	4C-1	16	10
	2C-2	13	8		4C-2	16	10
	2C-3	13	8		4C-3	16	10
2D	2D-1	13	8				
	2D-2	13	8				
	2D-3	13	8				

4.1.4 LANDFILL GAS EXTRACTION PIPING SYSTEM

The Pilot Test extraction piping system was designed and constructed to facilitate simultaneous LFG extraction from each of the four cells. All 13 extraction wells were connected to a single extraction system consisting of 2-inch to 4-inch diameter schedule 40 PVC pipe. All piping was above grade except at the intersection of Stamps Drive and Lenardo Drive where an engineered low point was designed to allow proper sloping of the piping for condensate drainage. All piping was designed with a minimum of 1% slope. For each header and lateral segment of pipe, BAS designed the pipe diameter to be of sufficient size to accommodate potential build-up of condensate and to allow no more than approximately 1" of water column vacuum loss per 100 feet of pipe length.

The LFG extraction piping system was fabricated entirely from schedule 40 PVC pipe consisting of approximately 1,100 feet of 4-inch diameter, 3,300 feet of 3-inch diameter, and 3,000 feet of 2-inch diameter pipe. The overall design of the LFG extraction piping system used natural grade to the extent possible, however more than 200 Unistrut pipe supports were installed where necessary to maintain pipe slope to three engineered low points in the system.

To allow connection of each cell to one extraction and treatment system, a total three road crossings were installed to protect the piping from site traffic. One crossing connected Cell 4 piping to Cell 2 piping. The second crossing connected Cell 2 piping to Cell 1 piping, and the last crossing connected the treatment system diagonally to Cell 2 piping. These three crossings allowed all extraction system piping to be connected and operated simultaneously.

4.1.5 CONDENSATE SUMPS

When designing a LFG extraction system, potential condensate formation in the piping must be addressed to prevent ultimate failure of the extraction system by a condensate blockage. For design purposes, all LFG is considered to be saturated with water, even though the level of saturation can vary from site to site and region to region. Formation of condensate in the extraction system piping is a result of pressure and/or temperature reduction. At any given temperature and pressure, LFG can hold a finite amount of moisture. As the LFG pressure or temperature is reduced, the LFG can hold less water in suspension and condensate is formed in the piping. This particular problem is exacerbated on landfills because the natural process of anaerobic decomposition produces LFG temperatures in excess of 150 degrees Fahrenheit (°F). It is not uncommon for LFG temperatures at the well head to be greater than 120° F.

As hot LFG comes in contact with the much cooler above-ground extraction system piping, the LFG quickly cools, forming condensate within the piping. The condensate can collect in sufficient quantities to completely block the pipe cross section at pipe low points.

Prevention of condensate formation is not economically viable; however controlling the formed condensate is relatively easy. As previously discussed, all extraction system piping was engineered to slope in a controlled manner to three low points within the extraction system. Each low point drained into a condensate sump, each with a capacity of approximately 230 gallons. The system was design to be a "closed system" where the condensate sumps were at the same pressure as the extraction system. This was accomplished by a pressure equalization pipe that connected the sump to the extraction system piping. Being a closed system, the condensate can freely flow from the extraction system piping to the condensate sumps. Refer to Appendix D for detailed drawings.

4.2 TREATMENT SYSTEM

The treatment system was a pre-constructed blower trailer with all required controls and electrical components (Figure 4.2). It was operated in compliance with the SCAQMD Experimental Research Operations Permit to Construct and Operate (Application Nos. 466496, 466492, and 466491). For mobility of the assemble system, the trailer was mounted on a roll-off skid with two GAC vessels.

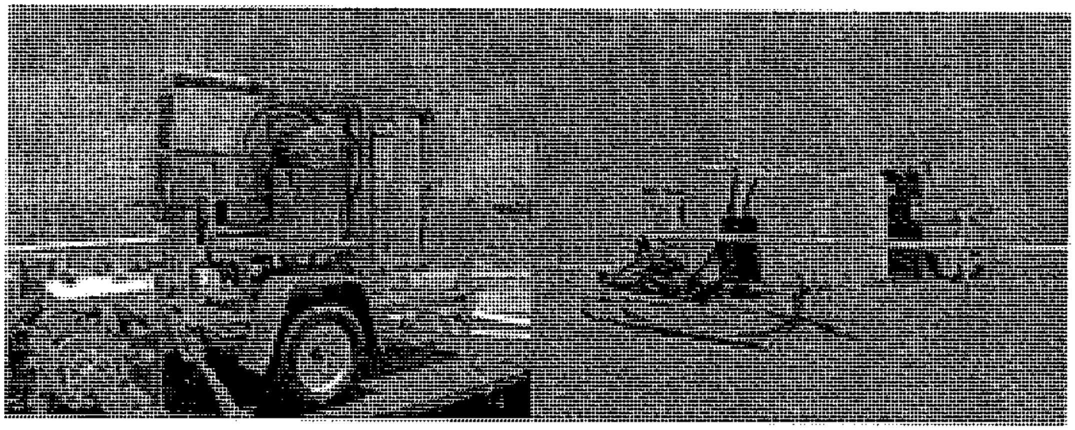


FIGURE 4.2
BLOWER TRAILER AND GRANULAR ACTIVATED CARBON TREATMENT

Because the blower trailer system operates on 240 volts, 3-phase electrical power, and does not have its own electrical source, temporary power was required. It was determined that a portable diesel operated generator (Figure 4.3) would be the most feasible choice, since the only viable temporary electrical source was more then 800 feet away. Since the blower system was intended to operate uninterrupted, 24 hours per day, a fueling service was hired to maintain the fuel level without lapse.

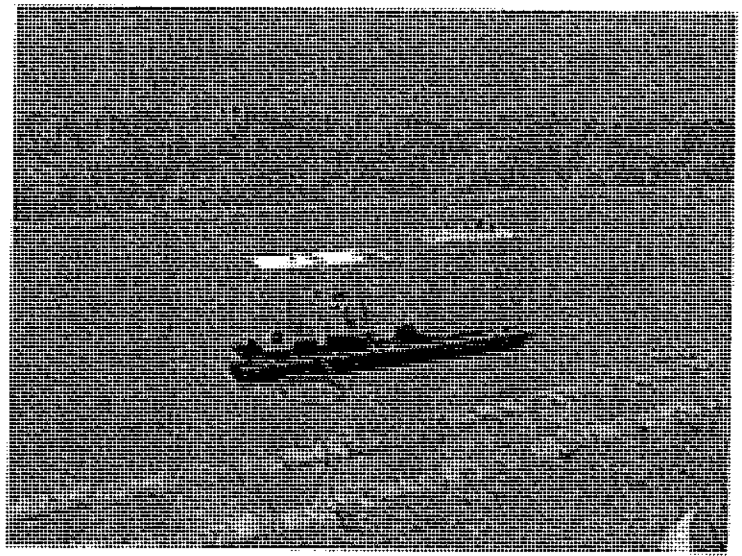


FIGURE 4.3
TEMPORARY POWER DIESEL GENERATOR

4.2.1 CONTROLS

As required by the SCAQMD permit, the blower skid included instruments, controls, and electrical components necessary for flow monitoring and recording. This skid assembly utilized an annubar flow element, which is essentially an averaging pitot tube measuring the velocity pressure of the LFG. By knowing the velocity pressure and subtracting the static line pressure, and knowing the cross sectional area of the piping, the flow rate of the LFG is calculated. The annubar was connected to an electronic differential pressure transmitter where the resultant differential pressure was converted into a 4-20 milliamp input signal to the panel mounted circular chart recorder.

4.2.2 BLOWER

The skid assembly incorporated a Hauck Manufacturing single stage centrifugal blower and remote backup blower. These blowers have been used for LFG compression for over 20 years. This blower (model number TBGB-24-7.5) incorporates an internal 24-inch diameter aluminum fan mounted in a fiberglass gas proof housing. This direct drive unit is coupled to a 7.5-horsepower totally enclosed fan cooled (TEFC) motor rated for Class 1 Division 2 hazardous environment. TEFC motors are enclosed and are classified as a non-arcing device suitable for this application. See Figure 4.4 for the blower performance curve.

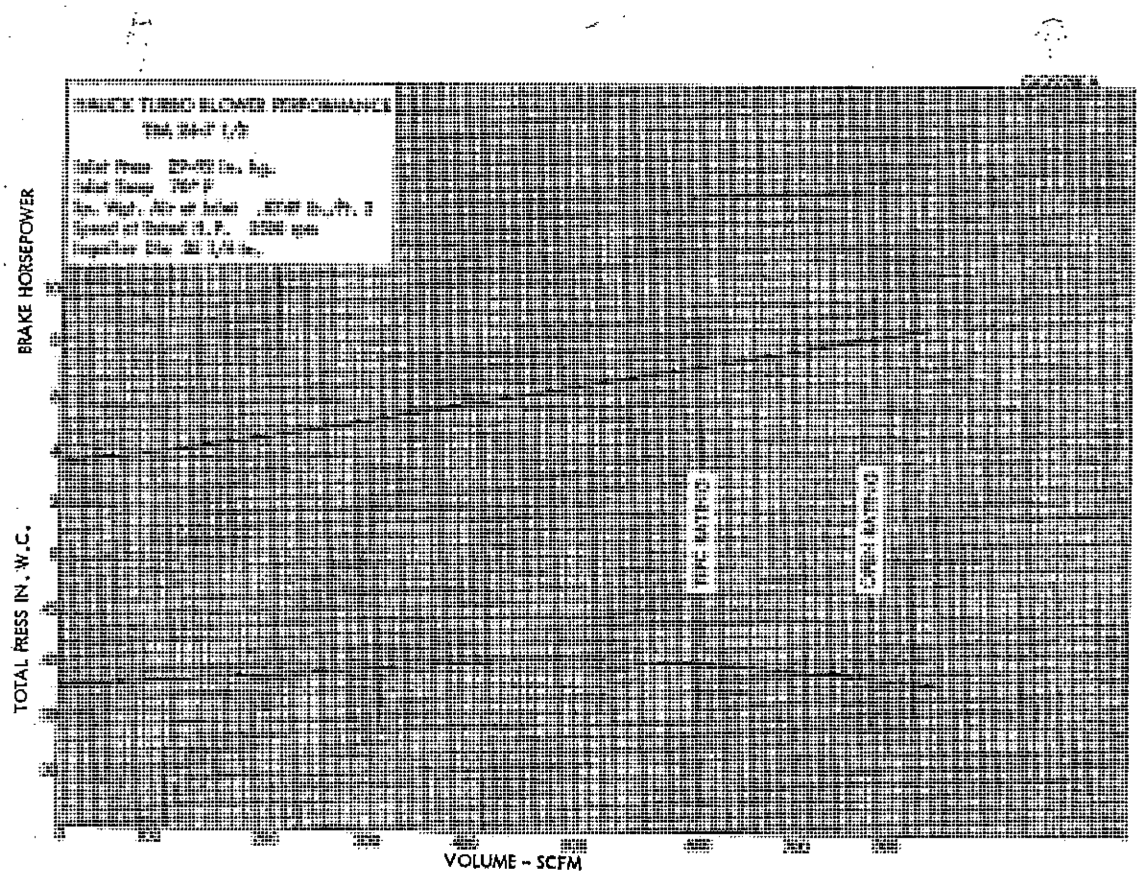


FIGURE 4.4
BLOWER PERFORMANCE CURVE

The blower performance curve pictured above shows this blower is capable of conveying up to 600 scfm of LFG at a maximum total pressure of 41 inches of water column. After correcting the curve for LFG density and the altitude of the Site, the maximum blower total pressure is approximately 35 inch of water column.

4.2.3 GRANULAR ACTIVATED CARBON

Since this was a short term Pilot Test requiring temporary systems, GAC was determined to be a cost effective and efficient choice for LFG treatment.

The blower skid assembly incorporated two 2,000-pound GAC vessels mounted directly on the roll-off skid. Two additional 2,000 pound units were also included with one of the vessels connecting in series to the two roll-off mounted vessels, totaling three 2,000 pound vessels in series. Each vessel was filled with 2,000 pounds of virgin coconut shell carbon. The fourth vessel was not connected and was used as a standby backup. To facilitate rotation of the vessels when the GAC was saturated, each vessel was connected in series by use of quick disconnect Camlock fittings and hoses, as shown in Figure 4.5.

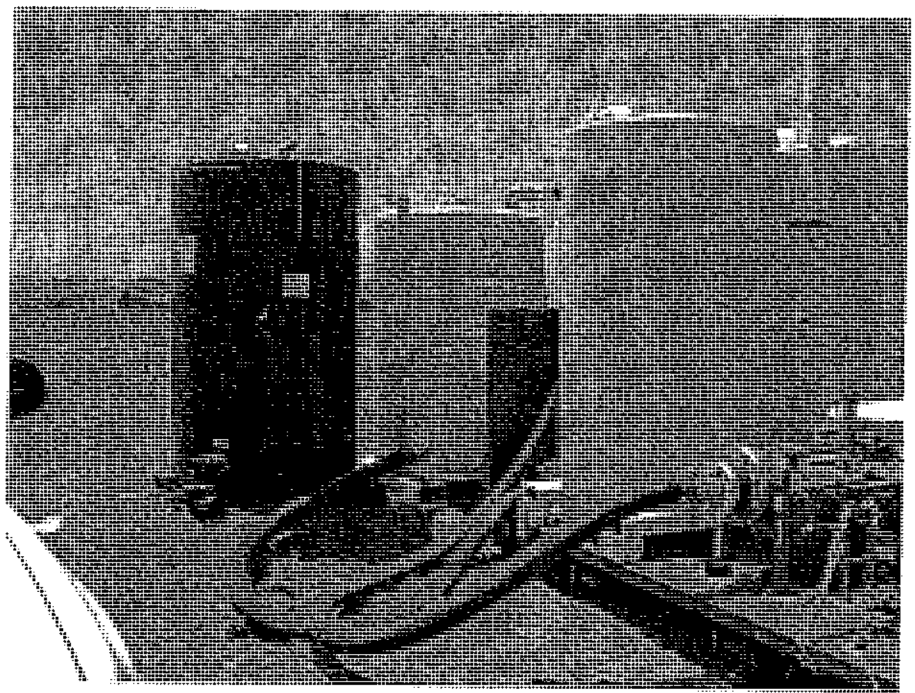


FIGURE 4.5
GRANULAR ACTIVATED CARBON VESSELS

4.2.4 POTASSIUM PERMANGANATE

In addition to GAC, BAS designed and permitted the system to incorporate one 4,000-pound $KMNO_4$ vessel as the outlet vessel. Even thought the vessel sizes are very similar, the $KMNO_4$ is approximately twice the density of GAC, increasing the mass of single vessel to 4,000 pounds of media.

BAS has been permitting, designing, and constructing GAC treatment systems for many years. These systems have proven to be a cost effective method of treating LFG on smaller and older landfills where the VOC concentrations are typically low in concentration. However, GAC is notoriously inefficient in adsorbing lighter VOCs, which includes several of the compounds typically found in LFG. The two main constituents of concern (COCs) are vinyl chloride (CH_2CHCl) and hydrogen sulfide (H_2S). Each of these compounds are included in SCAQMD Table 1 Core Group of Compounds and are some of the most commonly found toxics in LFG. Unlike GAC which captures compounds by adsorption, $KMNO_4$ is an oxidizer creating a reaction with certain chemicals rendering them non-toxic. $KMNO_4$ works very well with the vinyl chloride and hydrogen sulfide and is an effective method of treatment for specific isolated compounds in the LFG. Additionally the $KMNO_4$ was required in the permit conditions for treatment of vinyl chloride and hydrogen sulfide.

5.0 OPERATIONS, MAINTENANCE, AND MONITORING

Pilot Test operations, maintenance, and monitoring (OM&M) activities were initiated on July 10, 2007 and continued over a seven week period. Initially operations were to be performed for five weeks; however the program was extended two weeks in an effort to reach the desired steady state extraction rate of LFG. This information is important to estimate the landfill's methane generation rate in an effort to narrow the equipment performance range.

5.1 VERTICAL EXTRACTION WELLS

Each of the 13 vertical extraction wells were monitored during each site visit; typically three times per week. During the site visit, a BAS technician would monitor each well for:

- Well pressure
- Percent methane
- Percent carbon dioxide
- Percent oxygen
- Nitrogen (balance)
- Landfill gas temperature
- Header pressure
- Valve position
- Barometric pressure
- Atmospheric temperature

The LFG flow rate was also measured using a pitot tube and Landtec Gem 2000 LFG analyzer. For comparison of flow, the LFG velocity was also monitored using a hand held velocometer. Each data point monitored was recorded on the BAS monitoring form included in Appendix G. After data were collected, it was evaluated, and flow and vacuum adjustments were implemented, as necessary, to optimize the pilot testing.

Methane and LFG flow graphs associated with data from each well are included as Appendix H. As seen on the graphs, all wells show a distinct drop in methane concentration during the Pilot Test, indicating the extraction of LFG was having an effect on the "bubble" of LFG that had built up over time, but not establishing a steady state extraction rate.

5.2 SHALLOW PRESSURE PROBES

Each vertical extraction well was accompanied by three shallow pressure probes each monitored during every well monitoring event. Appendix I includes well probe graphs showing the performance of each shallow probe during the duration of the Pilot Test. Prior to monitoring the composition in each probe, static pressure was measured, which on average, showed a steady increase in vacuum over the Pilot Test period. After the pressure measurement, the probe case was purged to evacuate built-up static gases. At that time, the methane, carbon dioxide, oxygen, and nitrogen concentration in each probe was measured using a LandTec Gem instrument.

As shown in the Appendix I Probe Graphs, all shallow probes showed influence from its adjacent well indicating the induced vacuum on the refuse mass was slowly increasing over time. This is also evident by the steadily decreasing methane content.

5.3 DEEP PRESSURE PROBES

The deep pressure probes were monitored weekly in the same fashion as the shallow pressure probes. The static pressure was measured and recorded. The probe casing was then purged to evacuate the static build up of LFG. After being purged, the methane, carbon dioxide, oxygen, and nitrogen concentration of each probe was measured using a LandTec Gem instrument. Deep pressure probe data and graphs are shown in Appendix I. Data from each of the 117 deep pressure probes were included on one graph per cell. This data shows methane differential from the beginning to the end of the Pilot Test was not significant; however, a clear decline in methane and reduction in pressure is evident indicating the wells were inducing vacuum influence on the deep pressure probes in each of the four cells.

5.4 CONDENSATE SUMPS

During each site visit, the three condensate sumps were monitored to make sure that condensate build-up was not occurring which would potentially block the extraction system piping. During the entire Pilot Test no condensate was generated, however, a condensate transfer trailer (Figure 5.1) was maintained on site as a precaution. In addition, a condensate holding tank (Figure 5.2) was also maintained on site.

FIGURE 5.1
CONDENSATE TRANSFER TRAILER

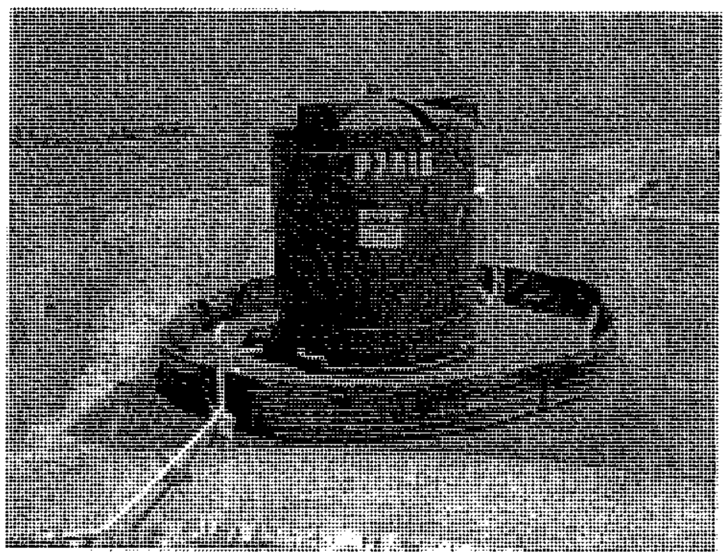


FIGURE 5.2
CONDENSATE HOLDING TANK

5.5 TREATMENT SYSTEM

During the Pilot Test, the blower/GAC treatment system was monitored three times per week. Each monitoring event included monitoring and recording of all pertinent process and performance data shown on the monitoring form that is included in Appendix G. As shown on the monitoring forms, data obtained during each visit included the treatment system inlet composition consisting of percent methane, carbon dioxide, oxygen, and nitrogen, and VOC concentration of the treatment system inlet LFG; as well as the VOC concentration between each GAC vessel, and the GAC outlet. As required by the SCAQMD permit, the treatment system flow was monitored and recorded on a circular chart recorder.

6.0 PROBE AND WELL ABANDONMENT

After completion of the Pilot test, ARCADIS coordinated with BAS to dismantle and remove all Pilot test components to the extent possible. This included dismantling and removal of the following components:

- Blower skid
- GAC vessels
- Condensate holding tank
- Below and above grade condensate sumps
- Pipe supports
- Well lateral and header piping
- 117 deep pressure probes
- 39 shallow probes
- 13 vertical LFG extraction wells

LFG Extraction Well Abandonment

All 13 Pilot Test LFG extraction wells were successfully abandoned by the standard procedure. A bentonite/cement slurry mix was generated by mixing approximately 20% Portland cement (by weight) and clean water in a grout mixer/pump. After blending to a uniform consistency the finished grout was pumped until each well casing was filled. After each well casing was grouted, the area immediately adjacent was excavated to 5 to 6 feet below ground surface. The well casings were then cut 5 to 6 feet below grade and capped with a PVC slip caps. Two sacks (approximately 50 pounds each) of granular bentonite were poured over the capped well casings and the excavations were then backfilled with excavated soil.

Deep Pressure and Shallow Probe Abandonment

For abandonment of the deep pressure and shallow probes, the pipe caps and labcock sampling valves were removed. Each probe casing was then temporarily sealed with duct tape to prevent LFG emissions from escaping the probe casings. Using a backhoe, the casings were pulled vertically and removed. Typically the entire probe casing was successfully removed and the resultant voids left from the probe casing were filled with granular bentonite. To facilitate filling the void area with bentonite to the extent possible, the fine granular bentonite was installed in a non-hydrated manner. The final top 3 to 4 feet of the probe void was filled with hydrated bentonite to provide a sufficient seal to prevent surface emissions. The abandoned probe locations were then covered with several inches of cover soil.

7.0 TREATMENT SYSTEM COMPLIANCE SAMPLING AND ANALYSIS

As required by the SCAQMD permit, LFG samples were collected from the carbon and $KMNO_4$ vessels on August 6, 2007 and submitted to Acculab, Inc. for analysis of TGNMNEOCs by EPA Method 25C. Analytical data is included in Appendix B. Results of the analysis show the outlet concentration of TGNMNEOCs to be 231 ppm by volume as methane, 38.5 ppm converted to hexane. This indicated the GAC and $KMNO_4$ canisters were spent and required replacement. To continue operations, and in compliance with the permit conditions, BAS took the primary canister offline and positioned the secondary canister as the primary canister, the tertiary canister as the secondary canister, placed the clean unused backup canister as the tertiary canister, and maintained the $KMNO_4$ vessel as the outlet vessel. While the treatment system remained online utilizing the unused backup GAC canister, BAS coordinated and scheduled replacement of the three GAC and $KMNO_4$ canisters. A total 6,000 pounds of GAC and 4,000 pounds of $KMNO_4$ was replaced.

8.0 RESULTS AND CONCLUSIONS

Fundamentally, the Pilot Test was performed to gather data necessary for the future design of the LFG extraction and treatment system and consisted of four primary goals:

1. Establish a steady state extraction rate of LFG
2. Determine size of extraction system equipment
3. Determine the type of treatment equipment
4. Assist permitting the final system

The following section describes each of these goals in detail.

Establish a steady state extraction rate of Landfill Gas: During the first week of the Pilot Test, the average methane content of the LFG was greater than 58% by volume, while the oxygen content was zero. Since the initial monitoring, the LFG extraction flow rate from each of the wells was monitored and gradually increased, when appropriate, until all manual valves on all wells were completely open. At the completion of the Pilot Test, the average methane concentration at the blower/treatment facility had dropped to 48.6% by volume. Only wells 1A, 1B and 1C in Cell 1 and well 3B in Cell 3 showed significant influence from the extraction system, dropping in methane content from the initial concentrations of 59.8%, 56.3%, 57.6%, and 65.7% by volume; to 34%, 32.6%, 31.1%, and 40.7% by volume, respectively. Even though a clear reduction in the methane content of the LFG was evident, a steady state extraction of the LFG did not occur within the 7-week duration of the Pilot Test. This resulted in the use of theoretical methane generation models for estimating the methane flow rate, thus overall expected LFG flow rate from the Site (Figure 2.1).

The estimated methane generation is expected to be within a wide flow range between 4 and 83 scfm in the year 2008. BAS' approach to estimating the LFG flow rate incorporates multiple generation curves to establish a large envelope of possible flows in order to create a wide performance/flow range for the extraction and treatment system equipment. Based on similar designs, the extraction system will capture approximately 90% of the LFG produced at the site. This translates to an estimated methane extraction rate of 3.6 to 75 scfm. The anaerobic process produces methane at approximately 50% by volume; however, achieving 50% concentration of methane is not likely considering the small volume of trash and age of the landfill. A methane concentration of 25% by volume is a reasonable expectation given these conditions and thus establishes the high flow design parameter at 300 scfm.

Determine size of extraction system equipment: Since the Pilot Test was unable to establish a steady state flow rate of LFG within the 7-week period of operation, as previously discussed, use of theoretical methane generation models was necessary to estimate the expected methane, and thus LFG generation, from the Site (Figure 2.1).

As shown on the methane generation curves and (Figure 2.1), curve data in Appendix A, the methane production is quickly diminishing and in the near future the site may not produce enough methane to sustain combustion within the flare. Even though methane is flammable between 5% (lower explosive limit) and 15% (upper explosive limit) by volume in air, substantially higher concentrations are required in the LFG when combusted in an enclosed ground flare due to the volume of the flare stack and required retention time needed to destroy the VOCs in the LFG. Normally the minimum methane content in LFG to maintain stable combustion is approximately 25% by volume; however depending on the oxygen content in the LFG, combustion can be achieved down to 23% by volume methane. When methane levels (flow and concentration) approach these values, natural gas supplemental fuel will be required to aid maintaining the proper flare temperature and destruction levels for the VOCs. Inclusion of supplemental fuel will be required in the design phase of this project.

- **Flare Sizing:** This Report of Findings and conceptual design activities recommend the flare performance range to have a maximum LFG flow of 500 scfm with a minimum flow of 80 scfm, with a BTU performance range of a minimum 3:1 ratio. However, specific design parameters will be developed during the design phase of this project.

- **Flare Quantity:** Two – 100% capacity flares (one operational and one 100% backup) are recommended for this project. The treatment system will be designed to operate each flare independently or together depending on the current site conditions. Even though one flare serves as backup it could be operated simultaneously with the primary flare, effectively providing a performance range for 80 to 1,000 scfm of LFG. Specific flare BTU performance will be determined during the design phase of the project.

- **Blower Sizing and Quantity:** Blower capacity (turn-down) is often the weak link when developing a LFG treatment system. It is not practical to expect blower flow performance turn-down much greater then 3:1. These typical centrifugal blower limitations will require the design to include three – 50% capacity blowers. During high flow conditions, two blowers will be operated to attain the required LFG flow rate. During low flow conditions, one blower will operate. One blower will serve as backup. One blower may be designed to operate in parallel with the other two blowers, should it be necessary. It is anticipated that each blower flow design criteria will be a maximum of 250 scfm with a low flow performance of approximate 80 scfm. Using three blowers, this approach will allow for a blower flow rate range from approximately 80 scfm to 750 scfm.

- **Vertical Well Spacing:** Conceptual design of the vertical wells included a center to center (c/c) spacing of 120 feet under structures and 300 feet in parking lot areas. Even though steady state extraction rate was not determined, the deep probe data (Appendix I) shows influence from their respective wells as evident in the percent methane reduction in each of the probes. During the design phase of the project, well spacing will include, at a minimum, 120 feet c/c spacing under structures and 300 foot c/c spacing in open parking lot areas.

- **Horizontal Well Spacing:** In concurrence with the conceptual design, horizontal well spacing will be 120 feet c/c under structures and 200 feet in parking lot areas.

- **Landfill Gas Extraction System Piping:** LFG extraction system piping will consist of 2" diameter through 10" diameter Schedule 40 PVC and high-density polyethylene materials, exact sizes will be determined during the design phase; however, these pipe sizes are consistent with the anticipated LFG flows, and will allow considerable condensate flow in the pipe without unreasonable increases in frictions loss (pressure loss) in the final extraction system.

<u>Determine the type of treatment equipment</u>: Even though the steady state LFG extraction rate was not achieved during the 7-week Pilot Test period, BAS was able to obtain information for the final design consisting of an understanding and expectation of the TGNMNEOCs content in the LFG, and the effect of vapor extraction in reducing pressure and methane concentration in the monitoring probes. Additionally, monitoring results using a hand-held PID, as well as the laboratory analysis, showed inlet TGNMNEOC concentrations remained elevated during the duration of the Pilot Test at a concentration of 4,840 ppm. This resulted in the rapid saturation of all media beds (GAC and $KMNO_4$), thus substantiating the use of an enclosed ground flare as a cost effective treatment of the LFG.

Assist permitting the final system: The final objective to the Pilot Test was to obtain information necessary in developing and procuring the final SCAQMD permit applications. In this effort, critical information collected during, or as a result of, the Pilot Test included:

- Obtaining analytical data of speciated VOC and toxic compounds during dynamic extraction system operation critical in developing the health risk assessment and air dispersion modeling.

- Assisted in determining the best method of treatment for the LFG, by showing that sufficient quality (methane content) and quantity (flow) of LFG is present necessary for the sustaining an enclosed ground flare.

- Indication of possible persistently high concentrations of VOCs which determines and justifies the use of an enclosed ground flare and supplemental fuel as a long term cost effective method of LFG treatment.

- Determination/conformation of extraction and treatment system component sizing.

9.0 REFERENCES

Bryan A. Stirrat & Associates. Work Plan for Landfill Gas Pilot Tests Carson Marketplace, February 2006.

2.1 VERTICAL GAS EXTRACTION WELLS
(95% SUBMITTAL)

2.1.1 Background/Statement of Problem

To solve for the radius of influence of vertical gas extraction wells (horizontal spacing between vertical wells) using an empirical method and a theoretical approach.

2.1.2 Methodology

- Empirical formula used:

Radius of influence, $R_{Iv} = fz$

- Theoretical formula used:

Vacuum Head, $\Delta\Psi = \frac{1}{3}\frac{G_M \rho_w}{K}\left(R_I^2 \ln\frac{r_2}{r_1} - \frac{1}{2}r_2^2 + \frac{1}{2}r_1^2\right),\ 0 < r \leq R_I$

2.1.3 Assumptions and Inputs

Empirical method:

- z is the depth of the well casing, assumed to equal half to two thirds of the total depth of the vertical well, and measured from the ground surface to the top of the perforation (or screen). The Carson ASB wells are to be perforated to near the geomembrane cap. Therefore, a z value of 2/3s the total well depth is appropriate.
- f is the empirical factor that has been verified by field tests and confirmed by field experience and monitoring. Empirical factors ranging from 2 to 6 are defined below:

  $f = 2$ (or less than 2) – The landfill phase has no liner or clay cover. Some surface emissions and/or subsurface migration have been detected during monitoring. This factor is usually used for shallow perimeter vertical wells that have an increased risk of air intrusion (< 50 feet total depth). The landfill phase has high LFG production.

  $f = 3$ – The landfill phase has a clay liner and/or cover with insignificant surface emissions or subsurface migration. This factor is usually used for deeper vertical wells (> 50 feet total depth) with lower risk of air intrusion. The landfill phase has low to high LFG production.

  $f = 4$ – The landfill phase has a clay liner and/or cover with no detected surface emissions or subsurface migration exceeding regulatory limits. The landfill phase has low to high LFG production.

$f = 5$ – The landfill phase has a clay liner and/or cover coupled with a geomembrane liner and/or cover with no detected surface emissions or subsurface migration exceeding regulatory limits. The landfill phase has medium to low LFG production.

$f = 6$ – The landfill phase has a geomembrane liner and cover and there is no detectable surface emissions and subsurface migration. The landfill phase has medium to low LFG production.

The Carson ASB will have a geomembrane cap (over all areas with vertical wells), a robust gas collection system, and the landfill has a medium to low LFG production potential, thus an $f = 5$ or 6 is appropriate.

Theoretical method:

- Equation is derived for an almost full depth extraction well (installed to almost the full depth of the landfill), and yields a similar equation for a partial depth extraction well.

Vacuum head, Ψ	ft or inches water column
LFG generation rate/unit mass, G_M	0.05 to 0.10 cf/lb/yr
Waste density, ρ_w	1500 to 2000 lbs/cy
Landfill permeability, K	5E-05 cm/s to 5E-03 cm/s
Radial coordinate, r_1 (well bore radius)	6 in. and 12 in.
Radial coordinate, r_2	Equal to R_I ft

2.1.4 Calculations and Results

- The empirical method calculated the radius of influence, for well depths from 11ft to 44 ft, to be 40 ft to 161 ft for z=2/3*D and f = 6. See attached Table 2-1.
- The theoretical method calculated a range of radius of influence of 40-60 ft at a vacuum of 10 in WC, 50-90 ft at a vacuum of 20 inWC, and 60-100 ft at a vacuum of 30 in WC for 12 inch radius well borings. See attached Table 2-2.
- A slightly smaller radius of influence was found when the 6 inch radius well boring was evaluated.
- The values from the theoretical method fall within range of the values in the empirical method for the given depths of the well casings.
- A model of the volumes of influence (combined horizontal and vertical wells) is presented in Figures 1 and 2. For the plot, average values from the two methods were used for the vertical well radii of influence based on well depth and for 12 inch boring radius. Four inch boring radii would be similar. The design well spacing incorporates a 20% overlap of these theoretical radii of influence.

2.1.5 References

- Darrin Dillah, Greg McCarron, and Balwinder Panesar. "Vertical Landfill Gas Extraction Wells - The SCS Model." PGS 1-2. MSW Management. May/June 2007. SWANA's Annual Landfill Gas Symposium. March 4-8, 2007.
- SCS and Los Angeles County Sanitation Districts, Mesquite Regional Landfill Master Plan, <u>Section 2G.4 Landfill Gas Collection System</u>. April, 2004.

2.1.6 Quality Control

Prepared By: Jennifer Deguia

Checked By: Keith Johnson

Approved By: Michael Leonard, P.E.

Table 2-1

Vertical Gas Well Radius of Influence - Empirical Formula

	Radius of Influence, $R_{iv} = fz$		
	z=2/3D		
	Empirical Factor, f		
Well Depth, D	5	6	Average
11	37	44	40
12	40	48	44
13	43	52	48
14	47	56	51
15	50	60	55
16	53	64	59
17	57	68	62
18	60	72	66
19	63	76	70
20	67	80	73
21	70	84	77
22	73	88	81
23	77	92	84
24	80	96	88
25	83	100	92
26	87	104	95
27	90	108	99
28	93	112	103
29	97	116	106
30	100	120	110
31	103	124	114
32	107	128	117
33	110	132	121
34	113	136	125
35	117	140	128
36	120	144	132
37	123	148	136
38	127	152	139
39	130	156	143
40	133	160	147
41	137	164	150
42	140	168	154
43	143	172	158
44	147	176	161

Table 2-2
Vertical Gas Well Radius of Influence - Theoretical Formula - 12 Inch and 6 Inch Radius Well Boring

Radius of Influence, R_I	Pressure or Vacuum, P	Vacuum Head, ψ		LFG Generation Rate/Unit Mass, G_M	Waste Density, ρ_w		Landfill Permeability, K			Radial Distance From CL of Collector, r_1 or Borehole Radius	
ft	inWC	inWC	ftWC	cf/lb/yr	lbs/cy	lbs/cf	cm/s	ft/s	ft/yr	in	ft
30	2	18.7	1.6	0.1	1500	56	3.00E-03	9.84E-05	3.10E+03	12	1.000
40	3	36.5	3.0	0.1	1500	56	3.00E-03	9.84E-05	3.10E+03	12	1.000
50	5	61.1	5.1	0.1	1500	56	3.00E-03	9.84E-05	3.10E+03	12	1.000
60	8	92.6	7.7	0.1	1500	56	3.00E-03	9.84E-05	3.10E+03	12	1.000
70	11	131.5	11.0	0.1	1500	56	3.00E-03	9.84E-05	3.10E+03	12	1.000
80	14	177.9	14.8	0.1	1500	56	3.00E-03	9.84E-05	3.10E+03	12	1.000
90	19	232.0	19.3	0.1	1500	56	3.00E-03	9.84E-05	3.10E+03	12	1.000
100	24	293.9	24.5	0.1	1500	56	3.00E-03	9.84E-05	3.10E+03	12	1.000
30	6	74.8	6.2	0.05	2000	74	5.00E-04	1.64E-05	5.17E+02	12	1.000
40	12	146.1	12.2	0.05	2000	74	5.00E-04	1.64E-05	5.17E+02	12	1.000
50	20	244.3	20.4	0.05	2000	74	5.00E-04	1.64E-05	5.17E+02	12	1.000
60	30	370.6	30.9	0.05	2000	74	5.00E-04	1.64E-05	5.17E+02	12	1.000
70	43	526.0	43.8	0.05	2000	74	5.00E-04	1.64E-05	5.17E+02	12	1.000
80	58	711.5	59.3	0.05	2000	74	5.00E-04	1.64E-05	5.17E+02	12	1.000
90	76	927.8	77.3	0.05	2000	74	5.00E-04	1.64E-05	5.17E+02	12	1.000
100	96	1175.6	98.0	0.05	2000	74	5.00E-04	1.64E-05	5.17E+02	12	1.000
30	4	46.3	3.9	0.05	1500	56	3.00E-03	9.84E-05	3.10E+03	6	0.500
40	7	88.9	7.4	0.05	1500	56	3.00E-03	9.84E-05	3.10E+03	6	0.500
50	12	147.0	12.2	0.05	1500	56	3.00E-03	9.84E-05	3.10E+03	6	0.500
60	18	221.0	18.4	0.05	1500	56	3.00E-03	9.84E-05	3.10E+03	6	0.500
70	25	311.6	26.0	0.05	1500	56	3.00E-03	9.84E-05	3.10E+03	6	0.500
80	34	419.3	34.9	0.05	1500	56	3.00E-03	9.84E-05	3.10E+03	6	0.500
90	44	544.3	45.4	0.05	1500	56	3.00E-03	9.84E-05	3.10E+03	6	0.500
100	56	687.1	57.3	0.05	1500	56	3.00E-03	9.84E-05	3.10E+03	6	0.500

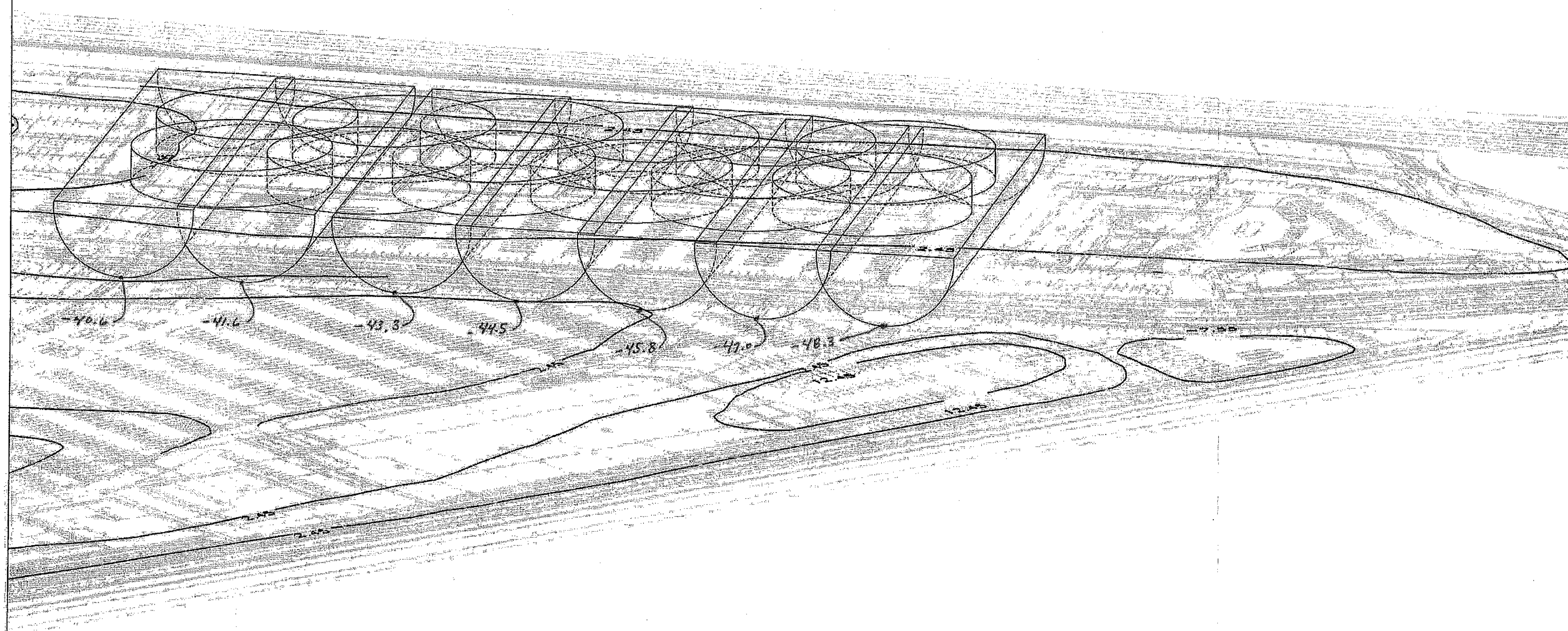


FIGURE 1

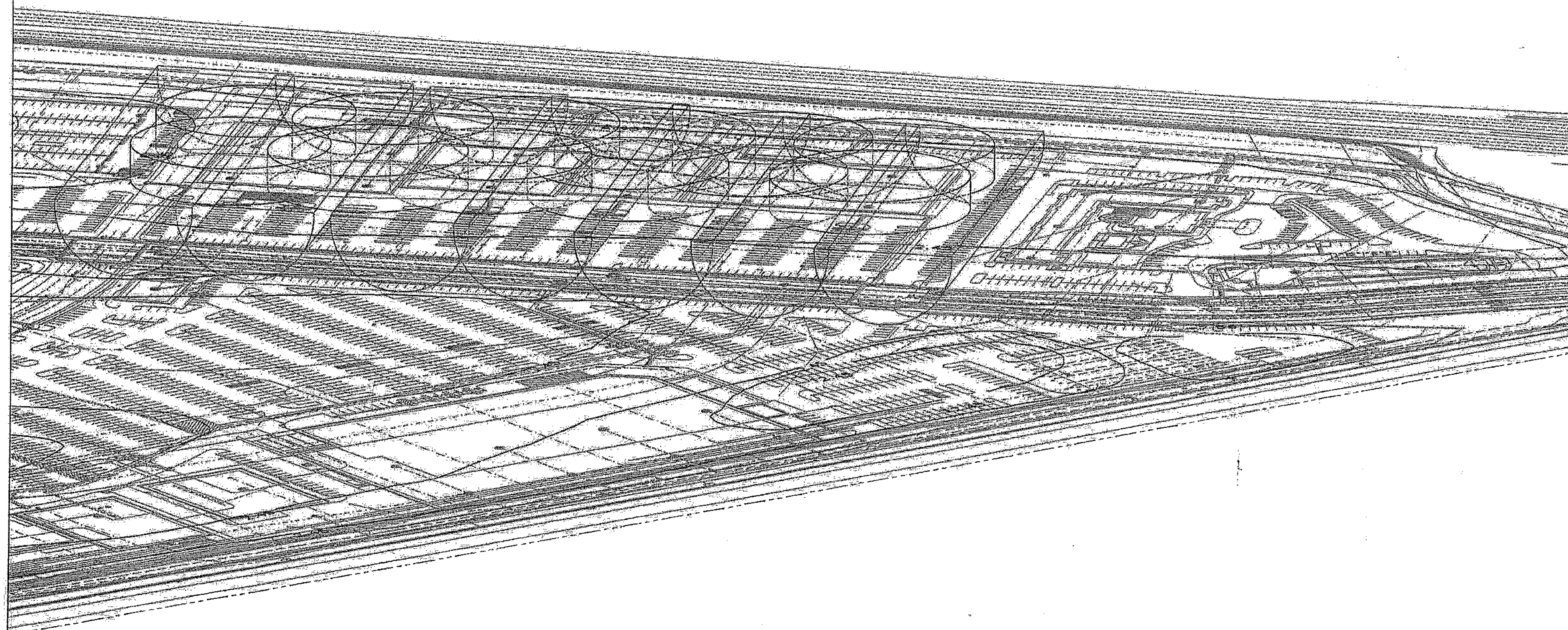


FIGURE 2

VERTICAL LANDFILL GAS EXTRACTION WELLS - THE SCS MODEL

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ABSTRACT
Since the beginnings of the landfill gas (LFG) industry in the late 1960s to early 1970s, the vertical extraction well has been the most commonly used LFG collection device. Because of its wide-spread use, its design is almost always accepted and never questioned. This has lead to "cookie cutter" approaches to well designs and wellfield layouts. Fundamentals sometimes are overlooked, and new costly systems have not performed as expected. As such, a step back to the basics is warranted.

Our literature review on this topic uncovered that the basis for well designs has been mostly either proprietary and unpublished or based on empirical observations. This paper presents SCS Engineers' mathematical model for the LFG vertical extraction well. It provides the design engineer with a theoretical basis for establishing the key system parameters. Our model addresses radius of influence and its relationship to landfill permeability, flow rate, well depth, applied vacuum, and other parameters. Combining this theoretical basis with empirical knowledge, the design engineer can develop a sound, practical, and cost-effective design for any landfill.

To demonstrate the validity and use of the model, the paper presents a case study of a recent pump test. Using field data for model calibrations, we established and verified parameters such as required well head vacuum, landfill permeability, well depth, well radius of influence, and well spacing.

INTRODUCTION
Vertical LFG extraction wells are the most commonly used collection device in the industry, dating back over 35 years to the beginning of the LFG industry. With a mature industry, typical well construction details have become available, and we have found that some designers are simply using these typical details without tailoring them to their particular sites, leading to costly systems that do not perform as expected.

The purpose of this paper is to review the fundamentals of the vertical LFG extraction well. An extraction well operates under the basic principle that LFG generated within the landfill moves towards the well due to a pressure gradient created by vacuum applied to the well.

We present a simple mathematical model for a full-depth extraction well, the evolution of which dates back to a concept presented in a 1983 report, prepared by Dr. Dallas E. Weaver. The model gives an understanding of flow dynamics around the well and indicates how various landfill properties like permeability, waste density, LFG generation rate and well design affects the dynamics around the well.

A recent pump test case study is presented to demonstrate use of the model and to establish design parameters. Finally, we present typical design parameters for extraction wells and suggest ways they should be tailored to specific site conditions.

MATHEMATICAL MODEL
Our mathematical formulation is based on the simple extraction well model presented in Figure 1. Several parameters are introduced in this figure and are defined below:

D	=	Well depth,
H	=	Maximum depth of influence,
S	=	Length of gravel pack around the well screen,
R_I	=	Radius of influence,
r	=	Radial coordinate (centered on the well), where $0 < r \leq R_I$,

$h(r)$	=	Height of the influenced volume at radius, r,
$Q(r)$	=	Flow rate to the well at radius, r, and
R_w	=	Borehole radius.

We assume that the induced well vacuum causes the formation of concentric, cylindrical isobars (i.e., surfaces of equal pressure) centered on the well and that LFG flows into the well in a radial and horizontal manner. As landfills are filled in lifts, it is typical of them to exhibit macroscopic heterogeneity, i.e., their horizontal permeability relative to LFG flow is substantially greater than their vertical permeability. Recognizing this, we assume that the volume of influence takes the shape of the upper half of an oblate or ellipse, such that

$$h = \frac{H}{R_I}\sqrt{R_I^2 - r^2} \quad (1)$$

The volume of influence, V,

$$V = \int_0^{R_I} 2\pi r h \, dr \quad (2)$$

Substituting Eq. [1] into Eq. [2] and integrating, we get

$$V = \frac{2}{3}\pi R_I^2 H \quad (3)$$

Assuming that the pressure head is the main driving force for LFG movement through the waste, we have from Darcy's equation that

$$Q = Av = -2\pi r h K \frac{\partial \psi}{\partial r} \quad (4)$$

where

K	=	Horizontal or radial landfill permeability with respect to LFG,
v	=	Average LFG velocity to the well,
A	=	$2\pi rh$ = Cross-sectional area,
ψ	=	Vacuum head (P/γ),
P	=	Vacuum,
γ	=	Specific weight of the LFG,

and the other parameters are as previously defined. Note that change of velocity and elevation heads with respect to radial distance is negligible and is ignored in Darcy's equation, Eq. [4]. LFG compressibility is ignored since the vacuums in the waste mass are typically relatively low (less than 1 psig range). The flow is assumed to be laminar.

Let's introduce another parameter, G_V, the LFG generation rate per unit volume. Now Q is a function of r and represents the amount of LFG generated outside r but within V, or

$$Q = G_V \int_r^{R_I} 2\pi r h \, dr \quad (5)$$

Substituting Eq. [1] into Eq. [5] and integrating, we get

$$Q = \frac{2\pi}{3}\frac{G_V H}{R_I}\left(R_I^2 - r^2\right)^{3/2} \quad (6)$$

Substituting Eqs. [1] and [6] into Eq. [4] and integrating from r_1 to r_2 (where r_2 is greater than r_1), we get

$$\int_{\psi_1}^{\psi_2} \partial\psi = -\frac{1}{3}\frac{G_V}{K}\int_{r_1}^{r_2} \frac{R_I^2 - r^2}{r} dr \quad (7)$$

$$\Delta\psi = \psi_1 - \psi_2 = \frac{1}{3}\frac{G_V}{K}\left(R_I^2 \ln\frac{r_2}{r_1} - \frac{1}{2}r_2^2 + \frac{1}{2}r_1^2\right) \quad (8)$$

but

$$G_V = G_M \rho_w \quad (9)$$

where

G_M	=	LFG generation rate per unit mass, and
ρ_w	=	Waste density.

From Eqs. [8] and [9],

$$\Delta\psi = \frac{1}{3}\frac{G_M \rho_w}{K}\left(R_I^2 \ln\frac{r_2}{r_1} - \frac{1}{2}r_2^2 + \frac{1}{2}r_1^2\right) \quad (10)$$

Eq. [10] is the general mathematical form of our model. It states that vacuum is a complex logarithmic function of distance from the well, proportional to ρ and G_M or Q, and inversely proportional to K.

Eq. [10] is a powerful tool for the design engineer. It tells the story of what happens to the LFG in the vicinity of the well. For given or reasonably assumed landfill properties, the engineer could use Eq. [10] to select suitable design parameter combinations, i.e., applied vacuum/flow rate/well spacing combinations.

Eq. [10] is derived for an almost full depth extraction well (i.e., the well is installed to almost the full depth of the landfill). Interestingly, the mathematical model for a partial depth extraction well, where the volume of influence takes the shape of a full oblate, yields a similar equation.

Model Analysis/Parameter Investigation

To help understand our model, let's consider an example. An extraction well is drilled to about the full depth of a landfill; R_w, the borehole radius is 1 foot. Table 1 lists the combination of waste parameters or scenarios analyzed. For comparison purposes, a K of 5E-4 cm/sec is typical of a sand soil type; 5E-3 is typical of gravel; and 5E-5 is typical of silty sand (*Dillah et al.*, 2001).

TABLE 1. WASTE PROPERTIES

Waste Type	K (cm/sec)	ρ_w (lb/yd^3)	G_M(cf/lb/yr)
Typical	5E-4	1,500	0.1
Higher ρ_w	5E-4	2,000	0.1
Higher G_M	5E-4	1,500	0.2
Higher K	5E-3	1,500	0.1
Lower K	5E-5	1,500	0.1

In order to investigate ψ relative to R_I, we will set r_1 at 1 foot (radius of the borehole) and r_2 at R_I. Thus, Eq. [10] is simplified to

$$\Delta\psi = \frac{1}{3}\frac{G_M \rho_w}{K}\left(R_I^2 \ln R_I - \frac{1}{2}R_I^2 + \frac{1}{2}\right) \quad (11)$$

For our example, we use Eq. [11] to calculate the results presented in Figure 2. For example, for typical waste as defined in Table 1, it is estimated (see Figure 2) that an applied vacuum of about 5 inches of water column (in.-wc) (i.e., the vacuum applied to the gravel pack) should cause a radius of influence of about 155 feet.

Figure 2 also plots curves for the other waste types presented in Table 1. For a given $\Delta\psi$, R_I increases for either a higher K, a lower ρ_w, or a lower G_M, and vice versa: R_I decreases for either a lower K, a higher ρ_w, or a higher G_M.

From the curves, it is clear that ψ-R_I relationship is most-impacted by K. For example, for an applied vacuum of 5 in.-wc, as K changes by one order of magnitude, from 5E-4 cm/sec to 5E-5, R_I changes from about 155 feet to about 55 feet. Differences in G_M and ρ_w have much less of an impact as these parameters usually do not change by orders of magnitude.

Care should be used when interpreting the results of the model. For example, Figure 2 suggests that for high permeable waste, R_I has the potential to be much greater than 300 feet for a relatively small applied vacuum, about 2 in.-wc. This would be valid only if there exists an ideal case that perfectly fits our model assumptions. Consideration should be given to real situations such as atmospheric short-circuiting (i.e., vertical flow), preferential movement, and other subsurface complexities that may exist, and adjustments should be made as appropriate. Similar to this, other real and practical considerations are discussed later in the paper.

CASE STUDY

As part of a landfill gas collection system expansion project at a landfill in the Northeast United States, a regulatory agency requested that the landfill owner conduct a field test to confirm that the selected R_I was appropriate. As such, the landfill owner undertook a field test program to evaluate the capability of the LFG collection system to influence the landfill mass. The objective of the field test program was to evaluate the zone of influence of a representative group of selected vertical wells.

Pump Test Layout

For the pump test, four clusters of three vertical extraction wells each were evaluated. At each well cluster, seven test probes were installed to monitor vacuum in the landfill. One of the test clusters, which included wells EW-108, EW-109 and EW-402, is selected for presentation here. Figure 3 shows a site plan, and Figure 4 shows the relative location of the wells and test probes. Note that test probe P-108-C is common to the three wells and the suction of each well might influence this probe.

The test probes were installed at locations, radiating out from each of the three test wells as shown on Figure 4. The probes were installed at the following approximate distances from each test well:

- "A" probes, closest to the extraction well: 1 to 3 feet.
- "B" probes: about 25 feet.
- "C" probes: equidistant from the three extraction wells, approximately 110 feet.

Each test probe was installed approximately 25 feet below grade, so the bottom of each probe is at about the same elevation.

The test probes were installed with a hollow-stem auger, 6-inch diameter. One foot of ¾-inch crushed stone was placed at the base of each boring. One-inch Schedule 40 PVC or 2-inch HDPE pipe with a 5-foot perforated section was placed in the borehole and backfilled with ¾-inch crushed stone to 1 foot above the screen. Geotextile fabric or liner was placed over the stone, followed by 1 foot of sand backfill and a 2-foot thick bentonite seal. General backfill was used to bring the borehole up to grade. Each monitoring probe was equipped with a quick connect fitting for pressure monitoring.

The depths and configuration of EW-108, EW-109, and EW-402 are presented in Table 2.

TABLE 2. WELL DEPTHS AND CONFIGURATION

	EW-108	EW-109	EW-402
Well Depth (ft)	94.9	92.3	92.5
Depth to Gravel Pack (ft)	18.9	16.3	19
Waste Depth (ft)	103	108	108

Field Activities and Data

The field activities are summarized below:

- Since the test wells are part of a comprehensive LFG collection system, all extraction wells in the vicinity of the pump test location were closed off.
- Upon closure of these wells, static measurements were taken at the test wells and probes until steady state was apparent. They all showed positive pressure readings at this point.
- The test wells were reactivated and adjusted to minimize air infiltration. The test wells were operated for at least two weeks to achieve steady state prior to beginning test probe measurements for the active portion of the test.
- During the active portion of the test, measurements were recorded in the morning and afternoon for 6 consecutive working days. The data consists of the following:
  - Vacuum at all test probes and wellheads.
  - Methane, oxygen, carbon dioxide, and balance gas at all test wellheads.
  - Differential pressure across the orifice plate at each test wellhead.
  - Temperature the test wells.

Vacuum data for the test probes and wellheads during the active portion of the test are presented in Table 3.

Parameter Estimation

Off-the-shelf statistical programs are not readily available to compute the parameters found in the non-linear logarithmic equation, Eq. [10]. As such, we developed a FORTRAN program to evaluate R_I and K using a best-fit analysis; i.e., values are selected such that the sum of the square of errors (SSE) between the actual data and the model output are minimized.

$$SSE = \sum_{i=1}^{n}\sum_{j=1}^{p}\left[\psi_a(i,j)-\psi_m(i,j)\right]^2 \qquad (12)$$

where

$\psi_a(i,j)$	=	actual vacuum at probe j during event i,
$\psi_m(i,j)$	=	modeled vacuum at probe j during event i (as calculated from Eq. [10]),
n	=	Number of events, and
p	=	Number of probes.

The program was run for each well, varying K for the well and R_I for each event while computing SSE. The values of K and R_I which minimize SSE are selected.

Table 4 presents the K and R_I estimates for our three test wells. The calculations were based on the following:

- R_I is estimated to be at the point along r where the vacuum is zero inches of water column (in.-wc), gauge. This results in a lower estimate than if R_I were defined as the point where the difference in static and active pressures is zero. Note, however, that the model also could estimate this other definition of R_I.
- G_M and ρ_w was assumed to be constant for the test area. The product of the two variables was assumed to be 200 as background information on the site suggests that G_M was 0.1 ft^3/lb waste/year and ρ_w was 2,000 lb/yd^3.
- The wellhead vacuum was not considered in the parametric estimation as headlosses between the wellhead and borehole/waste interface were uncertain.
- Adjustments were not made for overlap between each well's radius of influence.

Comparison to Model

Figure 5 shows a comparison of the actual probe vacuum data and the model results for each of the three wells for the March 30, 2005, morning event. An almost perfect fit is indicated. The other events also showed similar results. Furthermore, a calculation of an overall coefficient of determination, R^2, was made for each well, which incorporates all events into the calculation.

$$R^2 = \frac{SSY - SSE}{SSY} \tag{14}$$

where

SSY	=	Sum of squares of deviation between the actual vacuums and its mean, and
SSE	=	Sum of squares of errors between the actual vacuums and the model.

Table 4 shows the overall R^2 for each well: with each at or over 0.99, again supporting an almost perfect fit to the data.

DISCUSSION

The primary goal of the pump test described in this paper was to demonstrate that a spacing of about 200 feet between wells was appropriate for the landfill. Thus, the pump test was setup in a triangulated manner, and it focused on subsurface pressures or vacuums within the triangle. Reviewing the results shown in Figures 4 and 5 and Table 4, we note the following:

- The triangular region between the wells was under influence, satisfying the main goal regarding proper spacing between wells. Note that all test probes within the area were under vacuum.

- The wells are spaced only about 200 feet apart, but the variability in R_I and K is significant, demonstrating the inherent nature of variability in landfills.

- For a well spacing of 200 feet, the average R_I should be about 120 feet for wells located/spaced in a triangulated manner; i.e., well spacing equals $2R_I\cos30$. From Table 4, the average R_I for the three test wells is 180 feet.

- Figure 4 shows perfect circular influenced areas around each well, corresponding with our idealistic and simple model. In reality, these influenced areas are irregularly shaped, depending on varying parameters like landfill waste types and permeabilities. If additional test probes were installed around each test well radiating outwards from each well in different directions, R^2 would have not been as perfect.

Design Parameters

Based on this and other pump tests performed by SCS and our design, construction, and operational experience gathered over the years, we typically select the following general design parameters for vertical extraction wells:

- Typical well spacing of 200 feet. If the landfill was not very well compacted or is lined and capped, this spacing could be increased. Well spacing is decreased in shallow waste areas, side slopes, or if the overall landfill permeability is low.

- Well depth, D (refer to Figure 1), to about 15 feet off the landfill bottom or 100 feet maximum. Particularly in a lined landfill, well depths of 100 feet are sufficient as LFG in the lower regions of the landfill finally makes its way into the influence zone of the wells. If the leachate collection piping or sumps show the presence of LFG, these devices are connected to the LFG collection system.

- Solid pipe length, D-S, is typically set at 20 feet, recognizing that landfills are filled in lifts and typically exhibit high horizontal to vertical permeability ratios (e.g., 6:1). Because of air intrusion, this design limits R_I to about 120 feet (i.e., 20 times 6), but is consistent with the recommended spacing of 200 feet. The solid pipe length may be increased to further limit the potential for air intrusion, particularly at sites that have utilization projects that cannot handle air intrusion and the resulting degradation of LFG quality.

  The designer should investigate how the landfill was filled. If an alternative daily cover like a tarp is utilized, the horizontal to vertical permeability ratio may decrease, and the solid pipe length or well spacing should be adjusted.

  Solid pipe lengths may also be adjusted for high leachate levels. When the solid pipe is shorter, recognize that R_I and the well spacing also decrease. In severe cases, consider using leachate pumps in the wells or using horizontal collectors (*McCarron et al.*, 2003).

- Extraction blowers, header pipes, and laterals are sized such that the vacuum available to the wellhead is about 15 in.-wc. If landfill permeability is suspected to be low, such as in the test case presented in this paper, the design wellhead vacuum is increased.

- Well casings are typically constructed of 6-inch diameter PVC. We prefer PVC over HDPE because during differential settlement of the landfill, PVC typically shears and either cracks or breaks. When this happens, LFG extraction from the well is still feasible if shearing occurs in the gravel pack. If HDPE is used, the casings may pinch off, reducing the wells' effectiveness. Consideration should be given to 4-inch diameter casings if flows are anticipated to be low, due to minimal headlosses in the casing.

The model presented herein is for a full-depth vertical extraction well. Adjustment to the model is required for partial-depth wells. If the interest exists, we may publish this adjustment in the future.

REFERENCES

Weaver, D. E., 1983, "Analysis of Landfill Gas Data," Unpublished.

Dillah, D. D., E. R. Peterson and S. G. Lippy, 2001, "Air Injection to Control Off-Site Landfill Gas Migration: Design Parameters, Mathematical Model, and Case Study," WasteCon 2001 Proceedings.

McCarron, G. P., D. D. Dillah and O. R. Esterly, 2003, "Horizontal Collectors: Design Parameters, Mathematical Model, and Case Study," SWANA 26th Annual Landfill Gas Symposium Proceedings.

TABLE 3. VACUUM AT THE THREE WELLHEADS AND SEVEN TEST-PROBES (in.-wc)

Date	Time	EW-108	P-108-A	P-108-B	EW-109	P-109-A	P-109-B	P-402	P-402-A	P-402-B	P-108-C
3/30/2005	10 AM	19.2	3.26	0.35	8.2	4.48	2.31	1.0	0.37	0.24	0.15
3/30/2005	2 PM	19.1	3.26	0.32	8.1	4.47	2.26	2.8	0.95	0.54	0.16
3/31/2005	10 AM	19.7	3.30	0.34	8.3	4.62	2.34	3.5	1.27	0.69	0.20
3/31/2005	2 PM	18.9	3.31	0.31	7.8	4.20	2.10	3.2	1.00	0.54	0.14
4/1/2005	10 AM	18.7	3.20	0.33	7.8	4.30	2.20	3.0	1.07	0.59	0.17
4/1/2005	2 PM	18.4	3.00	0.07	7.7	4.10	0.52*	2.9	0.24	0.12	0.03
4/4/2005	9 AM	18.9	3.10	0.34	7.8	4.30	2.20	3.1	1.09	0.61	0.21
4/4/2005	2 PM	18.9	3.10	0.31	7.8	4.30	2.10	3.1	1.10	0.61	0.20
4/5/2005	10 AM	20.0	3.30	0.38	8.6	4.70	2.40	3.6	1.20	0.75	0.30
4/5/2005	2 PM	20.9	3.50	0.33	8.6	4.80	0.24*	3.5	1.10	0.61	0.34
4/6/2005	10 AM	21.0	3.50	0.40	7.8	4.20	2.20	3.8	1.30	0.76	0.25

* suspect data removed from analysis.

TABLE 4. R_i AND K ESTIMATES

Parameter	Date	Time	EW-108	EW-109	EW-402
K (cm/sec)			1.72E-5	3.87E-4	1.44E-2
R_i (feet)	3/30/2005	10 AM	57	146	238
	3/30/2005	2 PM	57	146	345
	3/31/2005	10 AM	57	148	388
	3/31/2005	2 PM	57	142	350
	4/1/2005	10 AM	57	144	362
	4/1/2005	2 PM	56		190
	4/4/2005	9 AM	56	144	366
	4/4/2005	2 PM	56	132	367
	4/5/2005	10 AM	57	149	388
	4/5/2005	2 PM	58		371
	4/6/2005	10 AM	58	143	397
Average R_i			56.9	143.8	342.0
Overall R^2			0.9991	0.9878	0.9909

Note: Average R_i for EW-108, EW-109 and EW402 = 180.9 feet.

6

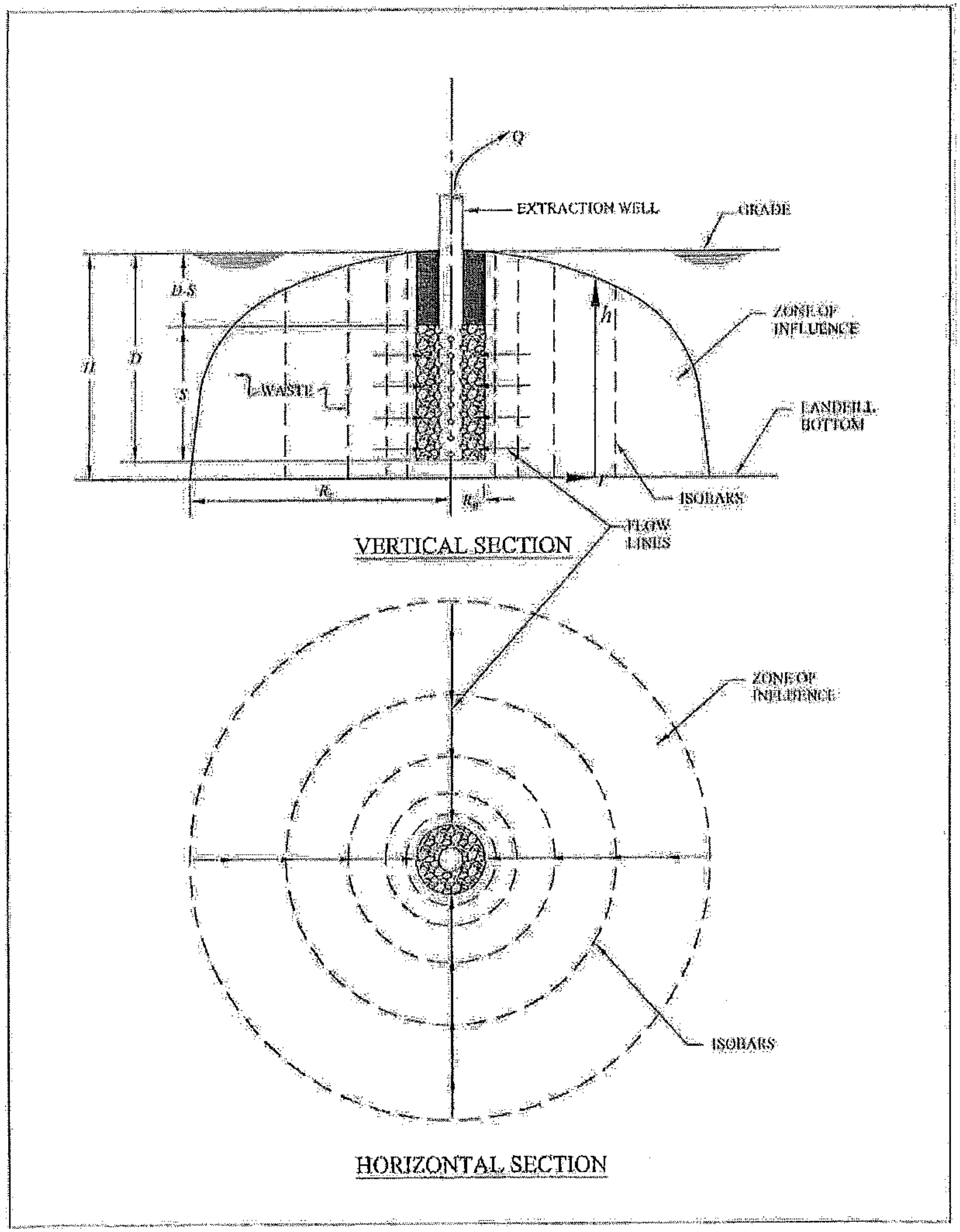

FIGURE 1. VERTICAL LFG EXTRACTION WELL MODEL

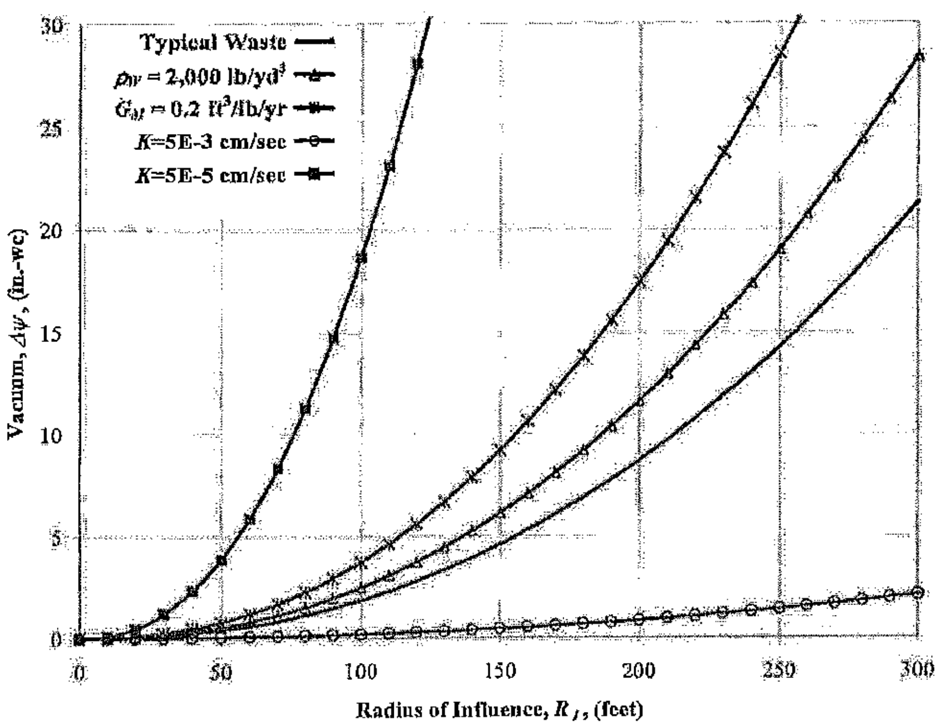

FIGURE 2. $\Delta\psi$ VERSUS R_I FOR VARIOUS WASTE TYPES

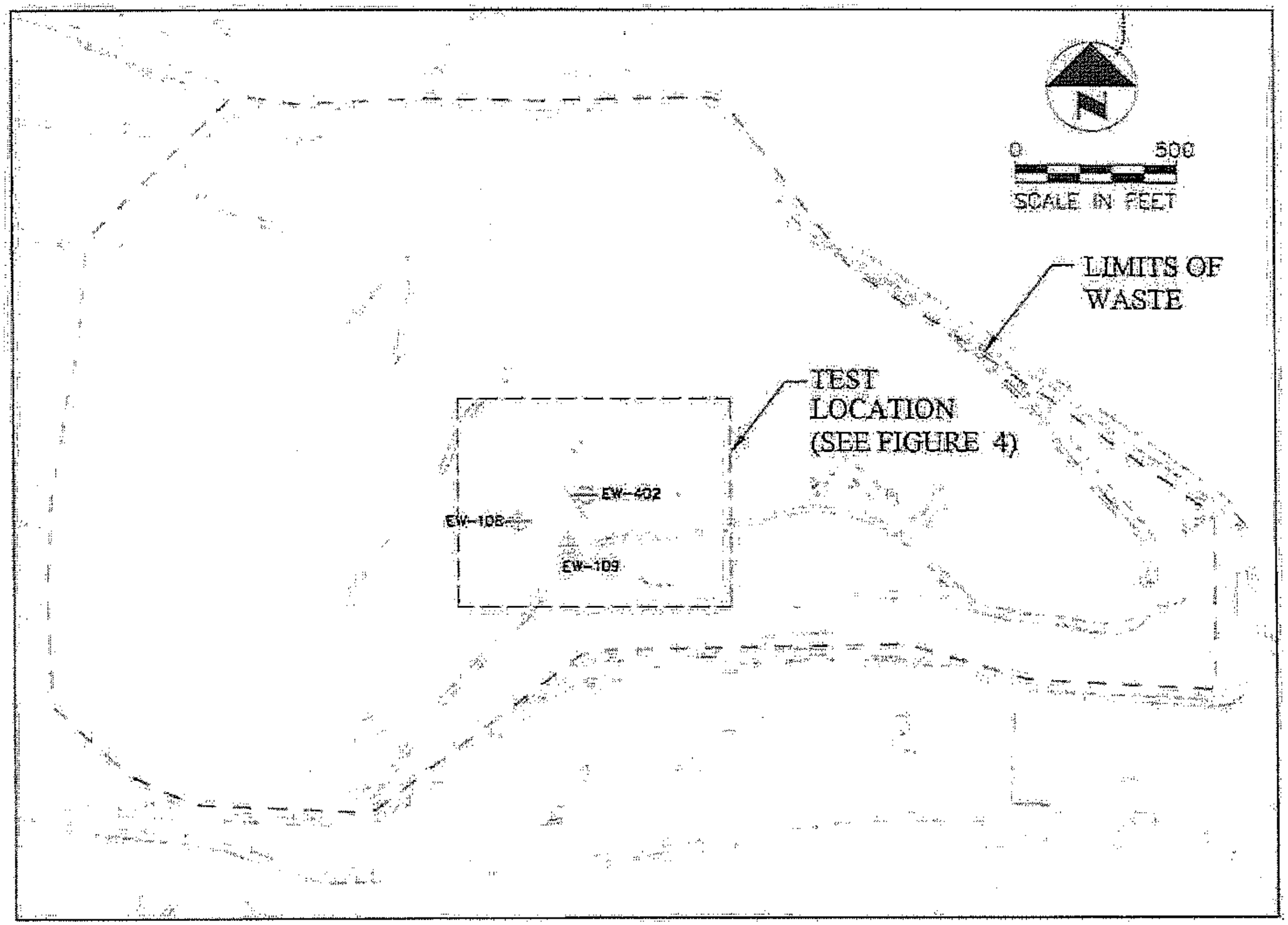

FIGURE 3 - SITE MAP

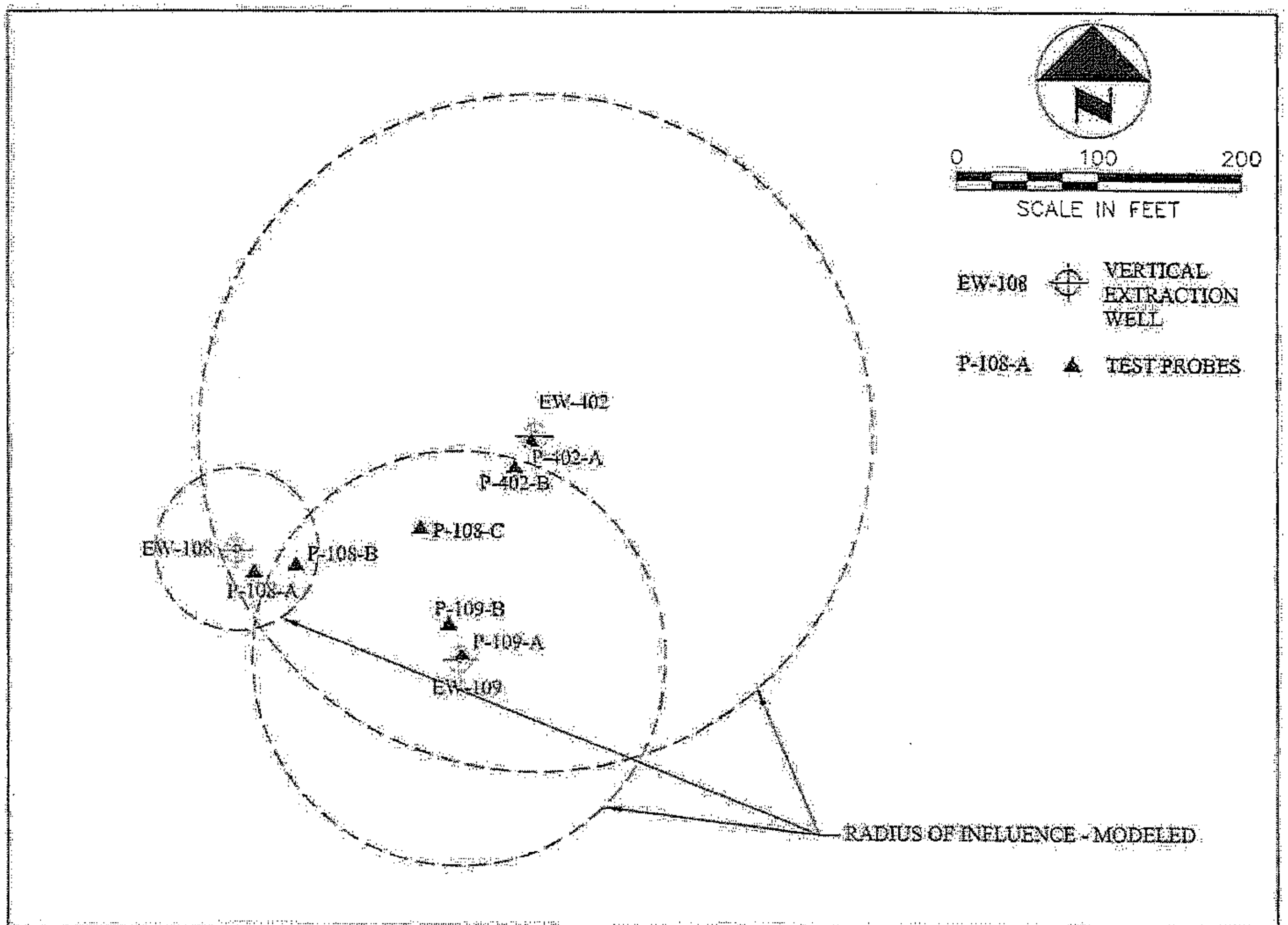

FIGURE 4 - TEST LOCATION

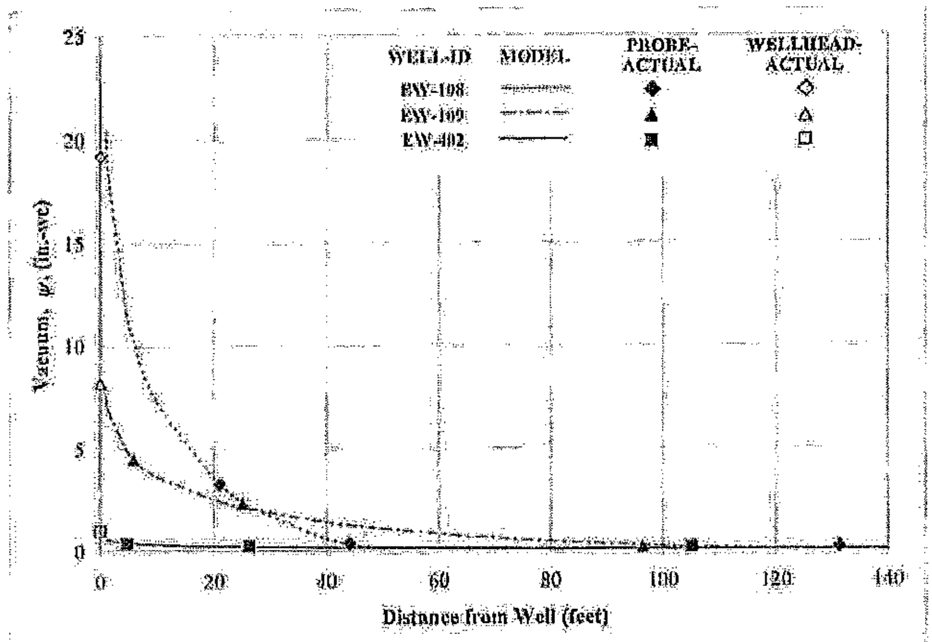

FIGURE 5. COMPARISON OF ACTUAL DATA TO MODEL FOR MARCH 30, 2005, 10 AM

2.2 HORIZONTAL WELLS
(95% SUBMITTAL)

2.2.1 Background/Statement of Problem

To estimate the radius of influence of horizontal gas wells using a theoretical method approach.

2.2.2 Methodology

Theoretical formula used (derived from Darcy's Equation):

- $$\Psi_1 - \Psi_2 = \frac{Q}{CR_I^2 LK}\left(R_I^2 \ln\frac{r_2}{r_1} - \frac{r_2^2}{2} + \frac{r_1^2}{2}\right),\ r_2 > r_1$$

2.2.3 Assumptions and Inputs

- Laminar, radial flow towards the collector.
- Negligible elevation and velocity heads, and gas compressibility.
- Waste is homogeneous and isotropic.
- Flow paths are radial and that isobars (lines of equal pressure) form concentric cylinders around the collector.
- Vacuum Head, Ψ, Mass Flux of LFG, Q, and Length of perforated pipe, L, are found on Table 1.
- Parameters:

Waste permeability, K	3E-03 cm/s
Radial coordinate (well radius), r_1	2 in
LFG flow rate, Q (assume from flow calcs)	3 scfm

2.2.4 Calculations and Results

- Table 2-1-1 presents the results of the calculation. The calculation varied the perforated pipe length over the range shown on the design plans. Where the computed vacuum approaches zero is the theoretical limit of the radius of influence from the collector.
- Conservatively the computed vacuum should be above 0.75 in W.C. at the indicated radius of influence.
- The radius of influence is over 70 ft. for all perforated pipe lengths.
- A model of the volumes of influence (combined horizontal and vertical wells) is presented in Figures 2.2.1 and 2.2.2.

2.2.5 References

- Greg McCarron, Darrin Dillah, and Owen R. Esterly. "Horizontal Collectors: Design Parameters, Mathematical Model, and Case Study." Proceedings from the Solid Waste Association of North America's 26th Annual Landfill Gas Symposium. Tampa, Florida. March 24-27, 2003.

2.2.6 Quality Control

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Table 2-2-1

Theoretical Radius of Influence of Horizontal Gas Well vs Vacuum

Vacuum (Vacuum Head/Specific Weight of LFG)		Radius of Influence, R_I	Mass Flux, Q	Length of Perforated Pipe, L	Waste Permeability, K			Radial Distance From CL of Collector, r_1	
ftWC	inWC	ft	scfm	ft	cm/s	ft/s	ft/min	in	ft
4.90E-01	5.89	10	2	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.98E-01	5.98	20	2	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.00E-01	6.00	30	2	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.01E-01	6.01	40	2	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.01E-01	6.01	50	2	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.01E-01	6.02	60	2	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.01E-01	6.02	70	2	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.02E-01	6.02	100	2	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.70E-01	3.24	10	2	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.74E-01	3.29	20	2	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.75E-01	3.30	30	2	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.75E-01	3.30	40	2	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.76E-01	3.31	50	2	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.76E-01	3.31	60	2	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.76E-01	3.31	70	2	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.76E-01	3.31	100	2	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.35E-01	1.62	10	2	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.37E-01	1.64	20	2	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.37E-01	1.65	30	2	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	40	2	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	50	2	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	60	2	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	70	2	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.66	100	2	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
8.99E-02	1.08	10	2	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.13E-02	1.10	20	2	300	3.00E-03	9.8E-05	5.91E-03	2	0.167

9.17E-02	1.10	30	2	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.18E-02	1.10	40	2	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.19E-02	1.10	50	2	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.19E-02	1.10	60	2	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.19E-02	1.10	70	2	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.20E-02	1.10	100	2	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.74E-02	0.81	10	2	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.85E-02	0.82	20	2	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.87E-02	0.82	30	2	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.88E-02	0.83	40	2	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-02	0.83	50	2	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-02	0.83	60	2	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-02	0.83	70	2	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.90E-02	0.83	100	2	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.39E-02	0.65	10	2	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.48E-02	0.66	20	2	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.50E-02	0.66	30	2	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.51E-02	0.66	40	2	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.51E-02	0.66	50	2	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.51E-02	0.66	60	2	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.52E-02	0.66	70	2	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.52E-02	0.66	100	2	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.50E-02	0.54	10	2	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.57E-02	0.55	20	2	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.58E-02	0.55	30	2	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.59E-02	0.55	40	2	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.59E-02	0.55	50	2	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.60E-02	0.55	60	2	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.60E-02	0.55	70	2	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.60E-02	0.55	100	2	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.85E-02	0.46	10	2	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.91E-02	0.47	20	2	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.93E-02	0.47	30	2	700	3.00E-03	9.8E-05	5.91E-03	2	0.167

3.93E-02	0.47	40	2	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.94E-02	0.47	50	2	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.94E-02	0.47	60	2	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.94E-02	0.47	70	2	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.94E-02	0.47	100	2	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.37E-02	0.40	10	2	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.42E-02	0.41	20	2	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.44E-02	0.41	30	2	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.44E-02	0.41	40	2	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.44E-02	0.41	50	2	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.45E-02	0.41	60	2	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.45E-02	0.41	70	2	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.45E-02	0.41	100	2	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.00E-02	0.36	10	2	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.04E-02	0.37	20	2	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.06E-02	0.37	30	2	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.06E-02	0.37	40	2	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.06E-02	0.37	50	2	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.06E-02	0.37	60	2	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.06E-02	0.37	70	2	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.07E-02	0.37	100	2	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.70E-02	0.32	10	2	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.74E-02	0.33	20	2	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.75E-02	0.33	30	2	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.75E-02	0.33	40	2	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.76E-02	0.33	50	2	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.76E-02	0.33	60	2	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.76E-02	0.33	70	2	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.76E-02	0.33	100	2	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.57E-02	0.31	10	2	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.61E-02	0.31	20	2	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.62E-02	0.31	30	2	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.62E-02	0.31	40	2	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167

2.62E-02	0.31	50	2	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.63E-02	0.32	60	2	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.63E-02	0.32	70	2	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.63E-02	0.32	100	2	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167

Table 2-2-1
Theoretical Radius of Influence of Horizontal Gas Well vs Vacuum

Vacuum (Vacuum Head/Specific Weight of LFG)		Radius of Influence, R_I	Mass Flux, Q	Length of Perforated Pipe, L	Waste Permeability, K			Radial Distance From CL of Collector, r_1	
ftWC	inWC	ft	scfm	ft	cm/s	ft/s	ft/min	in	ft
2.45E-01	2.94	10	1	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.49E-01	2.99	20	1	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.50E-01	3.00	30	1	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.50E-01	3.00	40	1	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.51E-01	3.01	50	1	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.51E-01	3.01	60	1	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.51E-01	3.01	70	1	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.51E-01	3.01	100	1	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.35E-01	1.62	10	1	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.37E-01	1.64	20	1	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.37E-01	1.65	30	1	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	40	1	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	50	1	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	60	1	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	70	1	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.66	100	1	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.74E-02	0.81	10	1	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.85E-02	0.82	20	1	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.87E-02	0.82	30	1	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.88E-02	0.83	40	1	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-02	0.83	50	1	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-02	0.83	60	1	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-02	0.83	70	1	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.90E-02	0.83	100	1	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.50E-02	0.54	10	1	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.57E-02	0.55	20	1	300	3.00E-03	9.8E-05	5.91E-03	2	0.167

4.58E-02	0.55	30	1	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.59E-02	0.55	40	1	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.59E-02	0.55	50	1	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.60E-02	0.55	60	1	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.60E-02	0.55	70	1	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.60E-02	0.55	100	1	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.37E-02	0.40	10	1	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.42E-02	0.41	20	1	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.44E-02	0.41	30	1	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.44E-02	0.41	40	1	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.44E-02	0.41	50	1	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.45E-02	0.41	60	1	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.45E-02	0.41	70	1	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.45E-02	0.41	100	1	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.70E-02	0.32	10	1	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.74E-02	0.33	20	1	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.75E-02	0.33	30	1	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.75E-02	0.33	40	1	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.76E-02	0.33	50	1	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.76E-02	0.33	60	1	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.76E-02	0.33	70	1	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.76E-02	0.33	100	1	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.25E-02	0.27	10	1	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.28E-02	0.27	20	1	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.29E-02	0.27	30	1	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.29E-02	0.28	40	1	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.30E-02	0.28	50	1	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.30E-02	0.28	60	1	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.30E-02	0.28	70	1	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.30E-02	0.28	100	1	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.93E-02	0.23	10	1	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.96E-02	0.23	20	1	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.96E-02	0.24	30	1	700	3.00E-03	9.8E-05	5.91E-03	2	0.167

1.97E-02	0.24	40	1	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.97E-02	0.24	50	1	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.97E-02	0.24	60	1	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.97E-02	0.24	70	1	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.97E-02	0.24	100	1	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.69E-02	0.20	10	1	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.71E-02	0.21	20	1	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.72E-02	0.21	30	1	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.72E-02	0.21	40	1	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.72E-02	0.21	50	1	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.72E-02	0.21	60	1	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.72E-02	0.21	70	1	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.72E-02	0.21	100	1	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.50E-02	0.18	10	1	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.52E-02	0.18	20	1	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.53E-02	0.18	30	1	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.53E-02	0.18	40	1	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.53E-02	0.18	50	1	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.53E-02	0.18	60	1	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.53E-02	0.18	70	1	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.53E-02	0.18	100	1	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.35E-02	0.16	10	1	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.37E-02	0.16	20	1	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.37E-02	0.16	30	1	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-02	0.17	40	1	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-02	0.17	50	1	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-02	0.17	60	1	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-02	0.17	70	1	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-02	0.17	100	1	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.28E-02	0.15	10	1	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.30E-02	0.16	20	1	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.31E-02	0.16	30	1	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.31E-02	0.16	40	1	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167

1.31E-02	0.16	50	1	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.31E-02	0.16	60	1	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.31E-02	0.16	70	1	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.31E-02	0.16	100	1	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167

Table 2-2-1
Theoretical Radius of Influence of Horizontal Gas Well vs Vacuum

Vacuum (Vacuum Head/Specific Weight of LFG)		Radius of Influence, R_I	Mass Flux, Q	Length of Perforated Pipe, L	Waste Permeability, K			Radial Distance From CL of Collector, r_1	
ftWC	inWC	ft	scfm	ft	cm/s	ft/s	ft/min	in	ft
7.36E-01	8.83	10	3	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.47E-01	8.97	20	3	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.50E-01	9.00	30	3	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.51E-01	9.01	40	3	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.52E-01	9.02	50	3	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.52E-01	9.02	60	3	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.52E-01	9.03	70	3	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.52E-01	9.03	100	3	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.05E-01	4.86	10	3	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.11E-01	4.93	20	3	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.12E-01	4.95	30	3	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.13E-01	4.96	40	3	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.13E-01	4.96	50	3	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.14E-01	4.96	60	3	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.14E-01	4.96	70	3	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.14E-01	4.97	100	3	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.02E-01	2.43	10	3	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.05E-01	2.47	20	3	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.06E-01	2.47	30	3	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.07E-01	2.48	40	3	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.07E-01	2.48	50	3	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.07E-01	2.48	60	3	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.07E-01	2.48	70	3	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.07E-01	2.48	100	3	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.35E-01	1.62	10	3	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.37E-01	1.64	20	3	300	3.00E-03	9.8E-05	5.91E-03	2	0.167

1.37E-01	1.65	30	3	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	40	3	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	50	3	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	60	3	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	70	3	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.66	100	3	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.01E-01	1.21	10	3	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.03E-01	1.23	20	3	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.03E-01	1.24	30	3	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.03E-01	1.24	40	3	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.03E-01	1.24	50	3	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.03E-01	1.24	60	3	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.03E-01	1.24	70	3	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.03E-01	1.24	100	3	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
8.09E-02	0.97	10	3	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
8.22E-02	0.99	20	3	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
8.25E-02	0.99	30	3	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
8.26E-02	0.99	40	3	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
8.27E-02	0.99	50	3	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
8.27E-02	0.99	60	3	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
8.27E-02	0.99	70	3	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
8.28E-02	0.99	100	3	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.74E-02	0.81	10	3	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.85E-02	0.82	20	3	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.87E-02	0.82	30	3	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.88E-02	0.83	40	3	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-02	0.83	50	3	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-02	0.83	60	3	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-02	0.83	70	3	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.90E-02	0.83	100	3	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.78E-02	0.69	10	3	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.87E-02	0.70	20	3	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.89E-02	0.71	30	3	700	3.00E-03	9.8E-05	5.91E-03	2	0.167

5.90E-02	0.71	40	3	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.91E-02	0.71	50	3	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.91E-02	0.71	60	3	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.91E-02	0.71	70	3	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.91E-02	0.71	100	3	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.06E-02	0.61	10	3	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.14E-02	0.62	20	3	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.16E-02	0.62	30	3	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.16E-02	0.62	40	3	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.17E-02	0.62	50	3	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.17E-02	0.62	60	3	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.17E-02	0.62	70	3	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.17E-02	0.62	100	3	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.50E-02	0.54	10	3	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.57E-02	0.55	20	3	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.58E-02	0.55	30	3	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.59E-02	0.55	40	3	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.59E-02	0.55	50	3	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.60E-02	0.55	60	3	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.60E-02	0.55	70	3	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.60E-02	0.55	100	3	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.05E-02	0.49	10	3	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.11E-02	0.49	20	3	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.12E-02	0.49	30	3	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.13E-02	0.50	40	3	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.13E-02	0.50	50	3	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.14E-02	0.50	60	3	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.14E-02	0.50	70	3	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
4.14E-02	0.50	100	3	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.85E-02	0.46	10	3	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.91E-02	0.47	20	3	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.93E-02	0.47	30	3	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.93E-02	0.47	40	3	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167

3.94E-02	0.47	50	3	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.94E-02	0.47	60	3	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.94E-02	0.47	70	3	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.94E-02	0.47	100	3	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167

Table 2-2-1
Theoretical Radius of Influence of Horizontal Gas Well vs Vacuum

Vacuum (Vacuum Head/Specific Weight of LFG)		Radius of Influence, R_I	Mass Flux, Q	Length of Perforated Pipe, L	Waste Permeability, K			Radial Distance From CL of Collector, r_1	
ftWC	inWC	ft	scfm	ft	cm/s	ft/s	ft/min	in	ft
9.81E-01	11.77	10	4	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.96E-01	11.95	20	4	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.00E+00	12.00	30	4	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.00E+00	12.02	40	4	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.00E+00	12.03	50	4	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.00E+00	12.03	60	4	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.00E+00	12.03	70	4	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.00E+00	12.04	100	4	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.39E-01	6.47	10	4	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.48E-01	6.58	20	4	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.50E-01	6.60	30	4	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.51E-01	6.61	40	4	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.51E-01	6.61	50	4	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.51E-01	6.62	60	4	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.52E-01	6.62	70	4	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.52E-01	6.62	100	4	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.70E-01	3.24	10	4	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.74E-01	3.29	20	4	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.75E-01	3.30	30	4	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.75E-01	3.30	40	4	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.76E-01	3.31	50	4	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.76E-01	3.31	60	4	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.76E-01	3.31	70	4	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.76E-01	3.31	100	4	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.80E-01	2.16	10	4	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.83E-01	2.19	20	4	300	3.00E-03	9.8E-05	5.91E-03	2	0.167

1.83E-01	2.20	30	4	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.84E-01	2.20	40	4	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.84E-01	2.20	50	4	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.84E-01	2.21	60	4	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.84E-01	2.21	70	4	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.84E-01	2.21	100	4	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.35E-01	1.62	10	4	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.37E-01	1.64	20	4	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.37E-01	1.65	30	4	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	40	4	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	50	4	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	60	4	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	70	4	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.66	100	4	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.08E-01	1.29	10	4	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.10E-01	1.32	20	4	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.10E-01	1.32	30	4	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.10E-01	1.32	40	4	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.10E-01	1.32	50	4	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.10E-01	1.32	60	4	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.10E-01	1.32	70	4	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.10E-01	1.32	100	4	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
8.99E-02	1.08	10	4	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.13E-02	1.10	20	4	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.17E-02	1.10	30	4	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.18E-02	1.10	40	4	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.19E-02	1.10	50	4	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.19E-02	1.10	60	4	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.19E-02	1.10	70	4	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.20E-02	1.10	100	4	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.71E-02	0.92	10	4	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.83E-02	0.94	20	4	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.86E-02	0.94	30	4	700	3.00E-03	9.8E-05	5.91E-03	2	0.167

7.87E-02	0.94	40	4	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.87E-02	0.94	50	4	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.88E-02	0.95	60	4	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.88E-02	0.95	70	4	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.88E-02	0.95	100	4	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.74E-02	0.81	10	4	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.85E-02	0.82	20	4	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.87E-02	0.82	30	4	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.88E-02	0.83	40	4	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-02	0.83	50	4	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-02	0.83	60	4	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-02	0.83	70	4	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.90E-02	0.83	100	4	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.99E-02	0.72	10	4	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.09E-02	0.73	20	4	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.11E-02	0.73	30	4	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.12E-02	0.73	40	4	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.12E-02	0.73	50	4	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.13E-02	0.74	60	4	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.13E-02	0.74	70	4	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.13E-02	0.74	100	4	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.39E-02	0.65	10	4	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.48E-02	0.66	20	4	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.50E-02	0.66	30	4	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.51E-02	0.66	40	4	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.51E-02	0.66	50	4	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.51E-02	0.66	60	4	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.52E-02	0.66	70	4	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.52E-02	0.66	100	4	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.14E-02	0.62	10	4	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.22E-02	0.63	20	4	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.24E-02	0.63	30	4	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.25E-02	0.63	40	4	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167

5.25E-02	0.63	50	4	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.25E-02	0.63	60	4	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.25E-02	0.63	70	4	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.25E-02	0.63	100	4	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167

Table 2-2-1
Theoretical Radius of Influence of Horizontal Gas Well vs Vacuum

Vacuum (Vacuum Head/Specific Weight of LFG)		Radius of Influence, R_I	Mass Flux, Q	Length of Perforated Pipe, L	Waste Permeability, K			Radial Distance From CL of Collector, r_1	
ftWC	inWC	ft	scfm	ft	cm/s	ft/s	ft/min	in	ft
1.23E+00	14.71	10	5	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.25E+00	14.94	20	5	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.25E+00	15.00	30	5	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.25E+00	15.02	40	5	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.25E+00	15.03	50	5	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.25E+00	15.04	60	5	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.25E+00	15.04	70	5	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.25E+00	15.05	100	5	55	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.74E-01	8.09	10	5	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.85E-01	8.22	20	5	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.87E-01	8.25	30	5	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.88E-01	8.26	40	5	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-01	8.27	50	5	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-01	8.27	60	5	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-01	8.27	70	5	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.90E-01	8.28	100	5	100	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.37E-01	4.05	10	5	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.42E-01	4.11	20	5	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.44E-01	4.12	30	5	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.44E-01	4.13	40	5	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.44E-01	4.13	50	5	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.45E-01	4.14	60	5	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.45E-01	4.14	70	5	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
3.45E-01	4.14	100	5	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.25E-01	2.70	10	5	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.28E-01	2.74	20	5	300	3.00E-03	9.8E-05	5.91E-03	2	0.167

2.29E-01	2.75	30	5	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.29E-01	2.75	40	5	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.30E-01	2.76	50	5	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.30E-01	2.76	60	5	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.30E-01	2.76	70	5	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.30E-01	2.76	100	5	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.69E-01	2.02	10	5	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.71E-01	2.05	20	5	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.72E-01	2.06	30	5	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.72E-01	2.07	40	5	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.72E-01	2.07	50	5	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.72E-01	2.07	60	5	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.72E-01	2.07	70	5	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.72E-01	2.07	100	5	400	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.35E-01	1.62	10	5	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.37E-01	1.64	20	5	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.37E-01	1.65	30	5	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	40	5	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	50	5	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	60	5	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	70	5	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.66	100	5	500	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.12E-01	1.35	10	5	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.14E-01	1.37	20	5	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.15E-01	1.37	30	5	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.15E-01	1.38	40	5	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.15E-01	1.38	50	5	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.15E-01	1.38	60	5	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.15E-01	1.38	70	5	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.15E-01	1.38	100	5	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.63E-02	1.16	10	5	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.78E-02	1.17	20	5	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.82E-02	1.18	30	5	700	3.00E-03	9.8E-05	5.91E-03	2	0.167

9.84E-02	1.18	40	5	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.84E-02	1.18	50	5	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.85E-02	1.18	60	5	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.85E-02	1.18	70	5	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
9.85E-02	1.18	100	5	700	3.00E-03	9.8E-05	5.91E-03	2	0.167
8.43E-02	1.01	10	5	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
8.56E-02	1.03	20	5	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
8.59E-02	1.03	30	5	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
8.61E-02	1.03	40	5	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
8.61E-02	1.03	50	5	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
8.62E-02	1.03	60	5	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
8.62E-02	1.03	70	5	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
8.62E-02	1.03	100	5	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.49E-02	0.90	10	5	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.61E-02	0.91	20	5	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.64E-02	0.92	30	5	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.65E-02	0.92	40	5	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.66E-02	0.92	50	5	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.66E-02	0.92	60	5	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.66E-02	0.92	70	5	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
7.66E-02	0.92	100	5	900	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.74E-02	0.81	10	5	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.85E-02	0.82	20	5	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.87E-02	0.82	30	5	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.88E-02	0.83	40	5	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-02	0.83	50	5	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-02	0.83	60	5	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-02	0.83	70	5	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.90E-02	0.83	100	5	1000	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.42E-02	0.77	10	5	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.52E-02	0.78	20	5	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.55E-02	0.79	30	5	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.56E-02	0.79	40	5	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167

6.56E-02	0.79	50	5	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.56E-02	0.79	60	5	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.57E-02	0.79	70	5	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.57E-02	0.79	100	5	1050	3.00E-03	9.8E-05	5.91E-03	2	0.167

HORIZONTAL WELL PIPE LENGTH

Total # Wells: 107

CELL #	WELL #	LENGTH FT
1	1	360.6
1	2	360.6
1	3	364.5
1	4	360.3
1	5	361.9
1	6	363.1
1	7	371.3
1	8	372.4
1	9	378.9
1	10	382.4
1	11	385.4
1	12	242.0

CELL #	WELL #	LENGTH FT
2	1	140.7
2	2	145.2
2	3	349.0
2	4	362.1
2	5	327.8
2	6	325.2
2	7	329.6
2	8	349.7
2	9	355.2
2	10	987.5
2	11	55.2
2	12	113.6
2	13	585.5
2	14	592.0
2	15	592.5
2	16	610.5
2	17	611.3
2	18	244.3
2	19	364.1
2	20	582.6
2	21	552.5
2	22	557.4
2	23	556.8
2	24	552.5
2	25	551.8
2	26	540.2
2	27	513.8
2	28	453.1
2	29	236.7

CELL #	WELL #	LENGTH FT
3	1	283.8
3	2	248.9
3	3	282.3
3	4	270.8
3	5	206.4
3	6	270.1
3	7	275.8
3	8	171.8
3	9	286.7
3	10	281.6
3	11	148.7
3	12	334.0
3	13	357.9
3	14	128.7
3	15	363.7
3	16	365.7
3	17	150.9
3	18	365.1
3	19	388.7
3	20	135.3
3	21	392.9
3	22	379.4
3	23	159.1
3	24	377.8
3	25	321.3
3	26	186.4
3	27	262.7
3	28	285.7
3	29	227.2
3	30	233.3
3	31	225.8

CELL #	WELL #	LENGTH FT
4	1	56.4
4	2	107.8
4	3	78.7
4	4	102.5
4	5	937.4
4	6	869.7
4	7	1043.9
4	8	1011.1
4	9	960.0
4	10	68.5
4	11	95.7
4	12	76.5
4	13	410.8
4	14	102.9
4	15	113.8
4	16	751.6
4	17	706.9
4	18	842.2
4	19	508.9
4	20	68.6
4	21	161.1
4	22	120.2
4	23	112.0

CELL #	WELL #	LENGTH FT
5	1	231.1
5	2	346.3
5	3	366.3
5	4	367.2
5	5	382.9
5	6	339.4
5	7	318.0
5	8	395.1
5	9	163.9
5	10	318.8
5	11	165.0
5	12	186.7

HORIZONTAL WELL PIPE LENGTH

CELL #	WELL #	LENGTH FT
2	11	55.2
4	1	56.4
4	10	68.5
4	20	68.6
4	12	76.5
4	3	78.7
4	11	95.7
4	4	102.5
4	14	102.9
4	2	107.8
4	23	112.0
2	12	113.6
4	15	113.8
4	22	120.2
3	14	128.7
3	20	135.3
2	1	140.7
2	2	145.2
3	11	148.7
3	17	150.9
3	23	159.1
4	21	161.1
5	9	163.9
5	11	165.0
3	8	171.8
3	26	186.4
5	12	186.7
3	5	206.4
3	31	225.8
3	29	227.2
5	1	231.1
3	30	233.3

2	29	236.7
1	12	242.0
2	18	244.3
3	2	248.9
3	27	262.7
3	6	270.1
3	4	270.8
3	7	275.8
3	10	281.6
3	3	282.3
3	1	283.8
3	28	285.7
3	9	286.7
5	7	318.0
5	10	318.8
3	25	321.3
2	6	325.2
2	5	327.8
2	7	329.6
3	12	334.0
5	6	339.4
5	2	346.3
2	3	349.0
2	8	349.7
2	9	355.2
3	13	357.9
1	4	360.3
1	1	360.6
1	2	360.6
1	5	361.9
2	4	362.1
1	6	363.1
3	15	363.7
2	19	364.1
1	3	364.5
3	18	365.1
3	16	365.7

5	3	366.3
5	4	367.2
1	7	371.3
1	8	372.4
3	24	377.8
1	9	378.9
3	22	379.4
1	10	382.4
5	5	382.9
1	11	385.4
3	19	388.7
3	21	392.9
5	8	395.1
4	13	410.8
2	28	453.1
4	19	508.9
2	27	513.8
2	26	540.2
2	25	551.8
2	21	552.5
2	24	552.5
2	23	556.8
2	22	557.4
2	20	582.6
2	13	585.5
2	14	592.0
2	15	592.5
2	16	610.5
2	17	611.3
4	17	706.9
4	16	751.6
4	18	842.2
4	6	869.7
4	5	937.4
4	9	960.0
2	10	987.5
4	8	1011.1

4	7	1043.9
Total # Wells:		107

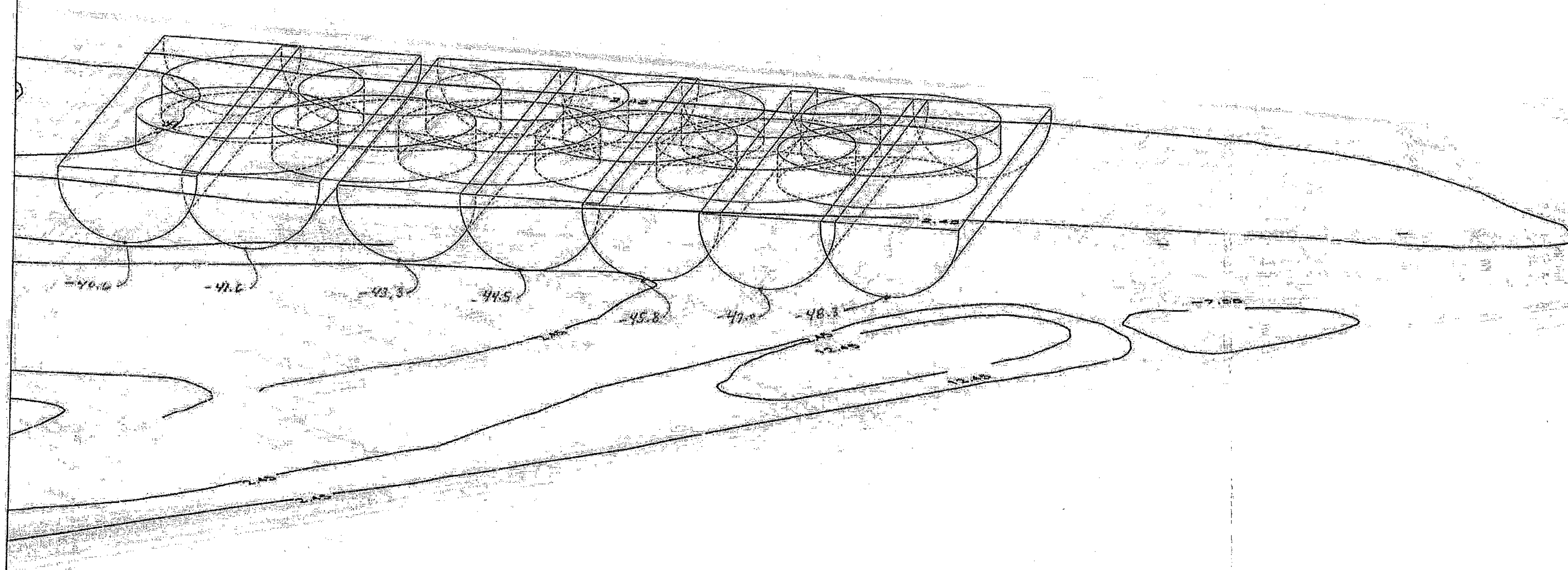

FIGURE 2.2.1

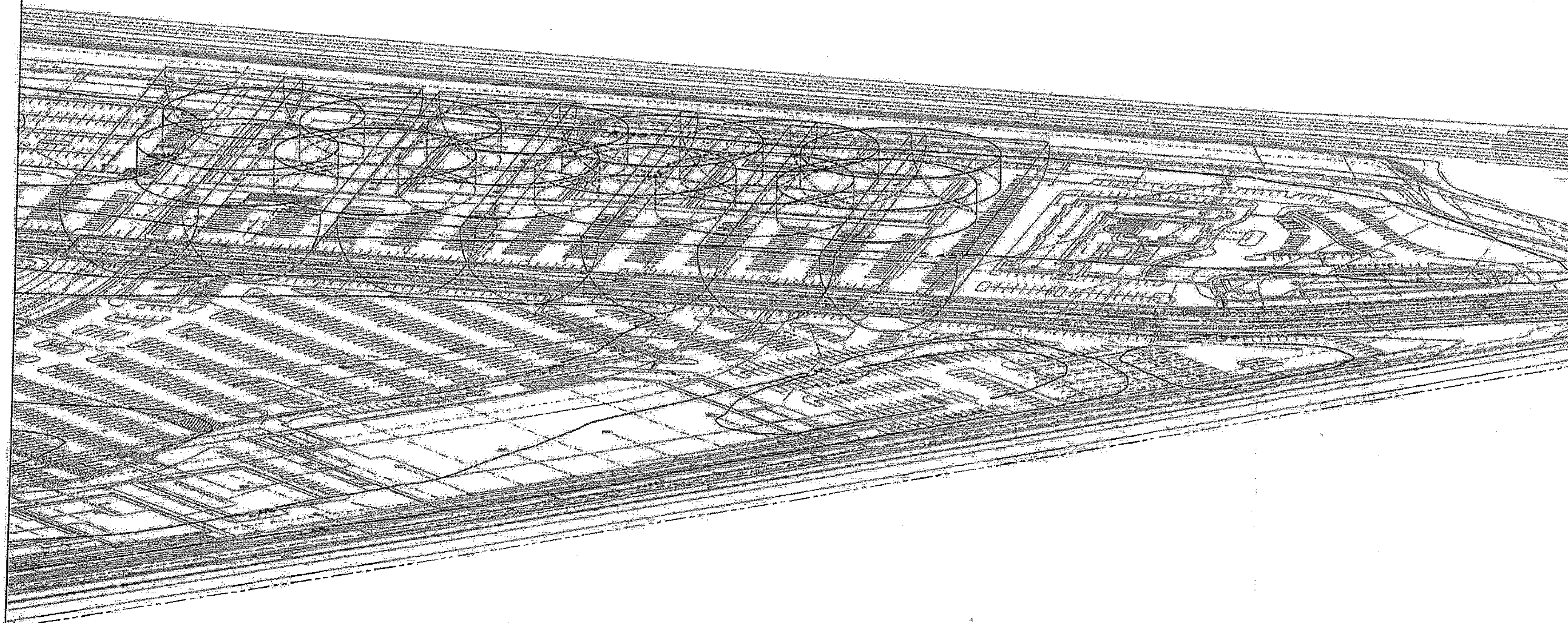

FIGURE 2.2.2

HORIZONTAL COLLECTORS: DESIGN PARAMETERS, MATHEMATICAL MODEL, AND CASE STUDY

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ABSTRACT

Horizontal collectors have been used successfully at many landfills to collect landfill gas (LFG) and are an acceptable method for collecting LFG under the New Source Performance Standards (NSPS) for municipal solid waste (MSW) landfills. Our literature review indicates that the Los Angeles County Sanitation District uses horizontal collectors extensively at its many landfills and first reported on their use in 1982. However, there is a dearth of published design criteria, design details, and performance data related to horizontal collectors that consider all of the critical system parameters. Most of the publications present limited empirical data and anecdotal observations. This paper is intended to advance the industry by providing the design engineer with a theoretical basis for establishing the key system parameters. It presents recommended design criteria, a mathematical model, and a case study.

Our mathematical model provides an understanding of radius of influence and its impacts due to other system parameters such as waste permeability, flow rate, and applied vacuum. Combining the theoretical basis with actual test data, the design engineer can develop a practical and cost-effective design for any particular landfill.

The case study summarizes our evaluation of a horizontal collector recently installed at a Pennsylvania MSW landfill. Using field data for model calibration, we established parameters such as required well head vacuum, maximum horizontal collector length, and collector spacing.

INTRODUCTION

For over 20 years, horizontal LFG collectors have been successfully employed at numerous landfills across the country. The Los Angeles County Sanitation District (LACSD) uses horizontal collectors extensively at its many landfills and first reported on their use in 1982. Horizontal collectors are being used more often at active landfills, as they are required or need to collect LFG from their active cells. The major advantages of horizontal collectors versus vertical wells are their compatibility with active landfill operations and their relative ease of installation.

Dated back to the inception of the NSPS, the EPA notes that horizontal collectors are an acceptable method for collecting LFG. Moreover, the NSPS Enabling Document includes case studies that discuss horizontal collector design (refer to Appendix E of the Enabling Document). One case study regarding the Scholl Canyon Landfill in California notes that the horizontal collectors ranged in length from 1300 feet to 1800 feet with a horizontal spacing of 250 feet. The trench dimensions were 2 feet, 3 inches wide by 5 feet, 9 inches deep. The collectors included alternating sections of 15-inch and 18-inch diameter pipe. Flows in each collector varied in the range of 200 to 300 cubic feet per minute (cfm) with an average vacuum of less than 1 inch of water column (in-w.c.).

In a 1982 presentation, LACSD presented design and operational information for the Puente Hills Landfill. Initial testing was performed on an 850-foot long horizontal collector. The collector trench was 4 feet wide by 5 feet deep and included alternating sections of 6-inch and 8-inch diameter polyvinyl chloride (PVC) pipe. The collector included 200 feet of solid pipe. At a flow of 450 cfm, the measured horizontal radius of influence was 150 feet. As such, additional collectors were designed at 300 feet spacing horizontally and 80 feet vertically.

Reporting on the Cedar Hills Landfill in Washington, designers used a 2-foot by 3-foot trench and 6-inch diameter pipe. The spacing of the trenches was 200 feet horizontally and 45 feet vertically. The longest collector was 600 feet but as many as four collectors were controlled by the same control valve.

Reporting on the Albany Landfill in New York, designers evaluated three different designs: alternating 6-inch and 10-inch diameter pipe, 4-inch pipe, and 4-inch pipe inside larger culvert pipe sections. The spacing of the trenches was 100 feet horizontally and 30 feet vertically.

As can be seen from these examples, design criteria for horizontal collectors vary widely from site to site. In this paper, a mathematical model is developed for horizontal collectors that is useful for establishing suitable system design and/or operational parameters (e.g., flow rate, pressure, and spacing). The paper also presents a case study, data from which is used to verify the model, and summarizes recommended design criteria.

MATHEMATICAL MODEL

SCS developed a simple mathematical model to describe the flow dynamics around a horizontal collector. Depending on the objective, the model can be used to estimate the pressure distribution around a collector, radius of influence, permeability, or other parameters. It is derived from Darcy's equation and the following assumptions:

- Laminar, radial flow towards the collector.
- Negligible elevation and velocity heads, and gas compressibility.
- Waste is homogeneous and isotropic.

In essence, the model assumes that the flow paths are radial and that isobars (lines of equal pressure) form concentric cylinders around the collector.

Our mathematical model is as follows:

$$\psi_1 - \psi_2 = \frac{Q}{CR_I^2 LK}\left(R_I^2 \ln\frac{r_2}{r_1} - \frac{r_2^2}{2} + \frac{r_1^2}{2}\right), r_2 > r_1 \qquad \text{Eq. (1)}$$

where

ψ	=	Vacuum,
r	=	Radial distance measured from the center line of collector,
Q	=	Flow rate,
C_1	=	Unit conversion constant,
R_I	=	Radius of influence,
L	=	Length of perforated pipe, and
K	=	Waste permeability.

CASE STUDY

Background

The Chester County Solid Waste Authority (CCSWA) operates the Lanchester Landfill, an active municipal solid waste landfill located on the border of Chester County and Lancaster County in Pennsylvania. The facility accepts municipal solid waste and permitted residual wastes for landfill disposal. The landfill complex includes a number of solid waste disposal areas including: IU (8 acres), Mountain Top (9 acres), and Areas A (76 acres), B (37 acres), and C (48 acres). All areas are closed to further waste disposal, except Area C, which is the active fill area. A future Area D is planned as well. Refer to Exhibit 1.

Landfilling in Area C began in April 1997. Area C includes a composite secondary liner and a geomembrane primary liner. Total airspace is approximately 4.2 million cubic yards and the projected life is until early 2007. CCSWA has installed a leachate recirculation system in Area C and began recirculating leachate in 2001. In 2000, CCSWA installed two horizontal gas collectors in Area C (see Exhibit 2).

Test Layout

Six multi-depth monitoring probes were installed at 90-degrees to the east end of the northern collector as shown in Exhibit 2. The probes were installed at the following distances from the collector:

- Probe Cluster P-1: 3.5 feet.
- Probe Cluster P-2: 17.3 feet.
- Probe Cluster P-3: 39.3 feet.
- Probe Cluster P-4: 1 foot.
- Probe Cluster P-5: 15 feet.
- Probe Cluster P-6: 45 feet.
- Probe Cluster P-7: 2.3 feet.

At each probe cluster, one probe was installed at the same elevation as the horizontal collector while a second probe was installed 10 feet higher (except at P-7).

Probe P-7 was located about 600 feet from the west end of the collector at an offset of 1 foot. This probe was used in our analysis to help evaluate the distribution of vacuum within the horizontal collector trench itself.

Exhibit 3 presents the typical monitoring probe cluster detail. Six inches of gravel pack were placed, and then 1-inch schedule 40 PVC with a 1-foot screen was placed in the borehole. An additional 1.5 feet of gravel pack was placed, then general fill soil and a two-foot bentonite seal. General fill brought the borehole up to the 10-foot depth and the monitoring probe configuration was repeated. Each monitoring probe was equipped with a quick connect fitting for pressure monitoring.

A monitoring port was also installed on the aboveground header to allow for flow measurements with a pitot tube. Refer to Exhibit 2.

Test Procedures

A three-day test of the horizontal collector system was undertaken on July 17 through 19, 2001. The test proceeded as follows:

- On day one, vacuum was kept at the historical setting at the east end of the northern collector (approximately 5.8 in-w.c.) and at the west end.
- Data was collected and recorded every hour (9 a.m. to 3 p.m.), on each day, as follows:
  - Pressure at all monitoring probes, both wellheads, and the flow monitoring port.
  - Methane, oxygen, carbon dioxide, balance gas and temperature at the east and west wellheads, and the flow monitoring port.
  - Flows at the east end of the Area C Landfill and at both wellheads.
- At the end of day one, the vacuum was adjusted at the east end to a higher setting (approximately 7.3 in-w.c.).
- At the end of day two, the vacuum was adjusted at the east end to a lower setting (approximately 6.6 in-w.c.).

Data Discussion

Pertinent data collected during the three-day test program included flow rate as measured at the flow monitoring port with a pitot tube, well head pressure, and probe pressures.

General comments regarding the data are as follows:

- The deep and shallow probe vacuums decrease the further the probe is from the collector.
- The deep probe vacuums at location 2 (i.e., probes 4, 5, and 6) were less than that at location 1 (i.e., probes 1, 2, and 3), which is expected since location 2 is further away from the vacuum source. The one exception was Probe 4, which was explained upon review of the probe construction notes: Probe 1 was actually drilled 3.25 feet away from the collector while Probe 4 was drilled at distance of 1 foot from the collector.
- The shallow probe vacuums were greater than the deep probe pressures at location 2. This was not expected as it suggests that the vertical permeability (and "radius" of influence) is greater than the horizontal permeability. We suspect that the shallow probes were affected by barometric pressure. Our experience is that a changing barometer can affect the upper reaches of the landfill and cause negative or positive pressures with a rising or falling barometer, respectively. We did not further analyze the shallow probes based on this barometric interference.
- Flow from the collector correlated with the vacuum applied; i.e., the flow increased when the vacuum increased.
- The methane content of the collected LFG suggests that minimal air intrusion was occurring during all three test days. The depth of waste over the collector is about 16 to 17 feet, which suggests that the vertical radius of influence is less than 16 feet.
- The deep probe at P-6 (45 feet away from the collector) was slightly positive on July 17 and July 19 when the average vacuum applied was 5.8 in-w.c. and 6.6 in-w.c., respectively. This probe was slightly negative on July 18 when the applied vacuum was 7.3 in-w.c. This suggests that the horizontal radius of influence was about 45 feet when the applied vacuum was about 7 in-w.c.
- The probe at P-7 was at positive pressure during the majority of the test. Probe P-7 is about 500 feet east of the west well head and about 1,000 feet west of the east well head. The probe was zero pressure when the applied vacuum was about 7 in-w.c. at both the east and west well heads.
- The flow rate measured at the flow monitoring port was higher than expected (ranging from 300 to 360 scfm). The limited extent of LFG collection facilities in the area may partly explain this. LFG may be entering the zone of influence of the horizontal collector due to positive LFG pressure. Once a more comprehensive system is installed, we would expect that the flow from a typical horizontal collector would be less than 300 scfm.

Modeling Results

For this test, the known/measured parameters in Eq. (1) are probe vacuums (ψ), probe distances from collector (r), and flow rate (Q). The unknown parameters are R_I, L, and K. We developed a computer program to evaluate these three unknown parameters using a best-fit analysis; i.e., values are selected such that the sum of the square of errors between the actual data and the model output are minimized.

For example, we first considered the data collected for the deep probes at location 2 (P-4, P-5, and P-6), on July 18, 2001. Average flow was 360 standard cubic feet per minute (scfm), and average vacuum at P-4, 5, and 6 were 0.74, 0.17, and 0.02 in-w.c., respectively. We estimate that probe distances from the collector are about 1 foot, 15 feet, and 45 feet, respectively. Using this data, the computer program evaluates the difference between actual and calculated probe vacuums (i.e., error) for a selected R_I, L, and K combination, and repeats this error calculation for a series of R_I, L, and K combinations. The R_I, L, and K combination that produces the least error is selected as the best fit. For the test data, the best-fit combination is R_I of 50 feet, L of 370 feet, and K of 1.53E-4 feet/sec. Exhibit 4 shows the results graphically, and indicates an almost perfect fit of the data.

The same approach was applied to the data collected at locations 1 and 2 for all three days at the deep probes. Exhibit 5 shows the results for location 1 on July 18, and similarly indicates a close fit of the data. The best fit combination is R_I of 52 feet, L of 440 feet, and K of 1.53E-4 feet/sec.

In summary, our modeling indicates that R_I is approximately 50 feet and L is on the order of about 400 feet, based on the July 18 flow and vacuum conditions.

Practical Considerations

Our model assumes that the zone of influence of the horizontal collector is a cylinder shape, with a radius of R_I and a length of L. However, based on the test data and our experience, we estimate that the cross section is more of an elliptic shape as opposed to a circular shape (i.e., the vertical "radius" is less than the horizontal "radius"). Also, we expect that the elliptic shape tapers as the distance from the vacuum source increases. The end result is a zone of influence that is analogous to a "squashed cone" as opposed to a perfect cylinder.

This suggests that our modeling results may underestimate L, the length of the zone of influence, while overestimating R_I in the vertical dimension. Considering the empirical test data and the width of the landfill, we recommend that one wellhead be provided for every 600 feet of horizontal collector. For example, for our case study landfill, we recommended a well head on both the east and west side of the horizontal collector. Two horizontal collectors should not be tied into one well head, unless the applied vacuum can be increased substantially or the collectors are very short.

To reduce the tapering effect or the cone shape, it is important to minimize the head loss within the horizontal collector pipe itself. Based on the test results and our experience, we recommend that 6-inch pipe be utilized to minimize head loss.

For our case study landfill, we recommended using a horizontal radius of influence of 50 feet, based on the test program and our analysis, which equates to spacing of 100 feet on-center for the horizontal collectors. The vertical radius of influence appears to be less than 16 feet. We recommended using a vertical radius of influence of 15 feet, which equates to a spacing of 30 feet vertically.

Examining Eq. [1], the important variables are applied vacuum, flow rate or gas generation, radius of influence, length, and permeability. As the applied vacuum increases, the radius of influence will increase, with everything else being equal. Based on the test results and other experience, the LFG blower and header system should be designed to provide a minimum of 10 in-w.c. vacuum to each well head to realize a horizontal radius of influence of 50 feet or more.

With installation of a comprehensive LFG collection system, we expect that the flow rate from a typical horizontal collector will be less than that measured during the test. With decreasing flow rate, the radius of influence will increase, with everything else being equal.

However, as the permeability decreases, the radius of influence will decrease. We expect that the permeability will decrease at a landfill as the waste decomposes and is loaded with additional waste. This process will be further accelerated at a landfill that recirculates leachate. The degree to which the permeability will decrease is dependent on several site-specific variables and is beyond the scope of this paper.

Additionally, it is possible that horizontal collectors can be flooded with leachate/condensate due to local perched conditions, preventing collection of LFG. The likelihood of water blockages increases when leachate recirculation is practiced. Hence, we note that horizontal collectors can effectively collect LFG initially, but with changing landfill conditions over time, their effectiveness may diminish. Vertical extraction wells may have to be installed at such a point in time.

DESIGN PARAMETERS

We recommend the following design parameters for a typical MSW landfill in the Northeast based on the model, the test program and our experience:

1. Space horizontal collectors at 100 feet horizontally and 30 feet vertically.

2. Use a minimum of 6-inch pipe within the typical horizontal collector. We suggest ADS pipe provided proper consideration is given to external pipe loads.

3. Make available 10 in-w.c. vacuum to each well head.

4. Provide a separate well head for every 600 feet of horizontal collector.

5. Provide 75 feet of solid pipe, measured from the outside side slope, prior to placement of the slotted pipe. If there is an air "short circuit", then the applied vacuum will be lost due to the large amount of air flow (i.e., high head loss), and vacuum will not reach the slotted sections further down the horizontal collector.

6. Locate the horizontal collectors away from leachate recirculation trenches to minimize water blockages.

REFERENCES

USEPA, 40 CFR 60 Subpart WWW.

USEPA, September 1998, "Summary of the Requirements for New Source Performance Standards and Emission Guidelines for Municipal Solid Waste Landfills", EPA-453R/96-004.

SCS Engineers, August 2001, "Test Report: Evaluation of Horizontal Landfill Gas Collection Trenches".

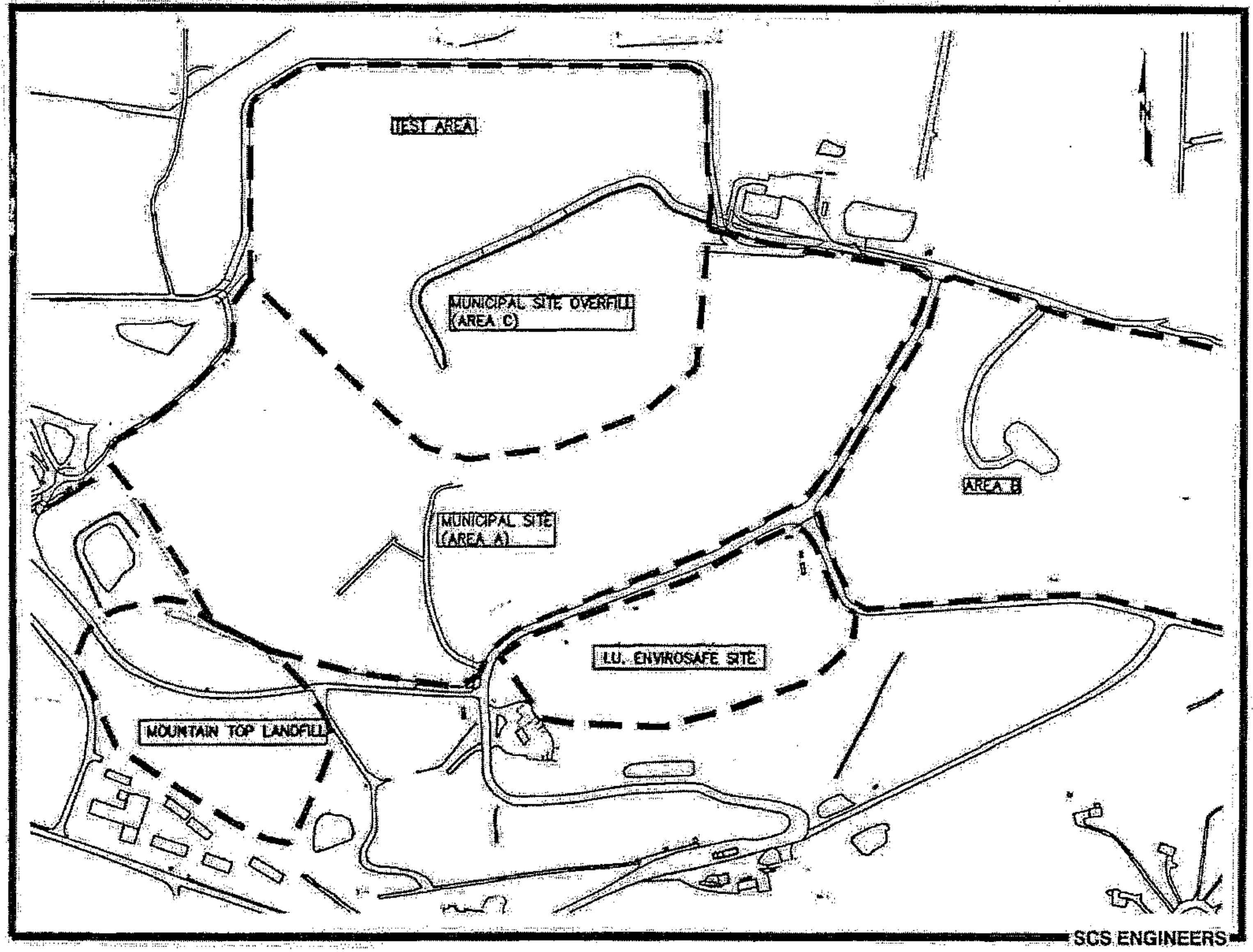
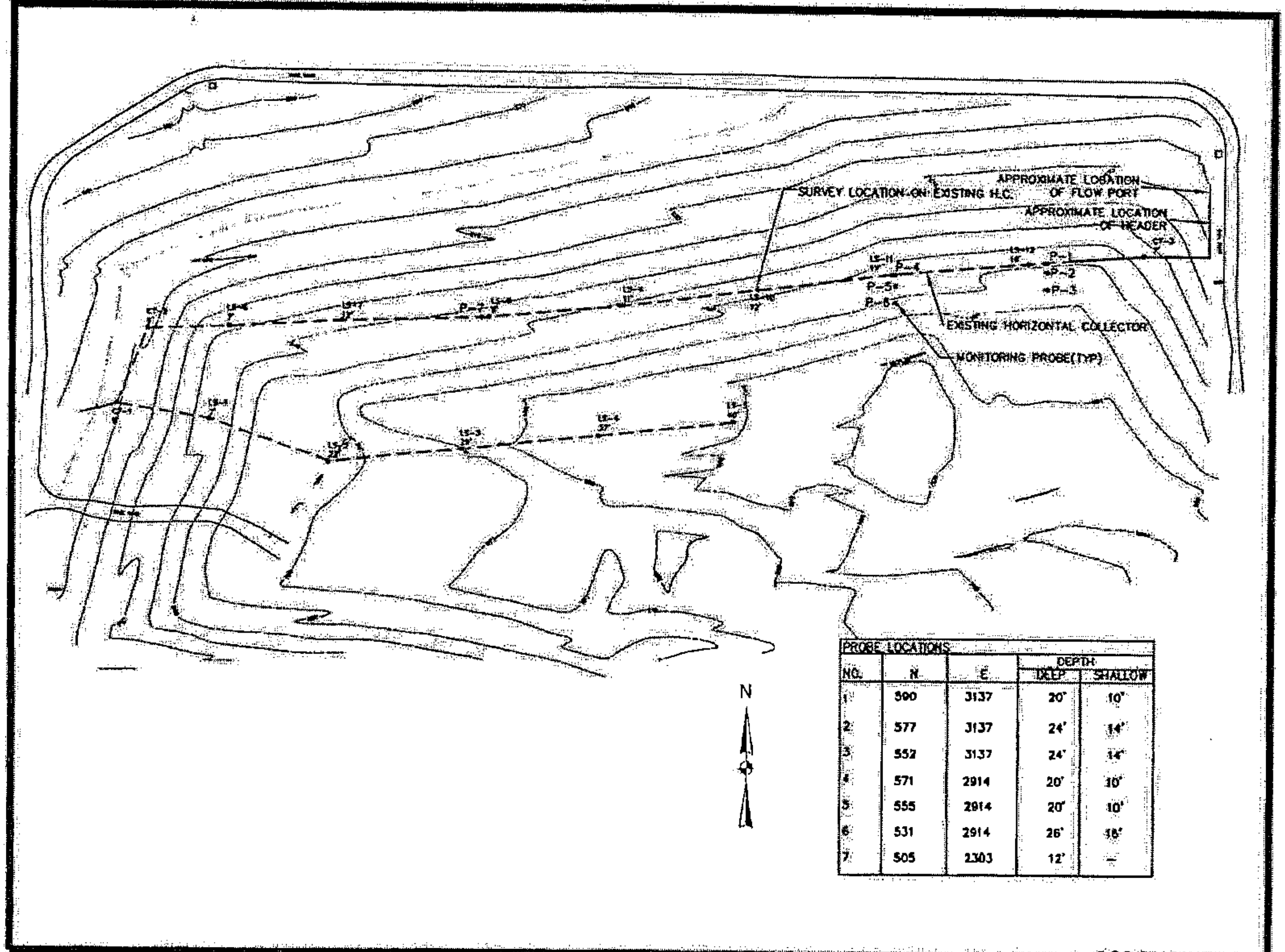


EXHIBIT 1. LANCHESTER LANDIFLL



PROBE LOCATIONS				
NO.	N	E	DEPTH DEEP	DEPTH SHALLOW
1	590	3137	20'	10'
2	577	3137	24'	14'
3	552	3137	24'	14'
4	571	2914	20'	10'
5	555	2914	20'	10'
6	531	2914	26'	16'
7	505	2303	12'	—

EXHIBIT 2. TEST FACILITY LAYOUT

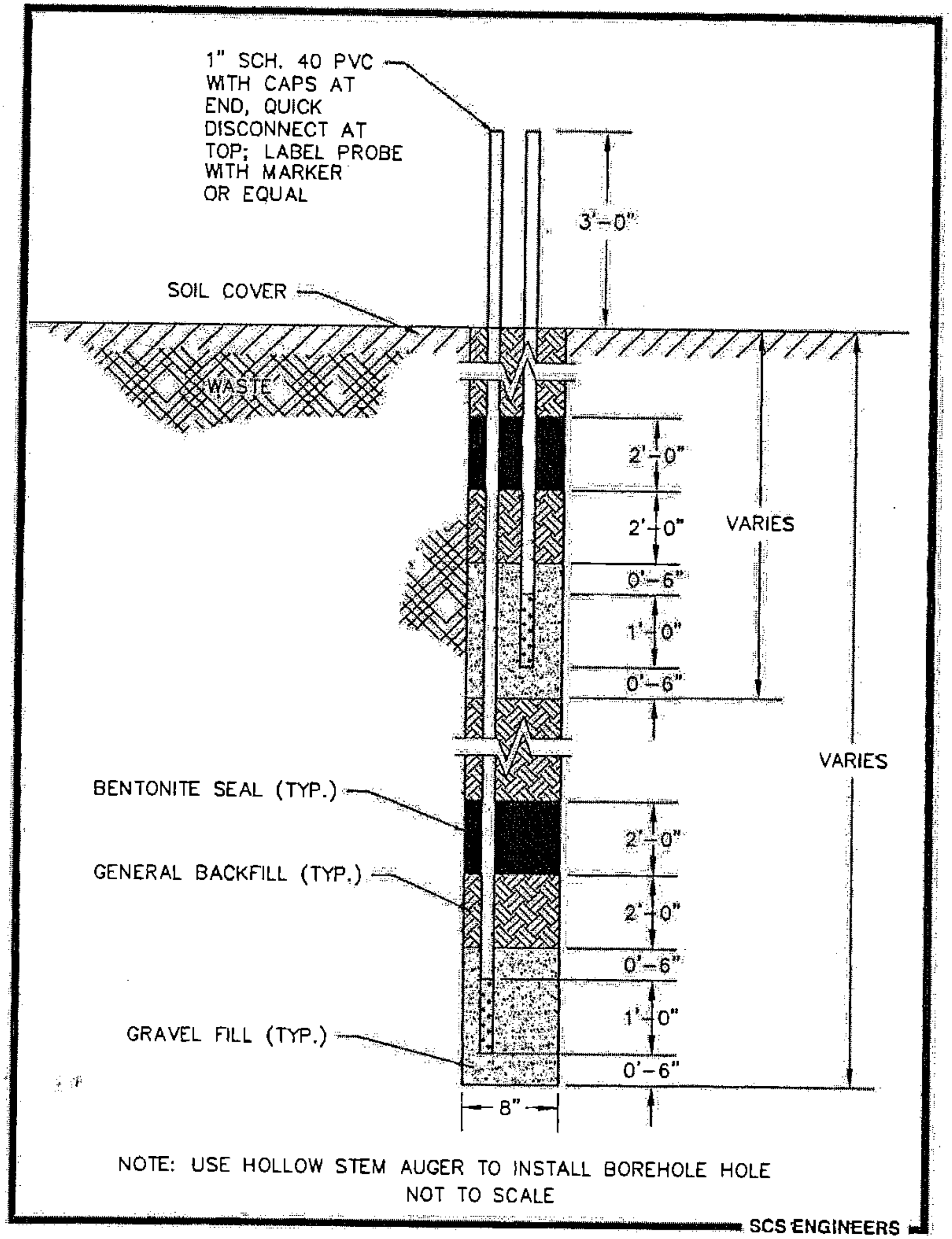


EXHIBIT 3. MONITORING PROBE DETAIL

EXHIBIT 4. Best Fit Curve for P4-P6, Deep Probes (7/18)

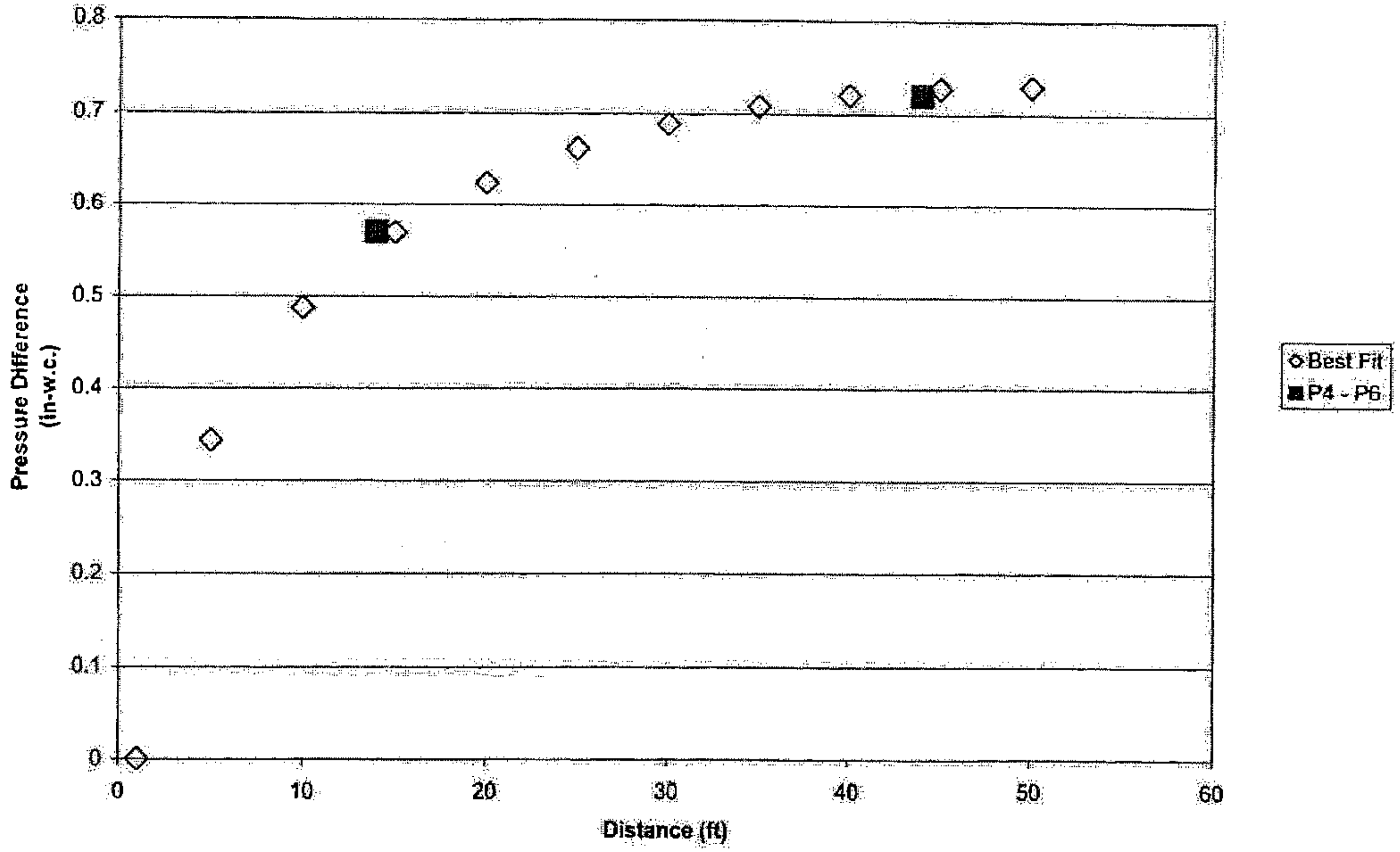


EXHIBIT 5. Best Fit Curve for P1-P3, Deep Probes (7/18)

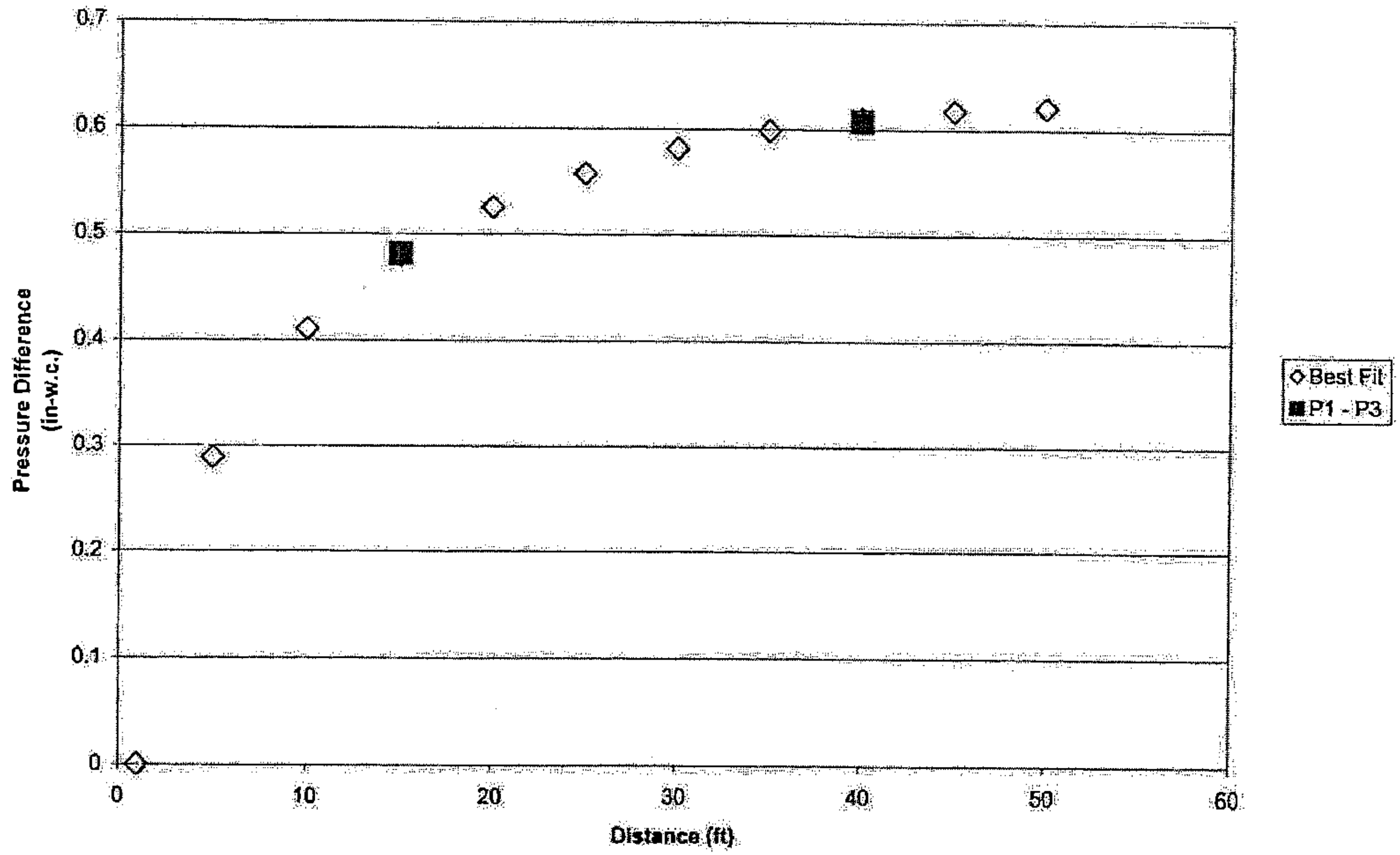


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TABLE OF CONTENTS

SESSION I – FINANCING LFG PROJECTS AND NEW MARKET OPPORTUNITIES

SESSION II – FOCUS ON LFG IN FLORIDA

SESSION III – EPA'S LANDFILL METHANE OUTREACH PROGRAM (LMOP): EMERGING LFG UTILIZATION TECHNOLOGIES AND PRACTICES

SESSION IV – CURRENT LFG RESEARCH AND MODELING PROJECTS

Table 2-2-1
Theoretical Radius of Influence of Horizontal Gas Well vs Vacuum

Vacuum (Vacuum Head/Specific Weight of LFG)		Radius of Influence, R_I	Mass Flux, Q	Length of Perforated Pipe, L	Waste Permeability, K			Radial Distance From CL of Collector, r_1	
ftWC	inWC	ft	scfm	ft	cm/s	ft/s	ft/min	in	ft
2.023E-01	2.43	10	3	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.055E-01	2.47	20	3	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.062E-01	2.47	30	3	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.065E-01	2.48	40	3	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.067E-01	2.48	50	3	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.068E-01	2.48	60	3	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.068E-01	2.48	70	3	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
2.069E-01	2.48	100	3	200	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.35E-01	1.62	10	3	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.37E-01	1.64	20	3	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.37E-01	1.65	30	3	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	40	3	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	50	3	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	60	3	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
1.38E-01	1.65	70	3	300	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.74E-02	0.81	10	3	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.85E-02	0.82	20	3	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.87E-02	0.82	30	3	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.88E-02	0.83	40	3	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-02	0.83	50	3	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-02	0.83	60	3	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
6.89E-02	0.83	70	3	600	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.06E-02	0.61	10	3	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.14E-02	0.62	20	3	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.16E-02	0.62	30	3	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.16E-02	0.62	40	3	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.17E-02	0.62	50	3	800	3.00E-03	9.8E-05	5.91E-03	2	0.167

5.17E-02	0.62	60	3	800	3.00E-03	9.8E-05	5.91E-03	2	0.167
5.17E-02	0.62	70	3	800	3.00E-03	9.8E-05	5.91E-03	2	0.167

2.3 GEOTEXTILE FLUX

2.3.1 Problem Statement

To evaluate the gas flux through the 12 oz. geotextile located immediately beneath the LLDPE membrane landfill cap to confirm that it is adequate to provide passive venting of landfill gas should a reasonable portion of the LFG collection system fail to operate for a short period of time until repairs can be made.

2.3.2 Methodology

Two Methods were used to calculate the required LFG transmissivity and compare the value to published data on measured transmissivity for non-woven 12 oz geotextile under similar overburden and gas mass flux conditions:

Advanced Geotechnical Systems Method

- LFG Mass Flux equation used for each surface area:

$$\Phi_{LFG} = \frac{flow_{LFG}}{Area_{surface}} \left[\frac{m^3/s}{m^2}\right]$$

- Required LFG Relief Layer Transmissivity Design Equation rearranged to solve for Maximum LFG pressure values:

$$\mu_{g\max} = \frac{\Phi_{LFG}\,\gamma_{LFG}}{\theta_{reqLFG}} \left(\frac{L^2}{8}\right) [kPa]$$

- Required LFG Relief Layer Transmissivity equation used to solve for various LFG pressure values:

$$\theta_{reqLFG} = \frac{\Phi_{LFG}\,\gamma_{LFG}}{\mu_{g\max}} \left(\frac{L^2}{8}\right) \left[\frac{m^2}{s}\right]$$

- The landfill gas mass flux is calculated for a reasonable area of the landfill assuming two adjacent vertical and horizontal collectors fail for some reason, i.e. 150x150 SF by prorating the total flow from the landfill of 700 SCFM over the 150x150 SF area and rounding to 2.5 SCFM.

Giroud et al Method

- LFG Mass Flux equation:

$$Q_{gas} = \frac{\text{Weight of Waste x 0.1scf/lb/yr}}{\text{Area of Final Cover }(1ft^2)}$$

- Required LFG Relief Layer or Geotextile Required Transmissivity equation:

$$\theta_{req} = \frac{Q_{gas}\, Y_{gas}}{u_{max}} \left[\frac{L^2}{8}\right]$$

- Recommends use of a Long-Term Service Reduction Factor for LFG Relief Layer of 6 be applied to the determine the safe value of transmissivity to select for design.

The computed values of transmissivity were then compared to an average value from published data on the geotextile transmissivity testing to confirm the 12 oz material provides adequate gas flux for the short term period of possible gas collection system non-operation.

2.3.3 Assumptions and Inputs

- Geotextile remains largely unplugged.
- The geotextile will be continuous but the equations require a spacing thus a very close spacing of 0.1 m was assumed.
- Gas flow from the surface in the subject area will be about 2.5 SCFM or less. This assumes the 700 SCFM design flow (see Calculation in Section 1.0) from the entire landfill surface pro-rated for a 150 x 150 SF area.
- Parameters used:

LFG Generation Rate	0.1 scf/yr/lb
LFG Unit Weight	0.00128 kN/m^3
Surface Area	1 sf
Spacing Between Strip Drains	0.1 m
Long-term Service Reduction Factor	6
Waste Depth (conservative)	40 ft
Waste Density	55 pcf
Average Spacing of Horizontal Collector Pipes	125 ft
12 oz GeotextileTransmissivity (Published Test Data)	0.0002 to 1.5 m^2/s

2.3.4 Calculations and Results

- See attached spreadsheet for calculations.
- The 12 oz geotextile has more than adequate transmissivity to vent all the gas that may flux from the landfill, i.e. 0.75 m^2/s vs. 2.30 x 10^{-05} to 1.16 x 10^{-04} m^2/s minimum required with long-term service reduction factor of 6 applied.
- Also, if required on slopes and gas wells fail the geotextile will eliminate the pressure that could build up below the cover; thus, not impact the cap/cover stability on slopes.

2.3.5 **References** (Attached)

- Advanced Geotech Systems. "Landfill Gas Pressure Relief Layer – Design Calculator." http://www.landfilldesign.com/cgi-bin/gaspressure.pl. 4820 Pulaski Highway. Baltimore, Maryland 21224. Phone (410) 522-1321. Fax (410)522-3977.
- Propex, Inc. "Gas and Water Transmissivity Testing of Non woven Geotextiles." http://www.sedimentremediation.com/TechRef/Dredge/GPD-SM-110.pdf. 6025 Lee Highway, Suite 435. Chattanooga, Tennessee 37421. Phone (423) 899-0444, (800) 621-0444. Fax (423) 899-7619. www.fixsoil.com.
- Gregory N. Richardson, Jean-Pierre Giroud, Aigen Zhao. "Design Of Lateral Drainage Systems For Landfills." PG 46. G.N. Richardson & Associates. Raleigh, North Carolina 27603. Geosyntec Consultants. Boca Raton, Florida 33487. Tenax Corporation. Baltimore, Maryland 21205. Published 2000.

DESIGN OF LATERAL DRAINAGE SYSTEMS FOR LANDFILLS

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2000

4.3 LFG Pressure Dissipation

Engineers have traditionally modeled the movement of both gas and fluids through porous media using Darcy's Law as follows:

$$Q = kiA \qquad \text{Eq. 4.7}$$

Where *Q* is the flow rate (L^3/T), *k* is permeability (L/T), *i* is the dimensionless flow gradient defined as the head loss (L) divided by the flow length (L), and *A* is the area of flow (L^2). This Law assumes that the permeability is independent of the gradient, which requires that the flow be laminar. The requirement for laminar flow means that we should be conscious of the concepts of laminar, transitional, and turbulent flows of fluids and their respective properties. The classical definitions of these flow regimes are as follows:

> **Laminar** flow occurs when the fluid particles move parallel to each other such that their respective flow lines do not cross. Under these flow conditions, the relative velocity between the flow lines is controlled by the viscosity of the fluid.
>
> **Turbulent flow** occurs when the particle flow lines cross such that a mixing occurs and energy is lost due to both viscosity and the mixing. Since additional mechanisms exist to remove energy from the fluid, turbulent flow is inherently less efficient than laminar flow.

Studies performed by men such as Terzaghi (1923) and Fancher et al. (1933) determined that the applicability of Darcy's Law to soils was limited by the Reynold's number, R_e, of the flow (Reynolds, 1883). R_e is defined as

$$R_e = \frac{dv\rho}{\mu} = \frac{dv}{\upsilon} \qquad \text{Eq.4.8}$$

where *d* is the diameter of flow path (L), < is the average velocity of flow, ***D*** is the fluid density (M/L^3), *:* is the dynamic viscosity (M-T/L^2) and *A* is the kinematic viscosity (L^2/T). Values of *D* and *:* for common liquids and gases of concern are presented in Table 1. Note that these values are temperature dependent.

Table 1 Intrinsic Permeability Variables for Common Fluids and Gases (70↓↑F)

	Density, ***D***		Unit Weight, (		Dynamic Viscosity, *:*			Kinematic Viscosity, *A*	
	slug/ft^3	kg/m^3	pcf	N/m^3	Centi-poise	lb-s/ft^2	N-s/m2	ft^2/s	m^2/s
Water	1.94	1000	62.4	9800	1.01	2.12E-5	1.01E-3	1.09E-5	1.01E-6
Air	.00234	1.2	.0753	11.8	.018	3.78E-7	1.79E-5	1.63E-4	1.48E-5
CO2	3.55E-3	1.83	.114	17.9	.015	3.15E-7	1.50E-5	8.88E-5	8.21E-6
Methane	1.29E-3	.666	.0416	6.54	.011	2.31E-7	1.1E-5	1.79E-4	1.65E-5
LFG$^{(1)}$	2.53E-3	1.31	.0815	12.8	.0132	2.77E-7	1.32E-5	1.09E-4	1.01E-5

(1) 55% CO_2, 45% CH_4

What complicates our use of Reynold's number is the discovery that value of R_e at the transition from laminar to turbulent flow is dependent on the flow diameter *d*. For flow of fluids in pipes, the transition from laminar flow, to transitional flow, to turbulent flow occurs at R_e values of 2000 and 4000 respectively. However, for porous media such as soils, having thousands on interconnecting flow tubes, the transition for laminar flow occurs at values of R_e from approximately 1 to 10! This means that fluid flows in gravel and rip-rap will be turbulent and not obey Darcy's Law *since the apparent permeability, k, is not independent of the gradient, i.* Most engineers, however, commonly apply Darcy's Law to such coarse materials.

For laminar flow, Darcy's Law can be expressed in terms of intrinsic permeability as

$$Q=K\frac{\gamma_f}{\mu_f}i_f A \qquad \text{Eq. 4.9}$$

where γ_f is the density of the fluid, μ_f is the dynamic viscosity of the fluid, and i_f is the fluid gradient. The permeability, k, commonly used by engineers is related to the intrinsic permeability, K, as follows

$$k_f=K\frac{\gamma_f}{\mu_f} \qquad \text{Eq. 4.10}$$

Thus if the permeability is known for a given fluid (or gas), it can be determined for any second fluid using the following expression

$$\frac{k_1}{k_2}=\frac{\mu_2}{\mu_1}\frac{\gamma_1}{\gamma_2} \qquad \text{Eq. 4.11}$$

This is true only for laminar flow, e.g. permeability, *k*, is independent of gradient, *i*. Thus, knowing the permeability of the porous media to water, k_{h2o}, the permeability for air, methane, and landfill gas can be obtained by dividing k_{h2o} by 14.8, 16.3, and 10.0 respectively. Application of this theory to geosynthetic Lateral drainage systems was first proposed by Giroud and Bonaparte (1984).

4.3.1 Application of Intrinsic Permeability to Gas Flow in Geonets

Geonets are the "gravel" of geosynthetic drainage media and therefore would reasonably be expected to have turbulent flow. This means the permeability, and therefore the transmissivity, are influenced by the gradient. This is clearly shown by the typical water transmissivity data obtained from a geonet presented on Figure 4.7. The approximate diameter of the flow path is approximately 6.1 mm (0.02 ft). Interpretation of this data is aided by solving for the flow velocity such that the Reynold's number for the flow is known. At a gradient of 0.02 and normal load of 512 psf (25 kPa), the flow rate is $Q_{h2o}\,i$ or 17.8 x 10^{-5} m3/sec-m (8.9 x 10^{-3} x 0.02 m^3/sec-m). For a typical geonet thickness of 6 mm, this indicates an average flow velocity of 3.0 x 10^{-2} m/s (9.2 x 10^{-2} ft/sec). The Reynold's number for this flow is then equal to

$$R_e=\frac{dv}{\upsilon}=\frac{0.02\bullet 9.2x10^{-2}}{1.09x10^{-5}}=168 \qquad \text{Eq. 4.12}$$

Similarly, the Reynold's numbers at gradients of 0.1 and 1.0 are equal to 394 and 1345 respectively. The actual flow rates for this test are plotted as a function of gradient on Figure 4.8. Since laminar flow is defined in sands at $R_e<\geq 10$ and pipes at $R_e<2000$, it is reasonable to assume that the transition for geonets will be between these two limits. The data from Figure 4.8 strongly suggests that the transition from laminar flow for geonets occurs approximately at $R_e<500$ for geonets. This will occur in most geonets at a flow gradient less than 0.1.

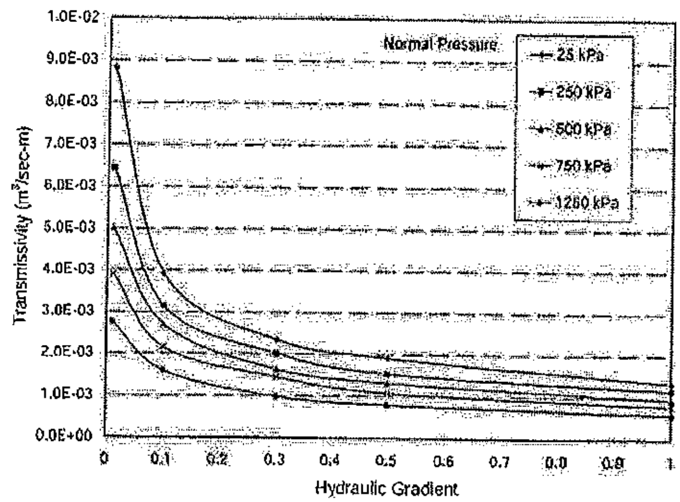


Figure 4.7 Transmissivity vs. Hydraulic Gradient for Geonet

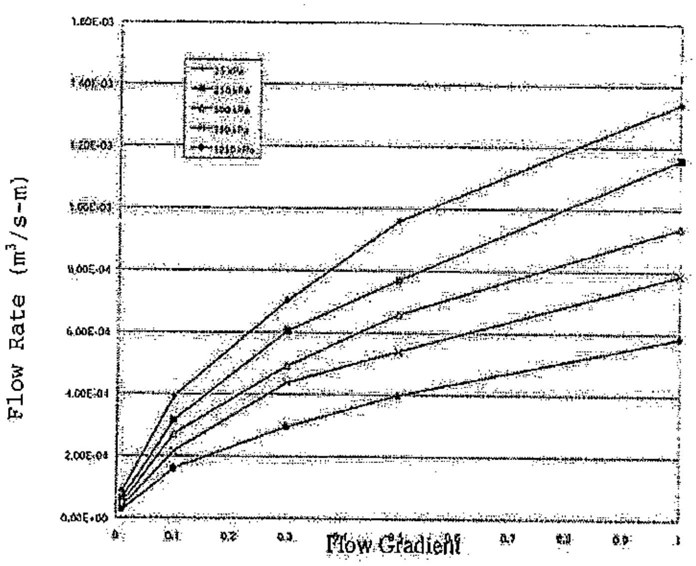


Figure 4.8 Flow Rate vs. Hydraulic Gradient for Geonet

It is very important to note the following: the intrinsic permeability conversion between fluids is conservative if the flow experienced in the field is laminar whether the measured flow, in the laboratory transmissivity test, is turbulent or laminar. Figure 4.8 clearly shows that, under turbulent flow, the measured transmissivity decreases dramatically. Projections based on turbulent measurements in the laboratory will be conservative in field applications as long as laminar flow conditions exist in the field. This is irrespective of the actual field gradient. Thus, it is very important that the actual flow conditions in the field application be verified. The assumption of laminar flow allows the use of Darcy's Law and is valid for low flow gradients common to landfill gas collection systems, see Emcon 1980.

LFG Generation Rate ---- LFG are generated during the biodegradation of fractions of the MSW. The actual rate of gas generation for a given landfill is dependent on the waste composition, waste moisture content, etc. such that a design engineer will have to make a assumption for the gas generation rate. For lined landfills that do not recirculate leachate, the gas generation rate, q_{gas}, can be typically assumed to equal 0.1 scf/year/lb. of MSW. The rate of gas flux, Q_{gas} (scf/ft^2/yr), immediately beneath the final cover can be conservatively estimated as follows:

$$Q_{gas} = \frac{\text{Weight of Waste x } q_{gas}}{\text{Area of Final Cover}} \qquad \text{Eq. 4.13}$$

The design of the geocomposite drain for gas removal can then be calculated using Equation 4.6 previously used for surface water infiltration.

The gas flow, Q_{in}, into a unit width of the geocomposite having a length, L, is given as follows:

$$Q_{in} = M_{gas}(L x 1)\cos\beta \qquad \text{Eq. 4.14}$$

The gas flow capacity of the geocomposite could be evaluated in the laboratory using gas flows. However such tests are exceptionally rare. An estimate for the air transmissivity of the drainage geocomposite can be calculated by *dividing* the water transmissivity by 14; for landfill gas divide by 10. This conversion is based on an assumption of laminar flow and the ratio of the intrinsic viscosity of the gas to water.

LFG Collection Blanket Capacity ---- The assumption of laminar flow allows the use of Darcy's Law and is valid for low flow gradients common to landfill collection systems. This assumption allows the maximum pressure generated by the gas collected by a blanket drain, u_{max}, be defined as follows, Thiel (1999):

$$u_{max} = \frac{Q_{gas}\gamma_{gas}}{\theta_{req}}\left[\frac{L^2}{8}\right] \qquad \text{Eq. 4.15}$$

where $(_{gas}$ is the density of LFG or 0.0815 pcf and L is the length of the gas collection blanket. Calculation of the required transmissivity requires an assumption for the maximum gas pressure that can be allowed beneath the barrier layer in the final cover. For example, typical landfill side slopes generally require the gas pressure remain below 3" H_2O or 15.6 psf relative pressure beneath the barrier for stability considerations. The required transmissivity, θ_{req}, is then calculated as follows:

$$\theta_{req} = \frac{Q_{gas}\gamma_{gas}}{u_{max}}\left[\frac{L^2}{8}\right] \qquad \text{Eq. 4.16}$$

While the density of the LFG is greater than that of air ($(_{air}$ = 0.75 pcf), the movement of LFG is essentially governed by gas pressure gradients and not gravity. Thus the "L" dimension can be either vertical up the slope or horizontal to the slope.

It is more difficult to establish a 'typical' range of required gas transmissivity since the volume of waste impacts the calculation and will vary from site-to-site. However, assuming a waste depth of approximately 100-ft (30.8 m), M_{gas} can be calculated to equal approximately 670 scf/year/ft^2 (6.5 x 10^{-6} m^3/sec/m^2). For a typical gas collector length, *L*, of 100-ft. (30.6m), the required gas transmissivity is approximately 5.0 x 10^{-5}

$m^3/s - m$. The equivalent water transmissivity would equal 5.0×10^{-5} $m^3/s - m$. The assumed 0.1 scf/year/lb gas generation rate was obtained from unlined landfills that exposed the waste to significantly more water than Subtitle D landfills do. Actual gas generation rates can be obtained by performing a NSPS (40 CFR Part 60) Tier 2 gas emissions survey.

4.3.2 Impact of Gas Pressures on Slope Stability

Landfill gas can exert a pressure beneath the final cover geomembrane that may lead to a decrease in the stability of final cover side slopes. Such gas pressures are a certainty in passive gas venting systems and may occur if active gas recovery systems are shut down by accident or for service. The slope stability for the case where seepage forces are not present is given as follows:

$$FS = \frac{Resisting\ Forces}{Driving\ Forces} = \frac{(\gamma_t d \cos\beta - u_g)\tan\delta}{\gamma_t d \sin\beta} \qquad \text{Eq.4.17}$$

where β is the slope angle, d is the vertical thickness of the soil cover (see Figure 4.1), $(_t$ is the total unit weight of the cover soil, and u_g is the effective gas pressure beneath the barrier layer. The effective gas pressure can be conservatively assumed to equal u_{max}, see Eq. 4.15.

An extreme condition can develop if an active gas system is shut down due to a major storm. If the storm conditions lead to saturation of the vegetative soil layer then seepage forces may develop and the slope stability factor of safety reduces to the following:

$$FS = \frac{Resisting\ Forces}{Driving\ Forces} = \frac{(\gamma_b d \cos\beta - u_g)\tan\delta}{\gamma_{sat} d \sin\beta} \qquad \text{Eq.4.18}$$

where $(_b$ is the bouyant weight and $(_{sat}$ is the saturated weight of the soil. Note that this conditions occurs only if the lateral drainage system is hydraulically insufficient to handle the infiltration through the vegetative soil layer.

4.4 Design Examples

Example 1: Determine the required water transmissivity for a geocomposite drainage layer for a final cover having the following properties:

- 6% slopes
- pipe spacing of 35 meters
- long-term service reduction factor = 6
- 2-foot vegetative cover with $K = 1 \times 10^{-4}$ cm/sec
- Assume both HELP model infiltration rates and the saturated case

Typical "east coast" locations yield HELP peak design rate of fluid supply, r or $k_h = 9 \times 10^{-6}$ cm/sec. From Figure 5.5 (see the following chapter), the minimum required drainage layer permeability for the HELP case is 0.016 cm/sec. For the saturated or unit gradient case, r or $k_h = 1 \times 10^{-4}$ cm/sec and the required permeability is 0.16 cm/sec. The required ultimate transmissivity, $2_{ultimate}$, are calculated assuming an equivalent 30 cm thick drainage layer such that **2** = k * thickness * long-term service reduction factor. The required transmissivities are 3.8×10^{-4} m^3/sec-m and 3.8×10^{-3} m^3/sec-m respectively. Note that the HELP model significantly underestimates the transmissivity required if the cover saturates.

The normal load acting on the geocomposite drainage blanket in this application is typically less than 25 kPa (500 psf). The geocomposite drain is then selected using laboratory transmissivity test data such as shown on Figure 2.3 for a flow gradient *equal to or greater than* the 0.06 field condition, e.g. use a 0.1 laboratory gradient.

Example 2: Determine the required gas transmissivity for a geocomposite drainage layer for a final cover having the following properties:

- gas collector pipe spacing, L, of 35 meters (115 ft)
- average waste thickness of 40 meters (131 ft)
- allowable gas pressure of 1" H_2O
- long-term service reduction factor = 6

The rate that landfill gas enters the blanket collector can be estimated using Eq. 4.13 as follows:

$$Q_{gas} = \frac{\text{Weight of Waste x 0.1 scf/lb/yr}}{\text{Area of Final Cover}} = \frac{131' x 70\,pcf x 0.1}{1\,ft^2} = 917\,scf/ft^2/yr = 1.75x10^{-3}\,scf/ft^2/\min$$

The minimum required transmissivity can then be calculated using Eq. 4.16.

$$\theta_{req} = \frac{Q_{gas}\gamma_{gas}}{u_{max}}\left[\frac{L^2}{8}\right] = \frac{1.75x10^{-3}x0.0815\,pcf}{5.2\,psf}\left[\frac{115^2}{8}\right]$$

This reduces to a minimum transmissivity of 0.045 ft^3/min-ft (6.8×10^{-4} m^3/sec-m). Applying the long-term service reduction factor of 6 results in a minimum required LFG transmissivity of 3.8×10^{-4} m^3/sec-m. The required geonet would therefore be required to have a minimum <u>water</u> transmissivity of 3.8×10^{-5} m^3/sec-m.

Example 3: Evaluate influence of LFG pressures on the slope stability of final cover side slopes having the following properties:

- 3H:1V slopes ($= 18.4°)
- vertical thickness of soil cover, d = 2 ft.
- total unit weight of soil cover, ($_t$ = 100 lb/ft^3
- saturated unit weight of soil cover, ($_{sat}$ = 115 lb/ft^3
- effective LFG pressure = 3" H_2O (15.6 lb/ft^2)
- interface friction angle between lateral drain and barrier = 25°

Under normal service conditions, the sliding factor of safety of the slope is given by Eq. 4.17

$$FS = \frac{(\gamma_t d \cos\beta - u_g)\tan\delta}{\gamma_t d \sin\beta} = \frac{(100\ 2\ \cos 18.4° - 15.6)\tan 25°}{100\ 2\ \sin 18.4°} = 1.28$$

Under saturated conditions with an undersized lateral drainage system, seepage forces develop and reduce the factor of safety as given by Eq. 4.18

$$FS = \frac{(\gamma_b d \cos\beta - u_g)\tan\delta}{\gamma_{sat} d \sin\beta} = \frac{((115 - 62.4)2\cos 18.4^\circ - 15.6)\tan 25^\circ}{115\ 2\ \sin 18.4^\circ} = 0.54$$

The combination of seepage forces and LFG pressures will cause a significant decrease in final cover stability.

REQUIRED TRANSMISSIVITY FOR 12 OZ GEOTEXTILE
Advanced Geotechnical Systems Method

				Average
Range of LFG Transmissivity Per Published Test Data	m^2/s	θ_{reqLFG} = 1.5	2.000E-04	7.50E-01
LFG Unit Weight	kN/m^3	γ_{LFG} = 0.00128		

@ Surface Area = 150*150 [sf]

Mass Flux	$m^3/s/m^2$	$\Phi_{LFG} = \dfrac{(\text{Flow Rate/Surface Area}_{Landfill}) \times \text{Area}_{150x150}}{SF} = \dfrac{2.46\ [scfm]}{1\ [sf]} = \dfrac{0.0012\ [m^3/s]}{0.09\ [m^2]} = 1.25E-02$	
Spacing Between Strip Drain (assumed to simulate continuous geotextile)	m	L = 0.10	
		θ_{reqLFG} = 1.5	θ_{reqLFG} = 0.0002
Maximum LFG Pressure	kPa	u_{gmax} = 1.3E-08	1.0E-04
	psi	u_{gmax} = 1.9E-09	1.4E-05

Required LFG Transmissivity	m^2/s	θ_{reqLFG} = 4.60E-08	=	3 psi	
	m^2/s	θ_{reqLFG} = 2.76E-08	=	5 psi	
	m^2/s	θ_{reqLFG} = 3.83E-06	=	0.036 psi	Per 1 inWC
Req'd LFG Transmissivity Adjusted for Long-Term Service Reduction Factor of 6*	m^2/s	θ_{reqLFG} = 2.30E-05	=	0.036 psi	Per 1 inWC

*per recommendation in Giroud et al

REQUIRED TRANSMISSIVITY FOR 12 OZ GEOTEXTILE
Giroud et al Method

						Average
Range of LFG Transmissivity Per Published Test Data	m^2/s	θ_{reqLFG}	=	1.5	2.000E-04	7.50E-01
Waste Depth	40	ft				
Waste Density	55	pcf				
LFG Generation	0.1	scf/yr/lb				
Spacing	125	ft				
LFG Density	0.0815	pcf				
Maximum Pressure	1	inWC	=	5.2	psf	
Q_{gas} = $Depth_{waste}$ x $Density_{waste}$ x LFG Generation	220	$scf/ft^2/yr$	=	4.19E-04	$scf/ft^2/min$	
Req Transmissivity = Qgas x $Density_{gas}$/Max Pressure x L^2/8	1.28E-02	$ft^3/min\text{-}ft$				
Adjust for Long-term service factor =	6					
Adjusted Required Transmissivity =	7.69E-02	$ft^3/min\text{-}ft$				
	1.16E-04	$m^3/sec\text{-}m$		m^2/s		

2.4 PIPE FLOW CALCULATIONS

2.1 Problem Statement

To determine the appropriate pipe sizing for conveyance of the estimated flow of LFG such that adequate vacuum is applied to each LFG horizontal collector and vertical extraction well in order to collect LFG from all areas of the waste prism.

2.2 Collection System Description

As shown on the LFG plans for ASB, attached to the header system there will be an anticipated 235 vertical and 110 horizontal gas collectors. This collection system will convey the LFG from to the waste prism to the flare station for combustion. At the flare station there will be two (2) separate flares; one with a maximum capacity of 250 standard cubic feet per minute (SCFM) and a second with an additional capacity of 450 SCFM. The combination of these two flares will provide for a range of possible flows between 50 and 700 SCFM. The collection system includes two (2) identical LFG blowers, manufactured by Houston Service Industries (HSI), each with the capacity of 700 SCFM at 100 inches of water column (in. w.c.). One blower will operate at all times with the second blower remaining in stand-by status.

2.3 Methodology

In order to ensure adequate vacuum is obtained at each well, the system was modeled to provide the maximum vacuum requirement of 10" w.c. for the wells furthest from the flare station, where the vacuum loss would be the greatest. The isolation valve at the northeast corner of the property was assumed to be closed; the wells straddling this valve, vertical extraction wells 2-24 and 2-25, are the defined as the target wells.

The model was designed to account for the increasing flow as the system approached the flare station. The entrance location of each well's flow into the collection system was defined and the flow from each well/collector was quantified. The majority of the gas from each cell (95%) is assumed to be retrieved evenly from the vertical extraction wells and the remaining flow is assumed to be retrieved proportionally from the cell's horizontal collectors. Starting from the furthest wells, flow is increased and the increase in vacuum corresponding to that flow is calculated for each leg. The pressure drop parameters (Reynolds number, gas density, and velocity) are calculated for each leg. The net vacuum at the end of each leg is then the starting vacuum for the next consecutive leg.

The Darcy Weisbach formula was used to determine the vacuum loss in each leg of the header network. The following equation represents the gas format of Darcy's equation:

$$h_l = f\frac{L}{D}\frac{v^2}{2}$$

Where:

h_l	Head loss
f	Friction Factor (Darcy's, based on smooth pipe)
L	Length of branch
D	Diameter of branch pipe
v	Velocity of flow through branch

For the model, the path of the gas was varied. These gas pathways are included as Appendix A. For each path, four (4) different scenarios were presented in which the header line sizing and flow was varied. The results of the scenario are presented below.

2.4 Assumptions and Inputs

The assumptions and sizing criteria for the sizing model include the following:

- The collection system piping is HDPE with smooth internal surfaces;
- The target allowable pressure drop within the pipe is less than than ½ inch water column (WC) per 100 feet of lateral, or 0.005 inch water column per unit feet of lateral pipe;
- The target minimum well vacuum is 10 inch WC at each well; and
- The maximum LFG flow is 700 SCFM (see Calculation Section 1.0 for basis of the design flow).

2.5 Calculations and Results

Path 1, LFG flow from northern part of Cell 2, all of Cell 1, and the west side of Cell 3 flow through header west of the isolation valve, through the header west of Cell 3 towards the flare station results in the greatest head loss per foot.

Table 2.4.1: Path 1 Analysis

Scenario	Site LFG flow (SCFM)	Header Line size (IN nominal)	Total Vacuum Loss (INWC)	Maximum line loss (INWC/100 ft)
1	700	6	20	0.55
2	600	6	15	0.41
3	700	8	16	0.15
4	600	8	4	0.12

NOTE: See Appendix A for Pipe Flow Map, See Appendix B for Calculation Spreadsheets.

For Path 1, the modeling results indicate that the blowers selected provide sufficient vacuum to ensure a minimum of 10" WC vacuum at each well, with either a 6" or 8" header pipe. However, in order to meet the design criteria for the maximum line loss (0.5 INWC per 100 FT), the leg south of Cell 1 and west of the flare station is required to be 8". For consistency and ease of construction, and to allow for added capacity if needed, BAS recommends 8" piping for the entire header network.

2.6 References

- Houston Service Industries, Inc.; www.hsiblowers.com; 7901 Hansen Rd., Houston, TX 77061; Phone: 800-725-2291; E-mail: his@hsiblowers.com
- John Zink Company LLC; http://www.johnzink.com/products/flares/html/flar_prod_grf.htm; 11920 East Apache, Tulsa, OK 74116, United States of America; Phone: 1-918-234-1800

2.7 Quality Control

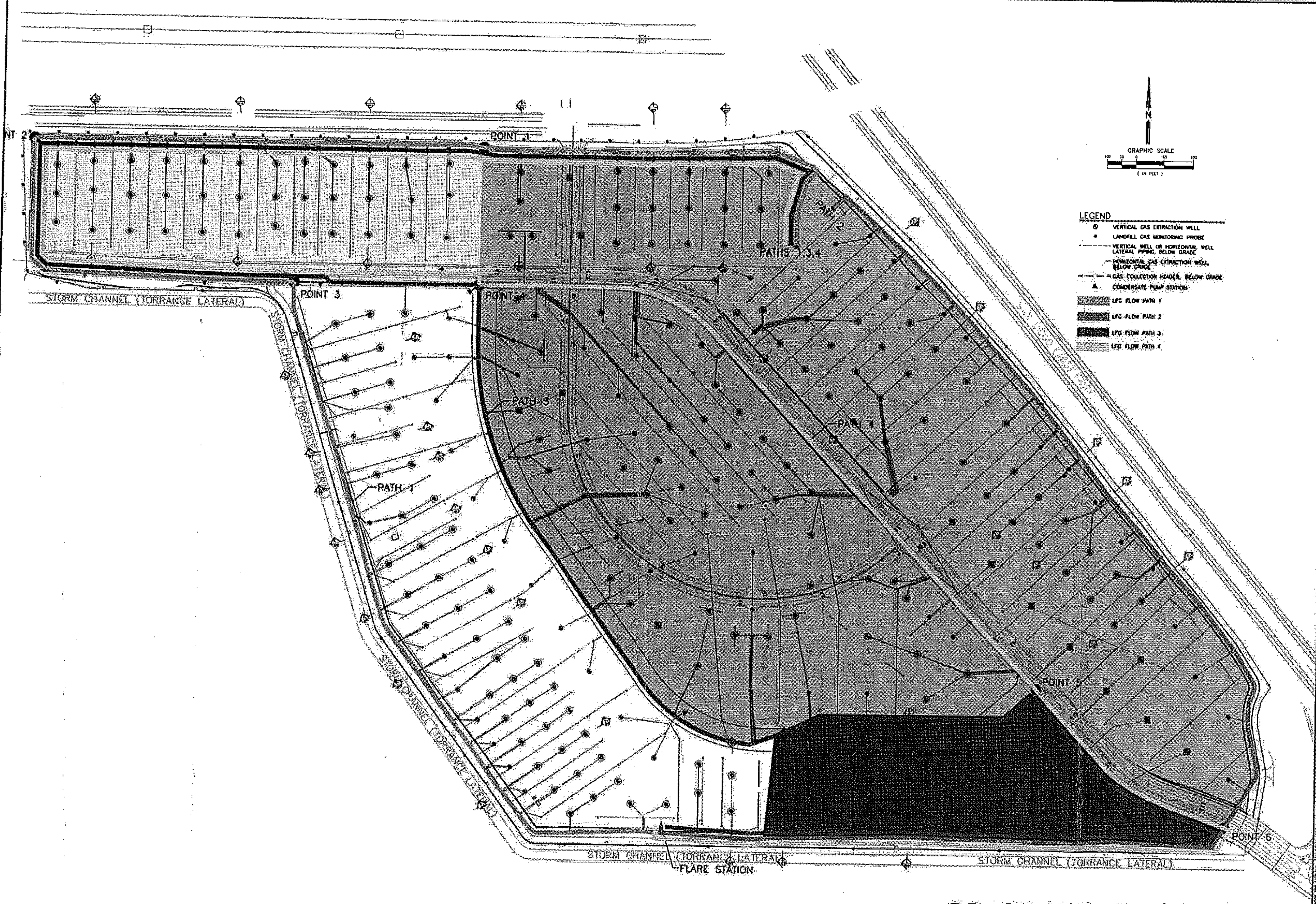
Prepared By: Jason D. Wolf

Checked By: Keith Johnson, P.E.

Approved By: Mike Leonard, P.E.

APPENDIX A

FLOW PATHS



DRAFT FOR REVIEW ONLY

FORMER CAL COMPACT LANDFILL CARSON MARKETPLACE L.L.C. AVALON AT SOUTH BAY	TETRA TECH, INC.	SCALE: AS NOTED DATE: 07/2006 DESIGNED: SML APPROVED: HLL	BAS	AVALON AT SOUTH BAY BAS LANDFILL GAS SYSTEM DESIGN SUBMITTAL LANDFILL GAS SYSTEM PLAN LFG HEADER FLOW PATHS 1–4	SHEET NUMBER FS02

APPENDIX B

CALCULATION SPREADSHEETS

LFG GAS FLOW CALCULATIONS FOR CARSON	
SCENARIO 1	
PATH	1
PATH DESCRIPTION	Flow from northern part of Cell 2, Cell 1 and West side of Cell 3 flow through header west of Cell 3
TOTAL FLOW	700
TOTAL BRANCH FLOW	260.6
OPERATIONS:	NORMAL
SOUTH HEADER SIZE:	0
TOTAL LINE LOSS, IN WC	20.05

Station	Flow Description	Length	Vacuum, Internal	Inlet Flow	Inlet Flow	Total flow	Pipe Size	Pipe Diameter	Pipe Velocity	Reynolds	friction	pressure, absolute	density, actual	section loss	section loss	total loss	total loss/100'
			in w.c	SCFM	ACFM	ACFM	in	in	fps	--	--	PSIA	lbm/ft^3	psi	inwc	in wc	in wc
Well 2-24 to Tie-In	From Well 2-24	279	-10	2.60	2.781686	2.781686	2	1.93	2.28	2295	0.02788	15.06	0.0725	2.0E-03	0.05	0.05	0.02
Tie-In to Point 1	Cell 2 North	1,182	-10.0547	64.00	68.4633	71.24498	6	5.845	6.38	19413	0.02595	15.06	0.0725	2.0E-02	0.55	0.61	0.05
Point 1 to Point 2	Cell 1	1,542	-10.6093	73.00	77.98728	149.2323	6	5.845	13.35	40718	0.02240	15.08	0.0726	9.9E-02	2.74	3.35	0.18
Point 2 to Point 3		1,340	-13.3541		0	149.2323	6	5.845	13.35	40986	0.02237	15.18	0.0731	8.7E-02	2.40	5.75	0.18
Point 3 to Flare Station	Cell 3 West	2,611	-15.2523	121	127.6947	276.927	6	5.845	24.78	76490	0.01976	15.27	0.0735	5.2E-01	14.30	20.05	[illegible]
Amount of Vacuum Required by Blower			-30.0477														

PATH	2																
PATH DESCRIPTION	Flow from east half of Cell 2 combines with flow from Cells 1, 4, 5 & the east side of Cell 3 at point 6.																
TOTAL FLOW	700																
TOTAL BRANCH FLOW	579																
OPERATIONS:	NORMAL																
SOUTH HEADER SIZE:	8																
TOTAL LINE LOSS, IN WC	15.59																
Station	**Flow Description**		**Vacuum, Internal**	**Inlet Flow**	**Inlet Flow**	**Total flow**	**Pipe Size**	**Pipe Diameter**	**Pipe Velocity**	**Reynolds**	**friction**	**pressure, absolute**	**density, actual**	**section loss**	**section loss**	**total loss**	**total loss/100'**
		Length	**in w.c**	**SCFM**	**ACFM**	**ACFM**	**in.**	**in.**	**fps**	**—**	**—**	**PSIA**	**lbm/ft^3**	**psi**	**inwc**	**in wc**	**in wc**
Well 2-25 to tie.-in	From Well 2-25	58	-10	2.60	2.781686	2.781686	2	1.93	2.28	2295	0.02788	15.06	0.0725	4.1E-04	0.01	0.01	0.02
Tie-In to Point 6	Cell 2 East	2775	-10.0114	94.00	100.5659	103.3476	6	5.845	9.25	28158	0.02410	15.06	0.0725	9.2E-02	2.55	2.56	0.09
Point 6 to Flare	Total less Cell 2 East, Cell 3 West	2013	-12.5571	482.40	512.9655	616.3131	8	7.611	32.53	129745	0.01780	15.15	0.0730	4.7E-01	13.03	15.59	0.65
Amount of Vacuum Required by Blower			-25.5904														

PATH	3
PATH DESCRIPTION	Flow from northern part of Cell 2, Cell 1 combine with the east side of Cell 3 and the west side of Cell 4 at point 4 and travels west of Cell 4. Flow from the north side of Cell 5, west side of Cell 2 and the north side of Cell 5 is added at Point 5. The flow from the east side of Cell 2 is combined at Point 6. Flow from the West side of Cell 3 is routed through Path 1.
TOTAL FLOW	700
TOTAL BRANCH FLOW	584.8
OPERATIONS:	NORMAL
SOUTH HEADER SIZE:	8"
TOTAL LINE LOSS, IN WC	29.09

Station	Flow Description		Vacuum, Internal	Inlet Flow	Inlet Flow	Total flow	Pipe Size	Pipe Diameter	Pipe Velocity	Reynolds	friction	pressure, absolute	density, actual	section loss	section loss	total loss	total loss/100'
		Length	in w.c	SCFM	ACFM	ACFM	in.	in	fps	—	—	PSIA	lbm/ft^3	psi	inwc	in wc	in wc
Well 2-24 to Tie-In	From Well 2-24	279	-10	2.60	2.781686	2.781686	2	1.93	2.28	2295	0.02788	15.06	0.0725	2.0E-03	0.05	0.05	0.02
			-10.0547	2.60	2.781321	5.563007	2	2.095	3.88	4229	0.03511	15.06	0.0725	0.0E+00	0.00	0.05	#DIV/0!
			-10.0547	2.60	2.781321	8.344329	2	2.095	5.81	6344	0.03240	15.06	0.0725	0.0E+00	0.00	0.05	#DIV/0!
Tie-In to Point 1	Cell 2 North	1182	-10.0547	64	68.4633	76.80763	6	5.845	6.87	20929	0.02556	15.06	0.0725	2.3E-02	0.64	0.69	0.05
Point 1 to Point 2	Cell 1	1542	-10.69	73	77.97222	154.7798	6	5.845	13.85	42240	0.02224	15.09	0.0726	1.1E-01	2.93	3.62	0.19
Point 2 to Point 3		1340	-13.6223	0	0	154.7798	6	5.845	13.85	42536	0.02221	15.19	0.0731	9.3E-02	2.56	6.18	0.19
Point 3 to Point 4		667	-16.1848	0	0	154.7798	6	5.845	13.85	42795	0.02218	15.28	0.0736	4.6E-02	1.28	7.47	0.19
Point 4 to Point 5, West	Cell 3 East, Cell 4 West	3013	-17.4666	123	129.2814	284.0612	8	7.611	14.99	60499	0.02071	15.33	0.0738	1.8E-01	4.88	12.34	0.16
Point 5 to Point 6	Cell 2 West, Cell 4 East, Cell 5 North	835	-22.3447	190	197.4349	481.4961	8	7.611	25.41	103727	0.01861	15.51	0.0747	1.3E-01	3.53	15.87	0.42
Point 6 to Flare Station	Cell 2 East, Cell 5 South	2013	-25.8747	127	130.8939	612.3901	8	7.611	32.32	133009	0.01771	15.63	0.0753	4.8E-01	13.21	29.09	0.66
Amount of Vacuum Required by Blower			-39.0855														

PATH	4																	
PATH DESCRIPTION	Flow from northern part of Cell 2, Cell 1 combine with all of Cell 4 and the west side of Cell 2 at point 4 and travels east of Cell 4. Flow from the north side of Cell 5 and the east side of Cell 3 are added in at Point 5. The flow from the east side of Cell 2 and the south side of Cell 5 is combined at Point 6. Flow from the West side of Cell 3 is routed through Path 1.																	
TOTAL FLOW	700																	
TOTAL BRANCH FLOW	584.8																	
OPERATIONS:	NORMAL																	
SOUTH HEADER SIZE:	8																	
TOTAL LINE LOSS, IN WC	32.94																	
Station	Flow Description		Vacuum, Internal	Inlet Flow	Inlet Flow	Total flow	Pipe Size	Pipe Diameter	Pipe Velocity	Reynolds	friction	pressure, absolute	density, actual	section loss	section loss	total loss	total loss/100'
		Length	In.w.c	SCFM	ACFM	ACFM	in	in	fps	---	---	PSIA	lbm/ft^3	psi	inwc	in wc	in wc
Well 2-24 to Tie-In	From Well 2-24	279	-10	2.60	2.781686	2.781686	2	1.93	2.28	2295	0.02788	15.06	0.0725	2.0E-03	0.05	0.05	0.02
			-10.0547	2.60	2.781321	5.563007	2	2.095	3.88	4229	0.03511	15.06	0.0725	0.0E+00	0.00	0.05	#DIV/0!
			-10.0547	2.60	2.781321	8.344329	2	2.095	5.81	6344	0.03240	15.06	0.0725	0.0E+00	0.00	0.05	#DIV/0!
Tie-In to Point 1	Cell 2 North	279	-10.0547	64	68.4633	76.80763	6	5.845	6.87	20929	0.02556	15.06	0.0725	5.4E-03	0.15	0.20	0.05
Point 1 to Point 2	Cell 1	1182	-10.2046	73	78.06289	154.8705	6	5.845	13.86	42216	0.02224	15.07	0.0725	8.1E-02	2.25	2.45	0.19
Point 2 to Point 3		1542	-12.4519	0	0	154.8705	6	5.845	13.86	42443	0.02222	15.15	0.0729	1.1E-01	2.94	5.40	0.19
Point 3 to Point 4		667	-15.3967	0	0	154.8705	6	5.845	13.86	42741	0.02219	15.26	0.0734	4.6E-02	1.28	6.68	0.19
Point 4 to Point 5 East	Cell 4, Cell 2 West	2535	-16.6779	279	293.7936	448.6641	8	7.611	23.68	95379	0.01892	15.30	0.0737	3.4E-01	9.34	16.01	0.37
Point 5 to Point 6	Cell 3 East, Cell 5 North	835	-26.0147	34	35.03115	483.6953	8	7.611	25.53	105091	0.01856	15.64	0.0753	1.3E-01	3.58	19.60	0.43
Point 6 to Flare Station	Cell 2 East, Cell 5 South	2013	-29.5982	127	129.7781	613.4734	8	7.611	32.38	134390	0.01767	15.77	0.0759	4.8E-01	13.34	32.94	0.66
Amount of Vacuum Required by Blower			-42.9424														

CARSON LFG CALCULATIONS																	
SCENARIO 2																	
PATH	1																
PATH DESCRIPTION	Flow from northern part of Cell 2, Cell 1 and West side of Cell 3 flow through header west of Cell 3																
TOTAL FLOW	598																
TOTAL BRANCH FLOW	222																
OPERATIONS:	NORMAL																
SOUTH HEADER SIZE:	0																
TOTAL LINE LOSS, IN WC	15.07																
Station	Flow Description		Vacuum, Internal	Inlet Flow	Inlet Flow	Total flow	Pipe Size	Pipe Diameter	Pipe Velocity	Reynolds	friction	pressure, absolute	density, actual	section loss	section loss	total loss	total loss/100'
		Length	in wc	SCFM	ACFM	ACFM	in	in	fps	—	—	PSIA	lbm/ft^3	psi	inwc	in wc	in wc
Well 2-24 to Tie-In	From Well 2-24	279	-10	2.20	2.353734	2.353734	2	1.93	1.95	1942	0.03295	15.06	0.0725	1.7E-03	0.05	0.05	0.02
Tie-In to Point 1	Cell 2 North	1,182	-10.0462	55.00	58.83683	61.19057	6	5.845	5.48	16673	0.02674	15.06	0.0725	1.5E-02	0.42	0.47	0.04
Point 1 to Point 2	Cell 1	1,542	-10.4679	62.00	66.25819	127.4488	6	5.845	11.41	34763	0.02311	15.08	0.0726	7.5E-02	2.07	2.53	0.13
Point 2 to Point 3		1,340	-12.5331		0	127.4488	6	5.845	11.41	34935	0.02309	15.15	0.0729	6.5E-02	1.80	4.33	0.13
Point 3 to Flare Station	Cell 3 West	2,611	-14.335	103	109.0643	236.513	6	5.845	21.17	65108	0.02041	15.22	0.0733	3.9E-01	10.73	15.07	0.41
Amount of Vacuum Required by Blower			[illegible]														

PATH	2																	
PATH DESCRIPTION	Flow from east half of Cell 2 combines with flow from Cells 1, 4, 5 & the east side of Cell 3 at point 6																	
TOTAL FLOW	598																	
TOTAL BRANCH FLOW	495																	
OPERATIONS:	NORMAL																	
SOUTH HEADER SIZE:	8																	
TOTAL LINE LOSS, IN WC	11.73																	
Station	Flow Description		Vacuum, Internal	Inlet Flow	Inlet Flow	Total flow	Pipe Size	Pipe Diameter	Pipe Velocity	Reynolds	friction	pressure, absolute	density, actual	section loss	section loss	total loss	total loss/100'
		Length	in w.c	SCFM	ACFM	ACFM	in	in	fps	--	---	PSIA	lbm/ft^3	psi	inwc	in wc	in wc
Well 2-25 to tie -in	From Well 2-25	58	-10	2.20	2.353734	2.353734	2	1.93	1.93	1942	0.03295	15.06	0.0725	3.5E-04	0.01	0.01	0.02
Tie-In to Point 6	Cell 2 East	2775	-10.0096	80.00	85.58836	87.94209	6	5.845	7.87	23961	0.02489	15.06	0.0725	6.9E-02	1.90	1.91	0.07
Point 6 to Flare	Total less Cell 2 East, Cell 3 West	2013	-11.913	412.31	439.1116	527.0537	8	7.611	27.82	110784	0.01836	15.13	0.0728	3.5E-01	9.82	11.73	0.49
Amount of Vacuum Required by Blower			-21.733														

PATH	3
PATH DESCRIPTION	Flow from northern part of Cell 2, Cell 1 combine with the east side of Cell 3 and the west side of Cell 4 at point 4 and travels west of Cell 4. Flow from the north side of Cell 5, west side of Cell 2 and the north side of Cell 5 is added at Point 5. The flow from the east side of Cell 2 is combined at Point 6. Flow from the West side of Cell 3 is routed through Path 1.
TOTAL FLOW	598
TOTAL BRANCH FLOW	499
OPERATIONS:	NORMAL
SOUTH HEADER SIZE:	8
TOTAL LINE LOSS, IN WC	21.88

Station	Flow Description		Vacuum, Internal	Inlet Flow	Inlet Flow	Total flow	Pipe Size	Pipe Diameter	Pipe Velocity	Reynolds	friction	pressure, absolute	density, actual	section loss	section loss	total loss	total loss/100'
		Length	in w.c	SCFM	ACFM	ACFM	in	in	fps	--	---	PSIA	lbm/ft^3	psi	inwc	in wc	in wc
Well 2-24 to Tie-In	From Well 2-24	279	-10	2.20	2.353734	2.353734	2	1.93	1.93	1942	0.03295	15.06	0.0725	1.7E-03	0.05	0.05	0.02
			-10.0462	2.20	2.353473	4.707207	2	2.095	3.28	3579	0.03630	15.06	0.0725	0.0E+00	0.00	0.05	#DIV/0!
			-10.0462	2.20	2.353473	7.060681	2	2.095	4.92	5368	0.03349	15.06	0.0725	0.0E+00	0.00	0.05	#DIV/0!
Tie-In to Point 1	Cell 2 North	1182	-10.0462	55	58.83683	65.89751	6	5.845	5.90	17956	0.02635	15.06	0.0725	1.7E-02	0.48	0.53	0.04
Point 1 to Point 2	Cell 1	1542	-10.5283	62	66.24861	132.1461	6	5.845	11.83	36049	0.02295	15.08	0.0726	8.0E-02	2.20	2.73	0.14
Point 2 to Point 3		1340	-12.7332	0	0	132.1461	6	5.845	11.83	36239	0.02292	15.16	0.0730	6.9E-02	1.92	4.66	0.14
Point 3 to Point 4		667	-14.6574	0	0	132.1461	6	5.845	11.83	36406	0.02290	15.23	0.0733	3.5E-02	0.96	5.62	0.14
Point 4 to Point 5, West	Cell 3 East, Cell 4 West	3013	-15.6187	105	110.8445	242.9906	8	7.611	12.82	51527	0.02138	15.26	0.0735	1.3E-01	3.67	9.29	0.12
Point 5 to Point 6	Cell 2 West, Cell 4 East, Cell 5 North	835	-19.2877	162	169.5459	412.5365	8	7.611	21.77	88239	0.01921	15.40	0.0741	9.6E-02	2.66	11.94	0.32
Point 6 to Flare Station	Cell 2 East, Cell 5 South	2013	-21.9445	108	112.3308	524.8673	8	7.611	27.70	112965	0.01829	15.49	0.0746	3.6E-01	9.93	21.88	0.49
Amount of Vacuum Required by Blower			-31.8778														

PATH	4
PATH DESCRIPTION	Flow from northern part of Cell 2, Cell 1 combine with all of Cell 4 and the west side of Cell 2 at point 4 and travels east of Cell 4. Flow from the north side of Cell 5 and the east side of Cell 3 are added in at Point 5. The flow from the east side of Cell 2 and the south side of Cell 5 is combined at Point 6. Flow from the West side of Cell 3 is routed through Path 1.
TOTAL FLOW	598
TOTAL BRANCH FLOW	500
OPERATIONS:	NORMAL
SOUTH HEADER SIZE:	8
TOTAL LINE LOSS, IN WC	24.79

Station	Flow Description		Vacuum, Internal	Inlet Flow	Inlet Flow	Total flow	Pipe Size	Pipe Diameter	Pipe Velocity	Reynolds	friction	pressure, absolute	density, actual	section loss	section loss	total loss	total loss/100'
		Length	in w.c	SCFM	ACFM	ACFM	in	in	fps	--	--	PSIA	lbm/ft^3	psi	inwc	in wc	in wc
Well 2-24 to Tie-In	From Well 2-24	279	-10	2.20	2.353734	2.353734	2	1.93	1.93	1942	0.03295	15.06	0.0725	1.7E-03	0.05	0.05	0.02
			-10.0462	2.20	2.353473	4.707207	2	2.095	3.28	3579	0.03630	15.06	0.0725	0.0E+00	0.00	0.05	#DIV/0!
			-10.0462	2.20	2.353473	7.060681	2	2.095	4.92	5368	0.03349	15.06	0.0725	0.0E+00	0.00	0.05	#DIV/0!
Tie-In to Point 1	Cell 2 North	279	-10.0462	55	58.83683	65.89751	6	5.845	5.90	17956	0.02635	15.06	0.0725	4.1E-03	0.11	0.16	0.04
Point 1 to Point 2	Cell 1	1182	-10.16	62	66.30707	132.2046	6	5.845	11.83	36033	0.02295	15.07	0.0725	6.1E-02	1.69	1.85	0.14
Point 2 to Point 3		1542	-11.8497	0	0	132.2046	6	5.845	11.83	36179	0.02293	15.13	0.0728	8.0E-02	2.21	4.06	0.14
Point 3 to Point 4		667	-14.0616	0	0	132.2046	6	5.845	11.83	36370	0.02291	15.21	0.0732	3.5E-02	0.96	5.02	0.14
Point 4 to Point 5, East	Cell 4, Cell 2 West	2535	-15.0226	238	251.6022	383.8068	8	7.611	20.26	81273	0.01953	15.24	0.0734	2.5E-01	7.03	12.05	0.28
Point 5 to Point 6	Cell 3 East, Cell 5 North	835	-22.0481	30	31.19548	415.0023	8	7.611	21.90	89341	0.01916	15.50	0.0746	9.7E-02	2.70	14.75	0.32
Point 6 to Flare Station	Cell 2 East, Cell 5 South	2013	-24.7475	108	111.6019	526.6041	8	7.611	27.79	114079	0.01826	15.59	0.0751	3.6E-01	10.04	24.79	0.50
Amount of Vacuum Required by Blower			-34.7924														

CARSON LFG CALCULATIONS	
SCENARIO 3	
PATH	1
PATH DESCRIPTION	Flow from northern part of Cell 2, Cell 1 and West side of Cell 3 flow through header west of Cell 3
TOTAL FLOW	700
TOTAL BRANCH FLOW	260.6
OPERATIONS:	NORMAL
SOUTH HEADER SIZE:	0
TOTAL LINE LOSS, IN WC	5.68

Station	Flow Description		Vacuum, Internal	Inlet Flow	Inlet Flow	Total flow	Pipe Size	Pipe Diameter	Pipe Velocity	Reynolds	friction	pressure, absolute	density, actual	section loss	section loss	total loss	total loss/100'
		Length	in w.c	SCFM	ACFM	ACFM	in	in	fps	—	—	PSIA	lbm/ft^3	psi	inwc	in wc	in wc
Well 2-24 to Tie-In	From Well 2-24	279	-10	2.60	2.781686	2.781686	2	1.93	2.28	2295	0.02788	15.06	0.0725	2.0E-03	0.05	0.05	0.02
Tie-In to Point 1	Cell 2 North	1,182	-10.0547	64.00	68.4633	71.24498	8	7.611	3.76	14909	0.02734	15.06	0.0725	5.6E-03	0.16	0.21	0.01
Point 1 to Point 2	Cell 1	1,542	-10.2108	73.00	78.06174	149.3067	8	7.611	7.88	31256	0.02361	15.07	0.0725	2.8E-02	0.77	0.98	0.05
Point 2 to Point 3		1,340	-10.9836		0	149.3067	8	7.611	7.88	31314	0.02360	15.10	0.0727	2.4E-02	0.67	1.66	0.05
Point 3 to Flare Station	Cell 3 West	2,611	-11.6562	121	128.9435	278.2502	8	7.611	14.69	58451	0.02085	15.12	0.0728	1.5E-01	4.03	5.68	0.15
Amount of Vacuum Req. by blower			-15.6835														

PATH	2																
PATH DESCRIPTION	Flow from east half of Cell 2 combines with flow from Cells 1, 4, 5 & the east side of Cell 3 at point 6																
TOTAL FLOW	700																
TOTAL BRANCH FLOW	579																
OPERATIONS:	NORMAL																
SOUTH HEADER SIZE:	8																
TOTAL LINE LOSS, IN WC	13.80																
Station	Flow Description		Vacuum, Internal	Inlet Flow	Inlet Flow	Total flow	Pipe Size	Pipe Diameter	Pipe Velocity	Reynolds	friction	pressure, absolute	density, actual	section loss	section loss	total loss	total loss/100'
		Length	in w.c.	SCFM	ACFM	ACFM	in	in	fps	—	—	PSIA	lbm/ft^3	psi	inwc	in wc	in wc
Well 2-25 to tie-in	From Well 2-25	58	-10	2.60	2.781686	2.781686	2	1.93	2.28	2295	0.02788	15.06	0.0725	4.1E-04	0.01	0.01	0.02
Tie-In to Point 6	Cell 2 East	2775	-10.0114	94.00	100.5659	103.3476	8	7.611	5.45	21625	0.02540	15.06	0.0725	2.6E-02	0.72	0.73	0.03
Point 6 to Flare	Total less Cell 2 East, Cell 3 West	2013	-10.728	482.40	515.2107	618.5583	8	7.611	32.65	129650	0.01780	15.09	0.0726	4.7E-01	13.07	13.80	0.65
Amount of Vacuum Req. by blower			-23.8011														

PATH	3																
PATH DESCRIPTION	Flow from northern part of Cell 2, Cell 1 combine with the east side of Cell 3 and the west side of Cell 4 at point 4 and travels west of Cell 4. Flow from the north side of Cell 5, west side of Cell 2 and the north side of Cell 5 is added at Point 5. The flow from the east side of Cell 2 is combined at Point 6. Flow from the West side of Cell 3 is routed through Path 1.																
TOTAL FLOW	700																
TOTAL BRANCH FLOW	584.8																
OPERATIONS:	NORMAL																
SOUTH HEADER SIZE:	8																
TOTAL LINE LOSS, IN WC	23.87																
Station	Flow Description		Vacuum, Internal	Inlet Flow	Inlet Flow	Total flow	Pipe Size	Pipe Diameter	Pipe Velocity	Reynolds	friction	pressure, absolute	density, actual	section loss	section loss	total loss	total loss/100'
		Length	in w.c	SCFM	ACFM	ACFM	in	in	fps	--	--	PSIA	lbm/ft^3	psi	inwc	in wc	in wc
Well 2-24 to Tie-In	From Well 2-24	279	-10	2.60	2.781686	2.781686	2	1.93	2.28	2295	0.02788	15.06	0.0725	2.0E-03	0.05	0.05	0.02
			-10.0547	2.60	2.781321	5.563007	2	2.095	3.88	4229	0.03511	15.06	0.0725	0.0E+00	0.00	0.05	#DIV/0!
			-10.0547	2.60	2.781321	8.344329	2	2.095	5.81	6344	0.03240	15.06	0.0725	0.0E+00	0.00	0.05	#DIV/0!
Tie-In to Point 1	Cell 2 North	1182	-10.0547	64	68.4633	76.80763	8	7.611	4.05	16073	0.02694	15.06	0.0725	6.5E-03	0.18	0.23	0.02
Point 1 to Point 2	Cell 1	1542	-10.2335	73	78.05749	154.8651	8	7.611	8.17	32421	0.02344	15.07	0.0725	3.0E-02	0.83	1.06	0.05
Point 2 to Point 3		1340	-11.059	0	0	154.8651	8	7.611	8.17	32485	0.02343	15.10	0.0727	2.6E-02	0.72	1.78	0.05
Point 3 to Point 4		667	-11.7776	0	0	154.8651	8	7.611	8.17	32541	0.02342	15.13	0.0728	1.3E-02	0.36	2.14	0.05
Point 4 to Point 5, West	Cell 3 East, Cell 4 West	3013	-12.1357	123	130.9249	285.79	8	7.611	15.08	60103	0.02073	15.14	0.0729	1.8E-01	4.88	7.02	0.16
Point 5 to Point 6	Cell 2 West, Cell 4 East, Cell 5 North	835	-17.0177	190	199.9142	485.7042	8	7.611	25.63	103336	0.01862	15.31	0.0737	1.3E-01	3.55	10.57	0.43
Point 6 to Flare Station	Cell 2 East, Cell 5 South	2013	-20.5679	127	132.5178	618.222	8	7.611	32.63	132630	0.01772	15.44	0.0743	4.8E-01	13.31	23.87	[illegible]
Amount of Vacuum Req. by blower			-33.8741														

PATH	4
PATH DESCRIPTION	Flow from northern part of Cell 2, Cell 1 combine with all of Cell 4 and the west side of Cell 2 at point 4 and travels east of Cell 4. Flow from the north side of Cell 5 and the east side of Cell 3 are added in at Point 5. The flow from the east side of Cell 2 and the south side of Cell 5 is combined at Point 6. Flow from the West side of Cell 3 is routed through Path 1.
TOTAL FLOW	700
TOTAL BRANCH FLOW	584.8
OPERATIONS:	NORMAL
SOUTH HEADER SIZE:	8
TOTAL LINE LOSS, IN WC	28.32

Station	Flow Description		Vacuum, Internal	Inlet Flow	Inlet Flow	Total flow	Pipe Size	Pipe Diameter	Pipe Velocity	Reynolds	friction	pressure, absolute	density, actual	section loss	section loss	total loss	total loss/100'
		Length	in w.c	SCFM	ACFM	ACFM	in	in	fps	---	---	PSIA	lbm/ft^3	psi	inwc	in wc	in wc
Well 2-24 to Tie-In	From Well 2-24	279	-10	2.60	2.781686	2.781686	2	1.93	2.28	2295	0.02788	15.06	0.0725	2.0E-03	0.05	0.05	0.02
			-10.0547	2.60	2.781321	5.563007	2	2.095	3.88	4229	0.03511	15.06	0.0725	0.0E+00	0.00	0.05	#DIV/0!
			-10.0547	2.60	2.781321	8.344329	2	2.095	5.81	6344	0.03240	15.06	0.0725	0.0E+00	0.00	0.05	#DIV/0!
Tie-In to Point 1	Cell 2 North	279	-10.0547	64	68.4633	76.80763	8	7.611	4.05	16073	0.02694	15.06	0.0725	1.5E-03	0.04	0.10	0.02
Point 1 to Point 2	Cell 1	1182	-10.0969	73	78.08305	154.8907	8	7.611	8.17	32416	0.02344	15.06	0.0725	2.3E-02	0.63	0.73	0.05
Point 2 to Point 3		1542	-10.7295	0	0	154.8907	8	7.611	8.17	32465	0.02343	15.09	0.0726	3.0E-02	0.83	1.56	0.05
Point 3 to Point 4		667	-11.5559	0	0	154.8907	8	7.611	8.17	32529	0.02342	15.12	0.0728	1.3E-02	0.36	1.91	0.05
Point 4 to Point 5, East	Cell 4, Cell 2 West	2535	-11.914	279	297.1331	452.0238	8	7.611	23.86	95015	0.01893	15.13	0.0728	3.4E-01	9.38	11.29	0.37
Point 5 to Point 6	Cell 3 East, Cell 5 North	835	-21.2918	34	35.41728	487.441	8	7.611	25.73	104750	0.01857	15.47	0.0745	1.3E-01	3.60	14.89	0.43
Point 6 to Flare Station	Cell 2 East, Cell 5 South	2013	-24.8937	127	131.1911	618.6322	8	7.611	32.65	134060	0.01768	15.60	0.0751	4.8E-01	13.43	28.32	0.67
Amount of Vacuum Req. by blower			-38.3236														

PATH	1
PATH DESCRIPTION	Flow from northern part of Cell 2, Cell 1 and West side of Cell 3 flow through header west of Cell 3
TOTAL FLOW	597
TOTAL BRANCH FLOW	222
OPERATIONS:	NORMAL
SOUTH HEADER SIZE:	0
TOTAL LINE LOSS, IN WC	4.27

Station	Flow Description	Length	Vacuum, Internal	Inlet Flow	Inlet Flow	Total flow	Pipe Size	Pipe Diameter	Pipe Velocity	Reynolds	friction	pressure, absolute	density, actual	section loss	section loss	total loss	total loss/100'
		Length	in w.c	SCFM	ACFM	ACFM	in	in	fps	—	—	PSIA	lbm/ft^3	psi	inwc	in wc	in wc
Well 2-24 to Tie-In	From Well 2-24	279	-10	2.20	2.353734	2.353734	2	1.93	1.93	1942	0.03295	15.06	0.0725	1.7E-03	0.05	0.05	0.02
Tie-In to Point 1	Cell 2 North	1,182	-10.0462	55.00	58.83683	61.19057	8	7.611	3.23	12805	0.02818	15.06	0.0725	4.3E-03	0.12	0.16	0.01
Point 1 to Point 2	Cell 1	1,542	-10.165	62.00	66.30629	127.4969	8	7.611	6.73	26687	0.02436	15.07	0.0725	2.1E-02	0.58	0.75	0.04
Point 2 to Point 3		1,340	-10.7463		0	127.4969	8	7.611	6.73	26725	0.02435	15.09	0.0726	1.8E-02	0.51	1.25	0.04
Point 3 to Flare Station	Cell 3 West	2,611	-11.2522	103	109.8678	237.3646	8	7.611	12.53	49814	0.02152	15.11	0.0727	1.1E-01	3.02	4.27	0.12
Amount of Vacuum Req. by blower			-14.2745														

PATH	2																
PATH DESCRIPTION	Flow from east half of Cell 2 combines with flow from Cells 1, 4, 5 & the east side of Cell 3 at point 6																
TOTAL FLOW	597																
TOTAL BRANCH FLOW	494																
OPERATIONS:	NORMAL																
SOUTH HEADER SIZE:	8"																
TOTAL LINE LOSS, IN WC	10.36																
Station	**Flow Description**		**Vacuum, Internal**	**Inlet Flow**	**Inlet Flow**	**Total flow**	**Pipe Size**	**Pipe Diameter**	**Pipe Velocity**	**Reynolds**	**friction**	**pressure, absolute**	**density, actual**	**section loss**	**section loss**	**total loss**	**total loss/100'**
		Length	in w.c.	SCFM	ACFM	ACFM	in	in	fps	--	---	PSIA	lbm/ft^3	psi	inwc	in wc	in wc
Well 2-25 to tie -in	From Well 2-25	58	-10	2.20	2.353734	2.353734	2	1.93	1.93	1942	0.03295	15.06	0.0725	3.5E-04	0.01	0.01	0.02
Tie-In to Point 6	Cell 2 East	2775	-10.0098	80.00	85.58836	87.94209	8	7.611	4.64	18401	0.02623	15.06	0.0725	1.9E-02	0.54	0.55	0.02
Point 6 to Flare	Total less Cell 2 East, Cell 3 West	2013	-10.5454	411.46	439.6351	527.5772	8	7.611	27.84	110532	0.01837	15.08	0.0726	3.5E-01	9.81	10.36	0.49
Amount of Vacuum Req. by blower			20.3573														

PATH	3
PATH DESCRIPTION	Flow from northern part of Cell 2, Cell 1 combine with the east side of Cell 3 and the west side of Cell 4 at point 4 and travels west of Cell 4. Flow from the north side of Cell 5, west side of Cell 2 and the north side of Cell 5 is added at Point 5. The flow from the east side of Cell 2 is combined at Point 6. Flow from the West side of Cell 3 is routed through Path 1.
TOTAL FLOW	597
TOTAL BRANCH FLOW	499
OPERATIONS:	NORMAL
SOUTH HEADER SIZE:	8
TOTAL LINE LOSS, IN WC	17.94

Station	Flow Description		Vacuum, Internal	Inlet Flow	Inlet Flow	Total flow	Pipe Size	Pipe Diameter	Pipe Velocity	Reynolds	friction	pressure, absolute	density, actual	section loss	section loss	total loss	total loss/100'
		Length	in w.c	SCFM	ACFM	ACFM	in	in	fps	--	---	PSIA	lbm/ft^3	psi	inwc	in wc	in wc
Well 2-24 to Tie-In	From Well 2-24	279	-10	2.20	2.353734	2.353734	2	1.93	1.93	1942	0.03295	15.06	0.0725	1.2E-03	0.05	0.05	0.02
			-10.0462	2.20	2.353473	4.707207	2	2.095	3.28	3579	0.03630	15.06	0.0725	0.0E+00	0.00	0.05	#DIV/0!
			-10.0462	2.20	2.353473	7.060681	2	2.095	4.92	5368	0.03349	15.06	0.0725	0.0E+00	0.00	0.05	#DIV/0!
Tie-In to Point 1	Cell 2 North	1182	-10.0462	55	58.83683	65.89751	8	7.611	3.48	13790	0.02777	15.06	0.0725	4.9E-03	0.14	0.18	0.01
Point 1 to Point 2	Cell 1	1542	-10.182	62	66.30359	132.2011	8	7.611	6.98	27673	0.02418	15.07	0.0725	2.2E-02	0.62	0.80	0.04
Point 2 to Point 3		1340	-10.8027	0	0	132.2011	8	7.611	6.98	27714	0.02418	15.09	0.0726	1.9E-02	0.54	1.34	0.04
Point 3 to Point 4		667	-11.3427	0	0	132.2011	8	7.611	6.98	27750	0.02417	15.11	0.0727	9.7E-03	0.27	1.61	0.04
Point 4 to Point 5, West	Cell 3 East, Cell 4 West	3013	-11.6118	105	111.905	244.1061	8	7.611	12.88	51223	0.02140	15.12	0.0728	1.3E-01	3.67	5.28	0.12
Point 5 to Point 6	Cell 2 West, Cell 4 East, Cell 5 North	835	-15.2831	162	171.153	415.2591	8	7.611	21.92	87987	0.01922	15.25	0.0734	9.6E-02	2.67	7.95	0.32
Point 6 to Flare Station	Cell 2 East, Cell 5 South	2013	-17.9513	108	113.3859	528.645	8	7.611	27.90	112719	0.01830	15.35	0.0739	3.6E-01	9.99	17.94	0.50
Amount of Vacuum Req. by blower			-27.9387														

PATH	4
PATH DESCRIPTION	Flow from northern part of Cell 2, Cell 1 combine with all of Cell 4 and the west side of Cell 2 at point 4 and travels east of Cell 4. Flow from the north side of Cell 5 and the east side of Cell 3 are added in at Point 5. The flow from the east side of Cell 2 and the south side of Cell 5 is combined at Point 6. Flow from the West side of Cell 3 is routed through Path 1.
TOTAL FLOW	597
TOTAL BRANCH FLOW	499
OPERATIONS:	NORMAL
SOUTH HEADER SIZE:	8
TOTAL LINE LOSS, IN WC	21.21

Station	Flow Description		Vacuum, Internal	Inlet Flow	Inlet Flow	Total flow	Pipe Size	Pipe Diameter	Pipe Velocity	Reynolds	friction	pressure, absolute	density, actual	section loss	section loss	total loss	total loss/100'
		Length	in w.c	SCFM	ACFM	ACFM	in	in	fps	--	---	PSIA	lbm/ft^3	psi	inwc	in wc	in wc
Well 2-24 to Tie-In	From Well 2-24	279	-10	2.20	2.353734	2.353734	2	1.93	1.93	1942	0.03295	15.06	0.0725	1.7E-03	0.05	0.05	0.02
			-10.0462	2.20	2.353473	4.707207	2	2.095	3.28	3579	0.03630	15.06	0.0725	0.0E+00	0.00	0.05	#DIV/0!
			-10.0462	2.20	2.353473	7.060681	2	2.095	4.92	5368	0.03349	15.06	0.0725	0.0E+00	0.00	0.05	#DIV/0!
Tie-In to Point 1	Cell 2 North	279	-10.0462	55	58.83683	65.89751	8	7.611	3.48	13790	0.02777	15.06	0.0725	1.2E-03	0.03	0.08	0.01
Point 1 to Point 2	Cell 1	1182	-10.0783	62	66.32006	132.2176	8	7.611	6.98	27670	0.02419	15.06	0.0725	1.7E-02	0.48	0.55	0.04
Point 2 to Point 3		1542	-10.5539	0	0	132.2176	8	7.611	6.98	27701	0.02418	15.08	0.0726	2.2E-02	0.62	1.18	0.04
Point 3 to Point 4		667	-11.1751	0	0	132.2176	8	7.611	6.98	27742	0.02417	15.10	0.0727	9.7E-03	0.27	1.44	0.04
Point 4 to Point 5, East	Cell 4, Cell 2 West	2535	-11.4442	237	252.6866	384.9042	8	7.611	20.31	80814	0.01955	15.11	0.0728	2.5E-01	7.01	8.46	0.28
Point 5 to Point 6	Cell 3 East, Cell 5 North	835	-18.4579	30	31.4586	416.3628	8	7.611	21.98	88884	0.01918	15.37	0.0740	9.7E-02	2.70	11.16	0.32
Point 6 to Flare Station	Cell 2 East, Cell 5 South	2013	-21.1551	108	112.5378	528.9006	8	7.611	27.91	113623	0.01827	15.46	0.0744	3.6E-01	10.06	21.21	0.50
Amount of Vacuum Req. by blower			-31.2115														

4.0 FLARE STATION LOADING CONDITIONS

(95% SUBMITTAL)

4.1 Background/Statement of Problem

Due to the loads incurred by the Landfill Gas Operation Center (LOC), a site specific foundation must be designed. In order to accommodate the loadings of the flare station, an analysis of the loadings is performed.

4.2 Methodology

Listed below are the major flare system components contained within the LOC:

- Condensate Storage/Holding Tank (5400 gallon) (T-801 A/B).
- Back up generator (approx. 300 kW).
- Landfill Gas Blower Skid
- 450 standard cubic feet per minute (SCFM) John Zink ZULE Flare #2 (I-2).
- 250 SCFM John Zink ZULE Flare #1 (I-1).
- Flare Blowers.
- Compressors (CO/A and CO/B).

The storage condensate tank will hold approximately 5400 gallons of condensate collected from the Landfill Gas (LFG) system. A back up generator of approximately 300 kW will be installed for emergency operations of the LOC only. The condensate tank and generator full capacity loads will be considered in the analysis.

The LFG blower skid includes several units of operation for the LOC including two (2) Houston Service Industries (HSI) blowers, knock-out/filter vessel, and an electrical panel rack. The LFG blower skid is the second largest load bearing object of the LOC. Following the LFG blower skid in loadings, are the two (2) Zink Ultra Low Emission (ZULE) Flares. Flare #1 is, a five (5) feet in diameter by 40 feet tall, rated for 450 SCFM. Flare #2, also 40 feet tall, has a four (4) feet diameter. Directly piped to the two ZULE Flare Stations will be specifically sized combustion air blowers for each station per the specifications of John Zink Company LLC (John Zink), the maker of the ZULE flares and blower skid.

4.3 Assumptions and Inputs

- Storage Condensate Tank is calculated with inner and outer liner. Volume of tank at 93 inches is the maximum at 5,426 gallons. Water unit weight per gallon used was 8.34 lb / gal. Weights of tank and volume were taken from the 5,400 gallon Safe-Tank from Poly Processing Company (this tank or a similar product will be used).
- A generator of around 300 kW will be needed in case of emergency outages of the main power supply. For the considerations of loading the QAS 325 from Atlas Copco was used for its similar characteristics. The generator will be selected by contractor, but at a similar size.

- The LFG Blower Skid loads have been determined from prior blower skids used by BAS.
- John Zink Co. LLC recommends a 20 percent increase in dead load. This has been calculated into the loading table in section 4.4 (this consideration of the added weight applies to both the 250 SCFM and 450 SCFM Flares).
- The flare combustion air blowers for the flares were assumed to be the same mass as the HSI blowers used on the blower skid for a factor of safety (the flare combustion blowers are to be determined by the manufacturer).
- The compressor and back-up compressor used in the loading scenario were the 60Hz CSA/UL GA 30 from Atlas Copco. The full feature workplace weight was the considered loading.
- The knock-out/filter vessel (V-101) and the Pneumatic Diaphragm Pumps on the LFG Blower Skid were considered within the specified loading of the LFG Blower Skid

4.4 Calculations and Results

FLARE STATION LOADINGS			
ITEM	QTY	EACH (lb.)	TOTAL (lb.)
Generator	1	9,700	9,700
Water Tank (Full)	1	48,000	48,000
LFG Blower Skid	1	20,000	20,000
ZULE Flare			
250 scfm + 20%	1	10,200	10,200
450scfm +20%	1	12,600	12,600
Flare Combustion Blowers	2	1,000	2,000
Compressors	2	1,287	2,574

Total 105,074 Lb

FLARE STATION FACILITY DIMENSIONS				
ITEM	MODEL	LENGTH (ft.)	WIDTH (ft.)	HEIGHT (ft.)
Generator	Atlas Copco QAS 30	7.00	3.17	3.92
Water Tank (Full)	Poly Processing Co. Safe Tank 5400 gal	11.92 (diameter)	11.92 (diameter)	8.58
LFG Blower Skid	Various	See sheet FS01	See sheet FS01	See sheet FS01
Flare	John Zink Company LLC			
250 scfm + 20%	Zink Ultra Low Emission (ZULE) 250scfm	4.00 (diameter)	4.00 (diameter)	40.00
450scfm +20%	Zink Ultra Low Emission (ZULE) 450scfm	5.00 (diameter)	5.0 (diameter)	40.00
Flare Blowers	Houston Service Industries (HSI) 5105	6.33	2.58	2.58
Compressors	Atlas Copco GA 30 VSD	5.90	2.17	4.58

Note: To see approximate locations and features included on the LOC see the attached drawing labeled Flare Station Design Loadings; Landfill Operations Center Sheet FS01.

4.5 References

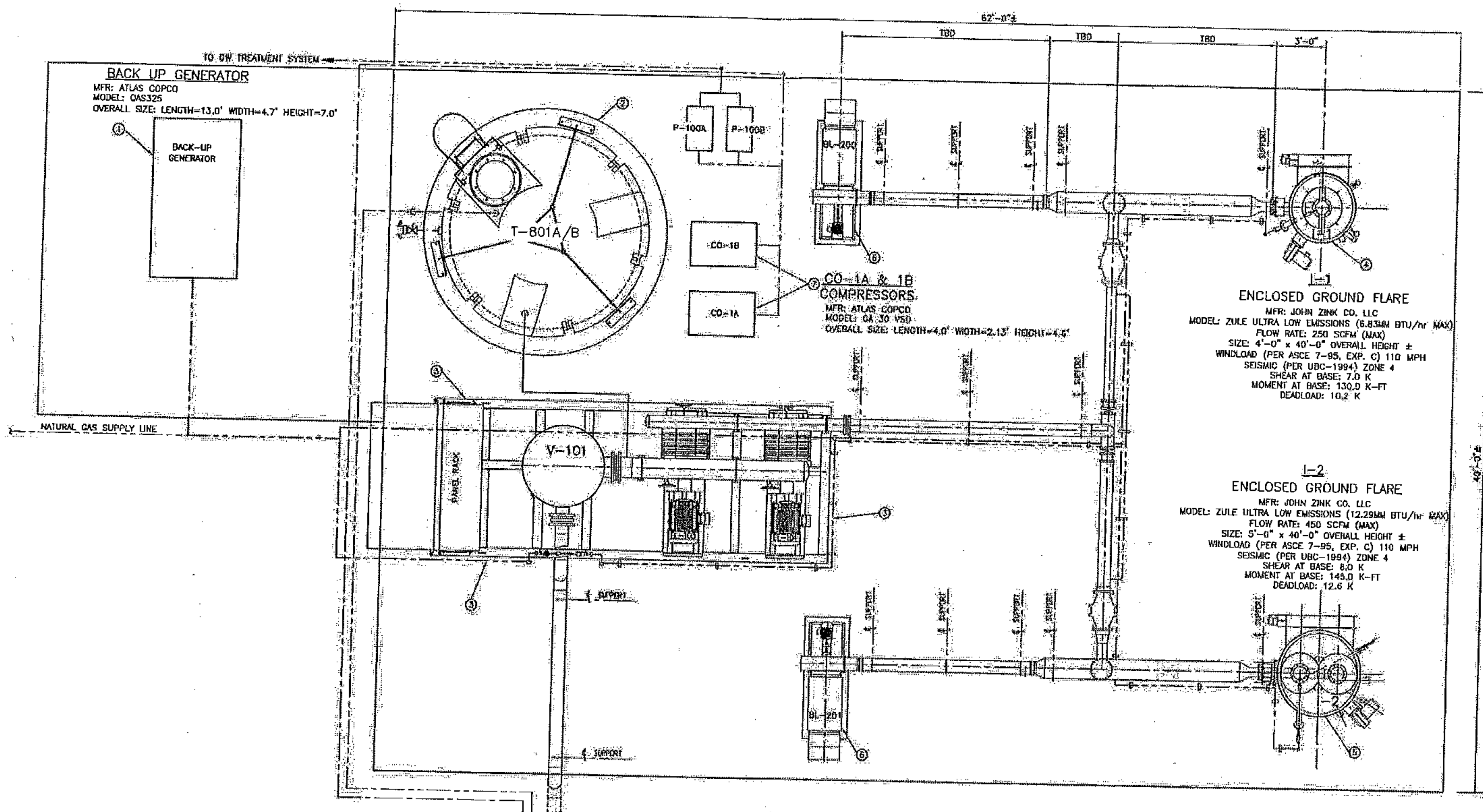
- Atlas Copco; http://productpagesct.atlascopco.com/ (Generator and Compressors)
- Houston Service Industries, Inc.; www.hsiblowers.com; 7901 Hansen Rd., Houston, TX 77061; Phone: 800-725-2291; E-mail: his@hsiblowers.com
- John Zink Company LLC; http://www.johnzink.com/products/flares/html/flar_prod_grf.htm; 11920 East Apache, Tulsa, OK 74116, United States of America; Phone: 1-918-234-1800
- Poly Processing Company; http://www.polyprocessing.com/html/safe-tanks.htm (Condensate tank)

4.6 Quality Control

Prepared By: Jason D. Wolf

Checked By: Jennifer Deguia

Approved By: ____________________
Mike Leonard, P.E.



FLARE STATION ASSEMBLY PLAN
NTS

1 / FS01

T-801A/B

CONDENSATE HOLDING TANK

MFR: POLY PROCESSING, INC
MODEL: 2005400/2106300
PRIMARY TANK CAPACITY: 5,400 GALLON WITH SECONDARY CONTAINMENT
OVERALL SIZE: 11'-11" O.D. X 9'-9" TALL
MATERIAL: HIGH DENSITY CROSS LINKED POLYETHYLENE
FITTINGS: 4-2" NPT FITTINGS ON TOP OF TANK TWO PRIMARY TANK DRAINS, SECONDARY CONTAINMENT TANK DRAIN, LADDER, SIGHT GLASS/LEVEL GAUGE, SEISMIC RESTRAINT SYSTEM

CONSTRUCTION NOTES:

	QTY.	LOAD (lb.)
(1) GENERATOR	1 (EA.)	10,700
(2) WATER TANK AT FULL CAPACITY	1 (EA.)	48,000
(3) LANDFILL GAS BLOWER SKID	1 (EA.)	20,000
(4) FLARE 250 SCFM	1 (EA.)	10,200
(5) FLARE 450 SCFM	1 (EA.)	12,600
(6) FLARE BLOWER (ESIMATION FROM PANEL RACK BLOWER)	2 (EA.)	1,000
(7) COMPRESSOR	2 (EA.)	1,300
	TOTAL:	106,100 lb.

GENERAL NOTES:

1. MANY OF THE COMPONENTS PROVIDED BY JOHN ZINK ARE SHIPPED LOOSE. THE CONTRACTOR SHALL PROVIDE FINAL ASSEMBLY, AS NEEDED, TO COMPLETE THE INSTALLATION AS SHOWN.

2. THE PIPING AND EQUIPMENT SHOWN IS SUBJECT TO CHANGE PENDING FINAL DESIGN BY JOHN ZINK COMPANY AND BAS.

DRAFT FOR REVIEW ONLY

REV NO.	DESCRIPTION	BY	DATE

FORMER CAL COMPACT LANDFILL
CARSON MARKETPLACE L.L.C.
AVALON AT SOUTH BAY

TETRA TECH, INC.

SCALE: NO SCALE
DATE: 08/2006

BAS
BRYAN A. STIRRAT & ASSOCIATES

AVALON AT SOUTH BAY
95% LANDFILL GAS SYSTEM DESIGN SUBMITTAL
FLARE STATION DESIGN LOADINGS
LANDFILL OPERATIONS CENTER

SHEET NUMBER
FS01

3.0 LANDFILL GAS CONDENSATE GENERATION ESTIMATE
(95% SUBMITTAL)

3.1 Background/Statement of Problem

Landfill gas is saturated with water vapor. As this gas flows from the waste prism to the flare station, it can cool considerably. When this saturated gas cools, the the amount of water vapor the gas can hold will drop, and the excess water vapor will condense and form landfill gas condensate. The condensate will flow by gravity to sumps located around the gas collection network then be pumped to a holding tank located at the Landfill Operations Center (LOC). The condensate will then be pumped to the liquids (ground water and condensate) treatment plant also located at the LOC. It is necessary to estimate the range of condensate expected for both sizing the holding tank and the pump rate to the liquids treatment plant.

3.2 Methodology

The amount of water vapor in the saturated gas at the well head was compared to the amount of water vapor in the saturated gas at the flare station. The difference of the two is the amount of water vapor which has condensed.

The first step is to calculate the percentage of water at the well head and at the flare station. The percentage is calculated as the ratio of the water vapor pressure to the operating pressure.

Knowing the percentage of water in the gas, the amount of dry gas at the well head can be calculated. (For the maximum case, the percentage water is calculated to be 8.63%; therefore the remaining portion, 91.37% of the gas flow is then "dry".) This amount of dry gas remains constant throughout the processing.

At Condition 2 the dry gas and the percentage of water is then known and the total flow can be calculated.

The difference between the total flow at Condition 1 and the total flow at Condition 2 is the water vapor which has condensed. The final step is to convert the water vapor to a liquid volume.

The calculation method for estimating condensate generation is as follows:

- Condition 1: Gas Temperature = 110 °F
  Gas Pressure = –1 Inch WC = 14.66 PSIA
- Condition 2: Gas Temperature = 55 °F
  Gas Pressure = –100 Inch WC = 11.09 PSIA

The following were calculated for both conditions:

- Partial pressure of Water in the Gas [PSI] (See attached spreadsheet for equation and calculation)
- Percent Water in the Gas $= \frac{PartialPressure_{WaterinGas}}{GasPressure} x100$

The following equations were used:

- In order to determine the outlet gas flow rate, we calculated the Dry gas flow rate [SCFM], $Q_{dry} = Q_{wellhead} * (1 - \%Water_{wellhead})$
- Outlet gas flow rate [SCFM], $Q_{flare} = \frac{Q_{dry}}{(1 - \%Water_{flare})}$
- The outlet gas flow rate was used to calculate the Water formation rate [SCFM], $= Q_{wellhead} - Q_{flare}$
- Water formation rate [GPH],

$$= (Q_{wellhead} - Q_{flare})\left[\frac{ft^3}{\min}\right] * \left(\frac{1lbmole}{379.3 ft^3} * \frac{60\min}{1hr} * \frac{18 lbm}{1lbmole} * \frac{1gal}{8.33 lbm}\right)$$

Two cases are addressed, i.e., the maximum gas flow rate expected (700 scfm) and an average flow rate (300 scfm). As discussed in Section 1.0, Landfill Gas Design Flow Rate, the 700 scfm was selected to attempt to account for a potential high gas recovery rate during the early years of operation of the gas collection system (the "worst case scenario) while a more likely average flow rate over the life of the system is 300 scfm as indicated by the LandGem Model results and experience.

3.3 Assumptions and Inputs

- LFG is saturated.
- LFG temperature in the landfill averages 110 degrees F.
- Ambient temperatures in the ground around the LFG header is 55 degrees F.
- Pressure drop is from -1inWC to -100 inWC as the gas moves from the well to the header.

3.4 Calculations and Results

See attached spreadsheets for the estimates.

A holding tank volume of 5,400 gallons is recommended as this would accommodate about 14 days of storage should the liquids treatment plant be inoperable.

A continuous pump rate to the liquids treatment plant averaging 400 GPD would be adequate for the worst case condition. It is more plausible that the pumping occur say 3 times per day for 1 hour duration giving:

$$\text{Pump rate, [GPM]} = \frac{400\left[{}^{gal}\!/_{day}\right]}{3*60\left[{}^{\min_{pumping}}\!/_{day}\right]} = 2.22 \sim 2-3$$

3.5 References

- Bryan A. Stirrat & Associates. Submittal of 75% Landfill Gas System Design. April 23, 2008.

3.6 Quality Control

Prepared By: Jennifer Deguia

Checked By: Keith Johnson

Approved By: Michael Leonard, P.E.

THE BOULEVARDS AT SOUTH BAY, LLC

APPENDIX 2

SCAQMD FORM 400-A
APPLICATION FOR PERMIT TO CONSTRUCT
AND PERMIT TO OPERATE

South Coast Air Quality Management District

Form 400-A

Application For Permit To Construct and Permit To Operate

Mail Application To:
P.O. Box 4944
Diamond Bar, CA 91765

Tel: (909) 396-3385
www.aqmd.gov

Section A: Operator Information

1. Business Name of Operator To Appear On The Permit: Tetra Tech Inc.

2. Valid AQMD Facility ID (Available on Permit or Invoice issued by AQMD): 151271

3. Owner's Business Name (only if different from Business Name of Operator):

Section B: Equipment Location

4. Equipment Location Address:
For equipment operated at various locations in AQMD's jurisdiction, provide address of initial site

20400 Main Street
Street Address

Carson, CA, 90745
City, State, Zip Code

County: (•) Los Angeles ( ) Orange ( ) San Bernardino ( ) Riverside

Contact Name: Javier Weckmann

Contact Title: Vice President Phone: (310) 965-0137

Fax: (310) 965-0273 E-Mail: javier.weckmann@tetratech

Section C: Permit Mailing Address

5. Permit and Correspondence Information:
[X] Check here if same as equipment location address

Street Address

City, State, Zip Code

Contact Name:

Contact Title: Phone:

Fax: E-Mail:

Section D: Application Type

The facility is in ( ) RECLAIM ( ) Title V ( ) RECLAIM & Title V Program (please check if applicable)

6. Reason for Submitting Application (Select only ONE):

- (•) New Construction (Permit to Construct)
- ( ) Equipment Operating Without A Permit or Expired Permit*
- ( ) Administrative Change
- ( ) Equipment On-Site But Not Constructed or Operational
- ( ) Title V Application (Initial, Revisions, Modifications, etc.)
- ( ) Compliance Plan
- ( ) Facility Permit Amendment
- ( ) Registration/Certification
- ( ) Streamlined Standard Permit
- ( ) Permitted Equipment Altered/ Modified Without Permit Approval*
- ( ) Proposed Alteration/Modification to Permitted Equipment
- ( ) Change of Condition For Permit To Operate
- ( ) Change of Condition For Permit To Construct
- ( ) Change of Location—Moving to New Site

Existing Or Previous Permit/Application Number:
(If you checked any of the items in this column, you MUST provide a existing Permit/ Application Number)

* A Higher Permit Processing Fee applies to those items with an asterisk (Rule 301 (c) (1) (D)

7. Estimated Start Date of Operation/Construction (MM/DD/YYYY): 01/19/2009

8. Description of Equipment:
Blower and enclosed ground flare for combustion of landfill gas extracted from the former Cal Compact landfill. System includes 2 flares, one 250 scfm and one 450 scfm to provide range of coverage. A separate application is provided for each flare. See attached documents for more detail.

9. Is this equipment portable AND will it be operated at different locations within AQMD's jurisdiction? (•) No ( ) Yes

10. For identical equipment, how many additional applications are being submitted with this application? (Form 400-A required for each)

11. Are you a Small Business as per AQMD's Rule 102 definition? (10 employees or less and total gross receipts are $500,000 or less, or a not-for-profit training center?) (•) No ( ) Yes

12. Has a Notice of Violation (NOV) or a Notice To Comply (NC) been issued for this equipment? (•) No ( ) Yes If yes, provide NOV/NC #:

Section E: Facility Business Information

13. What type of business is being conducted at this equipment location? vacant landfill being develped for commercial and res.

14. What is your businesses primary NAICS Code (North American Industrial Classification System)? N/A

15. Are there other facilities in the SCAQMD jurisdiction operated by the same operator? (•) No ( ) Yes

16. Are there any schools (K-12) within a 1000-ft. radius of the equipment physical location? (•) No ( ) Yes

Section F: Authorization/Signature

I hereby certify that all information contained herein and information submitted with this application is true and correct.

17. Signature of Responsible Official:

18. Title: Vice President

19. Print Name: Javier Weckmann

20. Date: 09/09/2008

Check List
- [X] Form(s) signed and dated by authorized official
- [X] Supplemental Equipment Form (400-E-XX or 400-E-GEN)
- [X] CEQA Form (400-CEQA) attached
- [X] Payment for permit processing fee attached

Your application will be rejected if any of the above items are missing.

AQMD USE ONLY	APPLICATION/TRACKING #	TYPE B C D	EQUIPMENT CATEGORY CODE:	FEE SCHEDULE: $	VALIDATION
ENG. A R DATE	ENG. A R DATE	CLASS I III IV	ASSIGNMENT Unit Engineer	CHECK/MONEY ORDER #	AMOUNT $	Tracking #

THE BOULEVARDS AT SOUTH BAY, LLC

APPENDIX 3

SCAQMD FORM 400-CEQA
CALIFORNIA ENVIRONMENTAL QUALITY ACT APPLICABILITY

South Coast Air Quality Management District

Form 400–CEQA

California Environmental Quality Act (CEQA) Applicability

Mail Application To:
P.O. Box 4944
Diamond Bar, CA 91765

Tel: (909) 396-3385

www.aqmd.gov

The SCAQMD is required by state law, the California Environmental Quality Act (CEQA), to review discretionary permit project applications for potential air quality and other environmental impacts. This form is a screening tool to assist the SCAQMD in clarifying whether or not the project[1] has the potential to generate significant adverse environmental impacts that might require preparation of a CEQA document [CEQA Guidelines §15060(a)].[2] Refer to the attached instructions for guidance in completing this form.[3] For each Form 400-A application, also complete and submit one Form 400-CEQA. If submitting multiple Form 400-A applications for the same project at the same time, only one 400-CEQA form is necessary for the entire project. If you need assistance completing this form, contact Lori Inga at (909) 396-3109.

FACILITY INFORMATION

Business Name of Operator to Appear on the Permit:	Facility ID (6-Digit):
Tetra Tech, Inc.	151271

Project Description:

Flare Facility for Landfill Gas Treatment

REVIEW FOR EXEMPTION FROM FURTHER CEQA ACTION

Check "Yes" or "No" as applicable

	Yes	No	Is this application for:
A.	◉	○	**A CEQA and/or NEPA document previously or currently prepared that specifically evaluates this project?** If yes, a permit cannot be issued until a Final CEQA document and Notice of Determination is submitted.
B.	○	◉	**A request for a change of permittee only (without equipment modifications)?**
C.	○	◉	**Equipment certification or equipment registration** (qualifies for Rule 222)?
D.	○	◉	**A functionally identical permit unit replacement with no increase in rating or emissions?**
E.	○	◉	**A change of daily VOC permit limit to a monthly VOC permit limit?**
F.	○	◉	**Equipment damaged as a result of a disaster during state of emergency?**
G.	○	◉	**A Title V** (i.e., Regulation XXX) **permit renewal (without equipment modifications)?**
H.	○	◉	**A Title V administrative permit revision?**
I.	○	◉	**The conversion of an existing permit into an initial Title V permit?**

If **"Yes"** is checked for any question above, your application does not require additional evaluation for CEQA applicability. Skip to page 2, "SIGNATURES" and sign and date this form.

REVIEW OF IMPACTS WHICH MAY TRIGGER CEQA

Complete Sections I-VI by checking "Yes" or "No" as applicable. To avoid delays in processing your application(s), explain all "Yes" responses on a separate sheet and attach it to this form.

	Yes	No	Section I – General
1.	○	○	**Has this project generated any known public controversy regarding potential adverse impacts that may be generated by the project?** Controversy may be construed as concerns raised by local groups at public meetings; adverse media attention such as negative articles in newspapers or other periodical publications, local news programs, environmental justice issues, etc.
2.	○	○	**Is this project part of a larger project?**
			Section II – Air Quality
3.	○	○	**Will there be any demolition, excavating, and/or grading construction activities that encompass an area exceeding 20,000 square feet?**
4.	○	○	**Does this project include the open outdoor storage of dry bulk solid materials that could generate dust?** If Yes, include a plot plan with the application package.

[1] A "project" means the whole of an action which has a potential for resulting in physical change to the environment, including construction activities, clearing or grading of land, improvements to existing structures, and activities or equipment involving the issuance of a permit. For example, a project might include installation of a new, or modification of an existing internal combustion engine, dry-cleaning facility, boiler, gas turbine, spray coating booth, solvent cleaning tank, etc.
[2] To download the CEQA guidelines, visit http://ceres.ca.gov/env_law/state.html.
[3] To download this form and the instructions, visit http://www.aqmd.gov/ceqa or http://www.aqmd.gov/permit

	Yes	No	
5.	◌	◌	**Would this project result in noticeable off-site odors from activities that may not be subject to SCAQMD permit requirements?** For example, compost materials or other types of greenwaste (i.e., lawn clippings, tree trimmings, etc.) have the potential to generate odor complaints subject to Rule 402 – Nuisance.
6.	◌	◌	**Does this project cause an increase of emissions from marine vessels, trains and/or airplanes?**
7.	◌	◌	**Will the proposed project increase the QUANTITY of hazardous materials stored aboveground onsite or transported by mobile vehicle to or from the site by greater than or equal to the amounts associated with each compound on the attached Table 1?**[4]
			Section III – Water Resources
8.	◌	◌	**Will the project increase demand for water at the facility by more than 5,000,000 gallons per day?** The following examples identify some, but not all, types of projects that may result in a "yes" answer to this question: 1) projects that generate steam; 2) projects that use water as part of the air pollution control equipment; 3) projects that require water as part of the production process; 4) projects that require new or expansion of existing sewage treatment facilities; 5) projects where water demand exceeds the capacity of the local water purveyor to supply sufficient water for the project; and 6) projects that require new or expansion of existing water supply facilities.
9.	◌	◌	**Will the project require construction of new water conveyance infrastructure?** Examples of such projects are when water demands exceed the capacity of the local water purveyor to supply sufficient water for the project, or require new or modified sewage treatment facilities such that the project requires new water lines, sewage lines, sewage hook-ups, etc.
			Section IV – Transportation/Circulation
10.			**Will the project result in** (Check all that apply):
	◌	◌	**a. the need for more than 350 new employees?**
	◌	◌	**b. an increase in heavy-duty transport truck traffic to and/or from the facility by more than 350 truck round-trips per day?**
	◌	◌	**c. increase customer traffic by more than 700 visits per day?**
			Section V – Noise
11.	◌	◌	**Will the project include equipment that will generate noise GREATER THAN 90 decibels (dB) at the property line?**
			Section VI – Public Services
12.			**Will the project create a permanent need for new or additional public services in any of the following areas** (Check all that apply):
	◌	◌	**a. Solid waste disposal?** Check "No" if the projected potential amount of wastes generated by the project is less than five tons per day.
	◌	◌	**b. Hazardous waste disposal?** Check "No" if the projected potential amount of hazardous wastes generated by the project is less than 42 cubic yards per day (or equivalent in pounds).

REMINDER: *For each "Yes" checked in the sections above, attach all pertinent information including but not limited to estimated quantities, volumes, weights, etc.*

SIGNATURES

I HEREBY CERTIFY THAT ALL INFORMATION CONTAINED HEREIN AND INFORMATION SUBMITTED WITH THIS APPLICATION IS TRUE AND CORRECT TO THE BEST OF MY KNOWLEDGE. I UNDERSTAND THAT THIS FORM IS A SCREENING TOOL AND THAT THE SCAQMD RESERVES THE RIGHT TO CONSIDER OTHER PERTINENT INFORMATION IN DETERMINING CEQA APPLICABILITY.

SIGNATURE OF RESPONSIBLE OFFICIAL OF FIRM:	**TITLE OF RESPONSIBLE OFFICIAL OF FIRM:** Vice President	
TYPE OR PRINT NAME OF RESPONSIBLE OFFICIAL OF FIRM: Javier Weckmann	**RESPONSIBLE OFFICIAL'S TELEPHONE NUMBER:** (310) 9650-137	**DATE Signed:** 09/09/2008
SIGNATURE OF PREPARER, IF PREPARED BY PERSON OTHER THAN RESPONSIBLE OFFICIAL OF FIRM: Michael L. Leonard, Sr.	**TITLE OF PREPARER:** Senior Project Manager	
TYPE OR PRINT NAME OF PREPARER: Michael L. Leonard, Sr. P.E.	**PREPARER'S TELEPHONE NUMBER:** (909) 8607-777	**DATE Signed:** 09/09/2008

THIS CONCLUDES FORM 400-CEQA. INCLUDE THIS FORM AND THE ATTACHMENTS WITH FORM 400-A.

[4] Table 1 – Regulated Substances List and Threshold Quantities for Accidental Release Prevention can be found in the Instructions for Form 400-CEQA.

DEPARTMENT OF TOXIC SUBSTANCES CONTROL
Region 4
245 West Broadway, Suite 425
Long Beach, CA 90802-4444

SUPPLEMENTAL NEGATIVE DECLARATION for

CAL COMPACT LANDFILL UPPER OPERABLE UNIT 20400 South Main Street Carson, California 90745

PROJECT PROPONENT:

Department of Toxic Substances Control
245 West Broadway, Suite 350
Long Beach, California 90802-4444

Contact: Thomas M. Cota (310) 590-4898

PROJECT DESCRIPTION:

BKK Corporation is requesting approval of a draft Remedial Action Plan (RAP) for the Cal Compact Landfill Upper Operable Unit from the Department of Toxic Substances Control (DTSC). This draft RAP is in accordance with Section 25356.1 of the California Health and Safety Code, and Subpart E of the National Oil and Hazardous Substances Pollution Contingency Plan, 40 Code of Federal Regulations 300.400 et seq. DTSC is acting as a Responsible Agency as that term is defined in the California Code of Regulations, Title 14, Section 15381.

The proposed project for which DTSC is acting on addresses the construction and operation of a landfill gas collection and treatment system and a groundwater treatment system. The construction of the landfill cover is not addressed in this document, however, it was addressed in the City of Carson's EIR for the Metro 2000 project. DTSC as a Responsible Agency has carefully reviewed the Final EIR entitled Final Project and Program Environmental Impact Report, MetroMall 2000, dated December 1993. DTSC, using its independent judgement, found that (a) the EIR for the Metro 2000 project adequately complied with the provisions of the California Environmental Quality Act, (b) adequately addressed the proposed construction of the landfill cover, and (c) is adequate for DTSC to assess potential impacts for the Remedial Action Plan. DTSC, after reviewing the Final EIR, concurred with the finding of the City of Carson. DTSC drafted a Statement of Overriding Conditions addressing significant impacts that were not feasibly mitigated to a level of insignificance with the mitigation measures found in the EIR.

The project objectives for this project is to reduce or eliminate the potential threat to human health and the environment. The project objectives for the contaminated groundwater in the Bellflower Aquitard are (1) limit production of leachate through control of surface water infiltration to minimize impact to groundwater, (2) control and prevent off-site migration of groundwater contaminated from waste in the saturated zone, and (3) draw back and contain the contaminant plume that is now off-site. The project objectives for the landfill gases are (1) control production of landfill gases through control of surface water infiltration and (2) control or prevent off-site migration of landfill gases and future releases of landfill gases to the atmosphere under proposed land use scenarios.

The landfill gas system will consist of a series of vertical extraction wells installed at the perimeter of the waste zone. The extraction wells will be connected by HDPE conveyance piping to a landfill flare. The collected landfill gasses will be transported through the series of pipes to the flare for thermal destruction. The landfill gas flare will be one unit with a maximum 750 cfm capacity.

In 1990, a vapor monitoring event was conducted at the project site. Two Calderon compounds were detected during the sampling event. Calderon compounds are chemicals established in California as indicators for hazardous waste landfills. Analytical results from five vadose wells detected vinyl chloride in concentrations ranging form 2 ppm (parts per million) to 20.5 ppm and benzene from 1.4 ppm to 8.8 ppm. Methane, a non-Calderon compound, was detected in the range of 26.7% to 64.4%. Other non-Calderon compounds detected included ethylbenzene, toluene, xylene and dichlorodifluoromethane.

Extraction wells will be installed using standard drilling practices such as a hollow stem auger drill rig. The design of the system shall be developed by a registered California civil engineer, submitted to DTSC for review and approval. A

Department approved quality control/quality assurance program shall be strictly followed by the contractors.

The proposed groundwater treatment system consists of a series of groundwater extraction wells installed along the western and southern portions of the project site. The groundwater extraction wells will be installed in the Bellflower Aquitard saturated zone. The groundwater collection and treatment system will be designed to contain contaminated groundwater migrating from the Bellflower Aquitard beneath the site and to capture contaminated groundwater off-site in the Bellflower Aquitard.

The remedial investigation identified groundwater contamination in the Bellflower Aquitard. Volatile organic compounds, semi-volatile organic compounds, and heavy metals were detected in the groundwater in the Bellflower Aquitard. The remedial investigation also concluded that some off-site contamination has occurred. The proposed groundwater collection and treatment system will control and contain both on-site and off-site contamination.

The groundwater system includes extraction wells, associated piping, dedicated wells pumps, a water equalization tank, filters, precipitation and clarification units, carbon absorbers units, and a final polishing filter unit.

The treated groundwater will be used for on-site irrigation, or discharged to the sewer system or storm drain system. The system is anticipated to treat approximately 100 to 150 gallons per minute.

PROJECT LOCATION DESCRIPTION:

The Cal Compact Landfill (the Site) is located at 20400 Main Street in the City of Carson, County of Los Angeles, California. The Site is located in the western portion of the City of Carson. It is bounded by Del Amo Boulevard to the north, the San Diego Freeway (I-405) to the east with the Dominguez Channel located just east of the San Diego Freeway (I-405), the Torrrance Lateral Channel to the south with residential development just south of the Torrance Lateral Channel, and Main Street and residential development on the west. The primary freeway access to the Site is by means of the Main Street ramps to the San Diego Freeway (I-405) and the Torrance Boulevard ramps to the Harbor Freeway (I-110). The Site is located within the City of Carson's Redevelopment Project Area No. 1.

FINDINGS OF SIGNIFICANT EFFECT ON ENVIRONMENT:

DTSC has determined that the project will not have a significant effect on the environment as that term is defined in the Public Resources Code Section 21068.

A copy of the Initial Study which supports this finding is attached.

MITIGATION MEASURES:

No mitigation measures have been proposed for this project.

Signature: Thomas M Cota　　　Date: 10/25/95
Thomas M. Cota, Project Manager

Signature: Hamid Saebfar　　　Date: 10/25/95
Hamid Saebfar, Chief
Site Mitigation Cleanup Operations
Southern California Branch

DEPARTMENT OF TOXIC SUBSTANCES CONTROL
Region 4
245 West Broadway, Suite 425
Long Beach, CA 90802-4444

Supplemental Negative Declaration Approval

Project Title:

Cal Compact Landfill, Remedial Action Plan, Upper Operable Unit

State Clearinghouse Number:

95081061

Contact Person and Telephone:

Thomas M. Cota - (310) 590-4898

Project Location:

20400 Main Street, City of Carson, County of Los Angeles, State of California

Project Description:

BKK Corporation is requesting approval of a draft Remedial Action Plan (RAP) for the Cal Compact Landfill Upper Operable Unit from the Department of Toxic Substances Control (DTSC). This draft RAP is in accordance with Section 25356.1 of the California Health and Safety Code, and Subpart E of the National Oil and Hazardous Substances Pollution Contingency Plan, 40 Code of Federal Regulations 300.400 et seq. DTSC is acting as a Responsible Agency as that term is defined in the California Code of Regulations, Title 14, Section 15381.

The proposed project for which DTSC is acting on addresses the construction and operation of a landfill gas collection and treatment system and a groundwater treatment system. The construction of the landfill cover is not addressed in this document, however, it was addressed in the City of Carson's EIR for the Metro 2000 project. DTSC as a Responsible Agency has carefully reviewed the Final EIR entitled Final Project and Program Environmental Impact Report, MetroMall 2000, dated December 1993. DTSC, using its independent judgement, found that (a) the EIR for the Metro 2000 project adequately complied with the provisions of the California Environmental Quality Act, (b) adequately addressed the proposed construction of the landfill cover, and (c) is adequate for DTSC to assess potential impacts for the Remedial Action Plan. DTSC, after reviewing the Final EIR, concurred with the finding of the City of Carson. DTSC drafted a Statement of Overriding Conditions addressing significant impacts that were not feasibly mitigated to a level of insignificance with the mitigation measures found in the EIR.

The project objectives for this project is to reduce or eliminate the potential threat to human health and the environment. The project objectives for the contaminated groundwater in the Bellflower Aquitard are (1) limit production of leachate through control of surface water infiltration to minimize impact to groundwater, (2) control and prevent off-site migration of groundwater contaminated from waste in the saturated zone, and (3) draw back and contain the contaminant plume that is now off-site. The project objectives for the landfill gases are (1) control production of landfill gases through control of surface water infiltration and (2) control or prevent off-site migration of landfill gases and future releases of landfill gases to the atmosphere under proposed land use scenarios.

The landfill gas system will consist of a series of vertical extraction wells installed at the perimeter of the waste zone. The extraction wells will be connected by HDPE conveyance piping to a landfill flare. The collected landfill gasses will be transported through the series of pipes to the flare for thermal destruction. The landfill gas flare will be one unit with a maximum 750 cfm capacity.

In 1990, a vapor monitoring event was conducted at the project site. Two Calderon compounds were detected during the sampling event. Calderon compounds are chemicals established in California as indicators for hazardous waste landfills. Analytical results from five vadose wells detected vinyl chloride in concentrations ranging form 2 ppm (parts per million) to 20.5 ppm and benzene from 1.4 ppm to 8.8 ppm. Methane, a non-Calderon compound, was detected in the range of 26.7% to 64.4%. Other non-Calderon compounds detected included ethylbenzene, toluene, xylene and dichlorodifluoromethane.

Extraction wells will be installed using standard drilling practices such as a hollow stem auger drill rig. The design of the system shall be developed by a registered California civil engineer, submitted to DTSC for review and approval. A Department approved quality control/quality assurance program shall be strictly followed by the contractors.

The proposed groundwater treatment system consists of a series of groundwater extraction wells installed along the western and southern portions of the project site. The groundwater extraction wells will be installed in the Bellflower Aquitard saturated zone. The groundwater collection and treatment system will be designed to contain contaminated groundwater migrating from the Bellflower Aquitard beneath the site and to capture contaminated groundwater off-site in the Bellflower Aquitard.

The remedial investigation identified groundwater contamination in the Bellflower Aquitard. Volatile organic compounds, semi-volatile organic compounds, and heavy metals were detected in the groundwater in the Bellflower Aquitard. The remedial investigation also concluded that some off-site contamination has occurred. The proposed groundwater collection and treatment system will control and contain both on-site and off-site contamination.

The groundwater system includes extraction wells, associated piping, dedicated wells pumps, a water equalization tank, filters, precipitation and clarification units, carbon absorbers units, and a final polishing filter unit.

The treated groundwater will be used for on-site irrigation, or discharged to the sewer system or storm drain system. The system is anticipated to treat approximately 100 to 150 gallons per minute.

Project Approval:

DTSC of Toxic Substances Control has found on the basis of the Initial Study and the Supplemental Negative Declaration that there is no substantial evidence that the construction and operation of the landfill gas collection and treatment system and the groundwater treatment system will have a significant effect on the environment.

I hereby approve the Supplemental Negative Declaration for this project.

Signature: ______________________ Date: 10/23/95

Hamid Saebfar, Chief
Site Mitigation Cleanup Operations
Southern California Branch

THE BOULEVARDS AT SOUTH BAY, LLC

APPENDIX 4

SCAQMD FORM 400-E-2-C
GASEOUS EMISSION CONTROL FORM FLARE 450 SCFM

South Coast Air Quality Management District

FORM 400-E-2c
GASEOUS EMISSION CONTROL FORM
FLARE

Mail Application To:
SCAQMD
P.O. Box 4944
Diamond Bar, CA 91765
Tel: (909) 396-3385
www.aqmd.gov

This form must be accompanied by a completed Application for a Permit to Construct/Operate -Form 400A, Form CEQA, Plot Plan and Stack Form

Permit to be issued to (Business name of operator to appear on permit):

Tetra Tech, Inc.

Address where the equipment will be operated (for equipment which will be moved to various location in AQMD's jurisdiction, please list the initial location site):

20400 Main Street, Carson, CA 90745 — ⦿ Fixed Location ○ Various Locations

SECTION A: EQUIPMENT DESCRIPTION

Equipment	Manufacturer: John Zink Co., LLC	Model No: FBFZULE050x40LFBSKD	Make: Z.U.L.E
Type	○ Elevated ⦿ Ground Level ○ Pit	How Is Flare Assisted?	⦿ Air Assisted ○ Steam Assisted ○ Non-Assisted
Operation (See Rule 1118 for definition)	○ Clean Service Flare	○ Emergency Service Flare	⦿ General Service Flare
Dimension	Flare Height 40.00 ft.	Flare Tip Inside Diameter 5.00 ft.	

Design Criteria for Waste Gas Stream

Retention Time at Normal Operating Temperature: 0.7 secs at 1600.0 °F

Combustion Chamber Volume: 580.00 cubic feet

Design Waste Stream Flow: 450.000 scfm

Btu: 455

	Minimum	Maximum
Velocity At Tip (Feet per Second)	3.000	45.000
Flow Rate (scfm)	90.000	450.000

For Steam Injection

Steam Pressure(psig) Minimum	Steam Pressure(psig) Maximum

Design Basis for Steam Injected (lb steam/lb hydrocarbons): ______

Total Steam Flow rate (pounds/hour): ______ Number of Jets: ______

Temperature: ______ Diameter of Jets: ______ (inches) Velocity (Feet per Second): ______

For Water Injection

Water Pressure (psig) Minimum	Water Pressure (psig) Maximum	Total Water Flow rate (gpm) Minimum	Total Water Flow rate (gpm) Maximum

Number of Water ______

Diameter of Water Jets: ______ (inches)

Auxiliary Fuel Data

Auxiliary Fuel Available? ⦿ Yes ○ No If yes, indicate Natural Gas or propane

Number of Pilots: 1 Fuel Rate (scfm [70 °F & 14.7psia) per pilot: 2700.000

Fuel Usage (Select One):	Maximum	Minimum	Average
○ Cubic Feet/Hour OR ○ Gallons/Hour			

SECTION B: WASTE GAS STREAM CHARACTERISTICS

Brief Description of Process

Describe equipment vented to this Flare. Also describe the type of ignition system and its method of operation. Provide an explanation of the control system for steam flow and rate and other operating variables. Please supply an assembly drawing, dimensioned to scale, to show clearly the operation of the flare system. Show interior dimensions and features of the equipment necessary to calculate its performance.

Landfill gas is vented to the flare. The flare ignition is by natural gas or propane pilot. A complete electronic control package is included to start and stop the flare combustion, control the air inlet settings and thereby maintain the required retention time and temperature. See the attached documents for complete details.

Waste Gas Stream

Material	Flow rate scfm (70 F & 14.7 psia) Minimum	Average	Maximum	Btu Rating
Landfill Gas	90.000	200.000	450.000	12

Instrumentation Data

Describe instrumentation data for measuring temperature, pressure drop and other operating parameters (attach description, if necessary).

A total of ~~four~~ 3 thermocouples (at various elevations) will be installed in the flare stack to monitor the combustion temperature and to provide information to the temperature controller, which modulates the combustion air dampers to maintain the pre-selected flare temperature. Three thermocouples will be installed along the length of the stack, which will be selectable. This will allow the site engineer to select the most appropriate thermocouple elevation based on the flow of LFG at that time. One thermocouple will be used for high temperature control.

Additional detail is provided in the attached documents.

Operating Schedule

Normal: 24 hours/day 7 days/week 52 weeks/yr

Maximum: ____ hours/day ____ days/week ____ weeks/yr

SECTION C: APPLICANT CERTIFICATION STATEMENT

I hereby certify that all information contained herein and information submitted with this application is true and correct.

SIGNATURE OF PREPARER:	TITLE OF PREPARER:	PREPARER'S TELEPHONE NUMBER: (909) 860-7777
Michael L. Leonard, Jr.	Sr. Project Manager	PREPARER'S E-MAIL ADDRESS: mlleonar@bas.com

CONTACT PERSON FOR INFORMATION ON THIS EQUIPMENT:	CONTACT PERSON'S		DATE SIGNED:
Clara Rowden	TELEPHONE NUMBER:	(918) 234-2801	
E-MAIL ADDRESS: clara.rowden@johnzink.com	FAX NUMBER:	(918) 234-1968	09/09/2008

[illegible]

THE BOULEVARDS AT SOUTH BAY, LLC

APPENDIX 5

SCAQMD FORM 400-E-2C
GASEOUS EMISSION CONTROL FORM FLARE 250 SCFM

South Coast Air Quality Management District

FORM 400-E-2c
GASEOUS EMISSION CONTROL FORM
FLARE

Mail Application To:
SCAQMD
P.O. Box 4944
Diamond Bar, CA 91765

Tel: (909) 396-3385
www.aqmd.gov

This form must be accompanied by a completed Application for a Permit to Construct/Operate -Form 400A, Form CEQA, Plot Plan and Stack Form

Permit to be issued to (Business name of operator to appear on permit):

Tetra Tech, Inc.

Address where the equipment will be operated (for equipment which will be moved to various location in AQMD's jurisdiction, please list the initial location site):

20400 Main Street, Carson, CA 90745 (●) **Fixed Location** ( ) **Various Locations**

SECTION A: EQUIPMENT DESCRIPTION

Equipment	**Manufacturer:** John Zink Co., LLC — **Model No:** FBFZULE040X40lfbskd0 — **Make:** Z.U.L.E
Type	( ) **Elevated** (●) **Ground Level** ( ) **Pit** — **How is Flare Assisted?** (●) **Air Assisted** ( ) **Steam Assisted** ( ) **Non-Assisted**
Operation (See Rule 1118 for definition)	( ) **Clean Service Flare** ( ) **Emergency Service Flare** (●) **General Service Flare**
Dimension	**Flare Height** 40.00 ft. **Flare Tip Inside Diameter** 4.00 ft.
Design Criteria for Waste Gas Stream	**Retention Time at Normal Operating Temperature:** 7 secs at 16000 °F; **Combustion Chamber Volume:** 335.00 cubic feet; **Design Waste Stream Flow:** 250.000 scfm; **Btu:** 455

	Minimum	Maximum
Velocity At Tip (Feet per Second)	2.800	45.000
Flow Rate (scfm)	50.000	250.000

For Steam Injection

Steam Pressure(psig)	
Minimum	**Maximum**

Design Basis for Steam Injected (lb steam/lb hydrocarbons): ______

Total Steam Flow rate (pounds/hour): ______ **Number of Jets:** ______

Temperature: ______ **Diameter of Jets:** ______ (inches) **Velocity** (Feet per Second): ______

For Water Injection

Water Pressure (psig)		Total Water Flow rate (gpm)	
Minimum	**Maximum**	**Minimum**	**Maximum**

Number of Water ______

Diameter of Water Jets: ______ (inches)

Auxiliary Fuel Data

Auxiliary Fuel Available? (●) Yes ( ) No If yes, indicate ______

Number of Pilots: 1 **Fuel Rate (scfm [70 °F & 14.7psia) per pilot:** 2700.000

Fuel Usage (Select One):	**Maximum**	**Minimum**	**Average**
( ) **Cubic Feet/Hour OR** ( ) **Gallons/Hour**			

SECTION B: WASTE GAS STREAM CHARACTERISTICS

Brief Description of Process

Describe equipment vented to this Flare. Also describe the type of ignition system and its method of operation. Provide an explanation of the control system for steam flow and rate and other operating variables. Please supply an assembly drawing, dimensioned to scale, to show clearly the operation of the flare system. Show interior dimensions and features of the equipment necessary to calculate its performance.

Landfill gas is vented to the flare. The flare ignition is by natural gas or propane pilot. A complete electronic control package is included to start and stop the flare combustion, control the air inlet settings and thereby maintain the required retention time and temperature. See the attached documents for complete details. This flare would operate alone or in conjunction with the other 450 scfm ZULE depending on gas extraction rate from the landfill.

Waste Gas Stream

Material	Flow rate scfm (70 F & 14.7 psia) Minimum	Average	Maximum	Btu Rating
Landfill Gas	50.000	100.000	250.000	12

Instrumentation Data

Describe instrumentation data for measuring temperature, pressure drop and other operating parameters (attach description, if necessary).

A total of three thermocouples (at various elevations) will be installed in the flare stack to monitor the combustion temperature and to provide information to the temperature controller, which modulates the combustion air dampers to maintain the pre-selected flare temperature. The three thermocouples will be installed along the length of the stack, which will be selectable. This will allow the site engineer to select the most appropriate thermocouple elevation based on the flow of LFG at that time. One thermocouple will be used for high temperature control.
Additional detail is provided in the attached documents.

Operating Schedule

	hours/day	days/week	weeks/yr
Normal:	24	7	52
Maximum:			

SECTION C: APPLICANT CERTIFICATION STATEMENT

I hereby certify that all information contained herein and information submitted with this application is true and correct.

SIGNATURE OF PREPARER:	TITLE OF PREPARER:	PREPARER'S TELEPHONE NUMBER: (909) 860-7777
Michael L. Leonard Jr.	Sr. Project Manager	PREPARER'S E-MAIL ADDRESS: mlleonar@bas.com

CONTACT PERSON FOR INFORMATION ON THIS EQUIPMENT:	CONTACT PERSON'S		DATE SIGNED:
Clara Rowden	TELEPHONE NUMBER:	(918) 234-2801	
E-MAIL ADDRESS: clara.rowden@johnzink.com	FAX NUMBER:	(918) 234-1968	09/09/2008

CONFIDENTIAL INFORMATION

Under the California Public Records Act, all information in your permit application will be considered a matter of public record and may be disclosed to a third party. If you wish to keep certain items as confidential, please complete the following steps:
(a) Make a copy of any page containing confidential information blanked out. Label this page "public copy."
(b) Label the original page "confidential." Circle all confidential items on the page.
(c) Prepare a written justification for the confidentiality of each confidential item. Append this to the confidential copy.

THE BOULEVARDS AT SOUTH BAY, LLC

APPENDIX 6

SCAQMD FORM 400-XPP
EXPRESS PERMIT PROCESSING

South Coast Air Quality Management District
P. O. Box 4944 Diamond Bar, CA 91765
(909) 396-2000

EXPRESS PERMIT PROCESSING REQUEST FORM
FORM 400 - XPP

Form 400-A, Form 400-CEQA and one or more 400-E-xx form(s) must accompany all submittals.

Print Form

Section I - Facility/Application Information

1. Business Name: Tetra Tech, Inc. Boulevards at South Bay — Facility ID: 151,271
2. The requested application is for a(n): — Date of Occurrence: Jan 19, 2009
   - a. [X] New Construction
   - b. [ ] Change of Location
   - c. [ ] Modification of Equipment/Process
   - d. [ ] Existing Equipment with Expired Permit
   - e. [ ] Existing Equipment Operating without a Permit; Initial Operation Date:
   - f. [ ] Change of Condition(s); specify the change of condition(s) requested:
   - g. [ ] Change of Operator; List previous name of operator and Facility ID #:
3. I hereby request Express Permit Processing for this application.
4. I understand that this request will incur additional fees.
5. This request is not cancelable once engineering review has been initiated.
6. Express Permit Processing neither guarantees action by any specific date nor does I guarantee permit approval.

Section II - Equipment Information

I HEREBY CERTIFY THAT ALL INFORMATION CONTAINED HEREIN AND INFORMATION SUBMITTED WITH THIS APPLICATION IS TRUE AND CORRECT.

SIGNATURE OF RESPONSIBLE OFFICIAL OF FIRM:

TITLE OF RESPONSIBLE OFFICIAL OF FIRM: Vice President

TYPE OR PRINT NAME OF RESPONSIBLE OFFICIAL OF FIRM: Javier Weckmann

RESPONSIBLE OFFICIAL'S TELEPHONE NUMBER: 310-965-0137

DATE SIGNED: Sep 9, 2008

I HEREBY CERTIFY THAT ALL INFORMATION CONTAINED HEREIN AND INFORMATION SUBMITTED WITH THIS APPLICATION IS TRUE AND CORRECT.

SIGNATURE OF PREPARER: Michael L. Leonard, Sr.

TITLE OF PREPARER: Senior Project Manager

TYPE OR PRINT NAME OF PREPARER: Michael L. Leonard, Sr., P.E.

PREPARER'S TELEPHONE NUMBER: 909-860-7777

DATE SIGNED: Sep 9, 2008

AQMD USE ONLY	APPLICATION/TRACKING #	PROJECT #	TYPE B C D	EQUIPMENT CATEGORY CODE: /	FEE SCHEDULE: $	VALIDATION
ENG. A R DATE	ENG. A R DATE	CLASS I III IV	ASSIGNMENT UNIT ENGINEER	ENF. SECT.	CHECK/MONEY ORDER #	AMOUNT $

South Coast Air Quality Management District
P. O. Box 4944
Diamond Bar, CA 91765
(909) 396- 2000

GENERAL INFORMATION SUMMARY
FORM 400-E-GI

The following data, specifications, plans, and drawings must be submitted with each application for Permit to Construct and/or Permit to Operate. Also, if a Form 400-E-xx does not exist for a specific piece of equipment, then the information requested in this Form shall be submitted in its place.

1. EQUIPMENT/PROCESS LOCATION DRAWING

The drawing or sketch shall be submitted to scale (suggested scale: 1 inch = 100 feet; accuracy of measurements to the nearest 5 feet will be satisfactory) and shall show at least the following:

a. The property involved and outlines and heights of all buildings on it. Identify property lines plainly.
b. Location and identification of the proposed equipment on the property.
c. Property location with respect to public and private streets, and all adjacent properties. Show surrounding property owners and uses within 600 feet radius of property. Identify all buildings (as residence, apartment house, machine shop, warehouse, etc.) specifying height of each building (number of stories). Indicate direction (north) on the drawing. Identify schools which have their outer boundaries located within 1000 feet of the equipment.

2. EQUIPMENT DESCRIPTION

Provide detailed description of equipment, including but not limited to, function, make, model, dimensions, size, and maximum capacity. Attach manufacturer's catalog or brochure, if available.

3. PROCESS DESCRIPTION

Provide a general description of each process line (i.e., the process to be carried out by the equipment) or the function of the equipment with respect to a process line. The descriptions must be complete and detailed. Explain all stages in the process where there may be a discharge of emissions to the atmosphere. Supply all obtainable data regarding the nature, volumes, particle sizes, weights, and concentrations of all types of air contaminants that may be discharged at each stage in the process. Similarly, control procedures must be described in sufficient detail to show the extent of the control of air contaminants anticipated, including the expected control efficiency.

4. OPERATING SCHEDULE

Specify the average and maximum number of hours per day, days per week, days per month, and weeks per year the equipment/process is to be operated.

5. PROCESS RATE

On the basis of pounds per hour, or other specified unit of time, indicate the type and total weight of each material charged into the equipment or the process. Include Material Data Safety Sheets (MSDS), when applicable.

6. FUELS AND BURNERS USED

a. For fuel gas, indicate the type and average and maximum cubic feet per hour burned. Except for natural gas, attach fuel gas analysis.
b. For fuel oil, indicate grade and average and maximum gallons per hour burned. Also, indicate the sulfur content of fuel oil.
c. For solid fuels, indicate the type and average and maximum pounds per hour burned. Also, attach fuel analysis.
d. For burners, indicate the make, model, size, type, number of burners, and capacity of each burner.

7. FLOW DIAGRAM

The diagram should illustrate the flow of materials processed or burned either on a separate flow diagram or on the drawings accompanying the application. Show all venting of equipment (see instruction # 9).

8. DRAWINGS OF EQUIPMENT/PROCESS

Supply an assembly drawing, dimensioned and to scale, in plan, elevation and as many sections as are needed to clearly show the design and operation of the equipment/process and the means by which air contaminants are controlled. The following must be shown:

a. Locations, size, and shape of the equipment. Show exterior and interior dimensions and features.
b. Locations, size, and shape details of all features which may affect the production, collection, conveyance, or control of any air contaminant. This includes the size of pressure relief devices.
c. All data and calculations used in selecting or designing the equipment/process.

NOTE: Structural design calculations and details are not required. When standard commercial equipment is to be installed, the manufacturer's catalog describing the equipment may be submitted in lieu of the above items. All information required above which the catalog does not include must be submitted by the applicant.

9. DRAWINGS OF THE EXHAUST SYSTEM

Supply drawing(s) clearly showing all ductwork and the connection between air pollution generating (basic) and control equipment. Show all of the following details which apply, using auxiliary drawings, if necessary:

a. Sizes and shapes of all hoods. Show accurately where and how the hood fits over the spot or area where air contaminants are generated or discharged. Show all openings clearly.
b. Diameters or cross-sectional dimensions and lengths of all branch and main ducts.
c. Locations, sizes and shapes of all bends, junctions and transition pieces.
d. Locations, sizes and shapes of all passageways other than ordinary ducts. Also show all cooling devices (spray chambers, heat exchangers, cooling columns, etc.).
e. Locations and descriptions of all dampers, baffles, and similar controls.
f. Locations of any by-passes around the control equipment. Describe how operated, stating under what conditions and for what lengths of time these by-passes are to be used.
g. Locations of all fans or blowers.
h. Location of control equipment and vent(s).

10. STACK/EXHAUST EMISSIONS DATA

Provide emissions data at each source. Include the following information:

a. The maximum mass emission rates (mass per hour) and stack concentrations of all air pollutants. Include emission calculations if available.
b. Stack diameter.
c. Stack height above ground level.
d. Exhaust temperature.
e. Exhaust flow rate (volumetric).

11. AIR QUALITY IMPACT

Provide an analysis of the air quality impact (including risk assessment) in accordance with specific AQMD requirements. Procedures for preparing air quality impact analysis, including screening analyses are available from the AQMD.

12. GENERAL PERMITTING INFORMATION

Further information or clarification concerning permits can be obtained by writing or calling:

South Coast Air Quality Management District
Permitting
21865 Copley Dr.
Diamond Bar, CA 91765
(909) 396 - 2000

THE BOULEVARDS AT SOUTH BAY, LLC

APPENDIX 7

PERMIT FEE CALCULATION

TABLE IB - PERMIT FEE RATES FOR BASIC EQUIPMENT

Equipment/Process	Schedule
IC Engine, Emergency, (> 500 HP)	B
IC Engine, Landfill/Digester Gas	D
IC Engine, Other, 51-500 HP	B
IC Engine, Other, >500 HP	C
Impregnating Equipment	C
Incineration, Hazardous Waste	H
Incinerator, < 300 lbs/hr, Non-Hazardous	E
Incinerator, >=300 lbs/hr, Non-Hazardous	F
Indoor Shooting Range	B
Ink Mfg./Blending Including, but not limited to, all or part of the following: Process Tanks, Mixers	B
Inorganic Chemical Mfg. Including, but not limited to, all or part of the following: Process Tanks, Mixers, Reactors	D
Insecticide Separation/Mfg Including, but not limited to, all or part of the following: Absorbers, Accumulators, Columns, Compressors, Condensers, Coolers, Drums, Ejectors, Heat Exchangers, Knock Out Pots, Pots, Pumps, Reactors, Regenerators, Scrubbers, Settling Tanks, Sumps, Tanks, Towers, Vessels	E
Iodine Reaction Including, but not limited to, all or part of the following: Columns, Compressors, Condensers, Coolers, Heat Exchangers, Pumps, Reactors, Regenerators, Scrubbers, Settling Tanks, Tanks, Towers	C
Isomerization Unit Including, but not limited to, all or part of the following: Absorbers, Accumulators, Columns, Compressors, Condensers, Drums, Fractionators, Heat Exchangers, Knock Out Pots, Pots, Pumps, Reactors, Regenerators, Scrubbers, Settling Tanks, Sumps, Tanks, Towers, Vessels	E
Jet Engine Test Facility	C
Kiln, Natural Gas	C
Landfill Condensate/Leachate Collection/Storage	B
Landfill Gas, Collection	D
Landfill Gas, Treatment	E
Landfill Gas, Treatment	E
Lime/Limestone, Conveying Including, but not limited to, all or part of the following: Bins, Conveyors, Bucket Elevators, Hoppers, Weigh Stations	C
Liquid Separation, Other Including, but not limited to, all or part of the following: Process Tanks, Settling Tanks, Separators, Tanks	D
Liquid Waste Processing, Hazardous Including, but not limited to, all or part of the following: Air Floatation Units, Floatation Units, Filter Presses, Reactors, Process Tanks, Clarifiers, Settling Tanks, Waste Water Separators, Tanks	E
Liquid Waste Processing, Non Hazardous Including, but not limited to, all or part of the following: Air Floatation Units, Floatation Units, Filter Presses, Reactors, Process Tanks, Clarifiers, Settling Tanks, Waste Water Separators, Tanks	C
LPG, Tank Truck Loading	D
LPG, Treating Including, but not limited to, all or part of the following: Absorbers, Accumulators, Columns, Compressors, Condensers, Drums, Fractionators, Heat Exchangers, Knock Out Pots, Pots, Pumps, Reactors, Regenerators, Scrubbers, Settling Tanks, Sumps, Tanks, Towers, Vessels	D
LPG Distillation Unit Including, but not limited to, all or part of the following: Absorbers, Accumulators, Columns, Compressors, Condensers, Drums, Fractionators, Heat Exchangers, Knock Out Pots, Pots, Pumps, Reactors, Regenerators, Scrubbers, Settling Tanks, Sumps, Tanks, Towers, Vessels	E
Lube Oil Additive/Lubricant Mfg.	B
Lube Oil Re-refining Including, but not limited to, all or part of the following: Absorbers, Accumulators, Columns, Compressors, Condensers, Drums, Fractionators, Heat Exchangers, Knock Out Pots, Pots, Pumps, Reactors, Regenerators, Scrubbers, Settling Tanks, Sumps, Tanks, Towers, Vessels	D

FY 08-09

Schedule	Permit Processing Fee	Change of Condition	Alteration/ Modification
A	$1,287.22	$670.49	$1,287.22
A1	$1,287.22	$670.49	$1,287.22
B	$2,051.52	$1,016.31	$2,051.52
B1	$3,244.91	$1,758.90	$3,244.91
C	$3,244.91	$1,758.90	$3,244.91
D	$4,478.51	$3,008.18	$4,478.51
E	$5,148.93	$4,416.74	$5,148.93
F	$12,939.58+T&M,	$6,448.14	$10,257.62+T&M
G	$15,272.72+T&M	$10,942.07*	$12,590.75+T&M
H	$23,666.52+T&M	$13,873.64*	$20,984.56+T&M

F: T&M = Time and Material charged at $134.10 per hour above 99hours; not to exceed $25,206.34
G: T&M = Time and Material charged at $134.10 per hour above 117hours; not to exceed $43,184.35
H: T&M = Time and Material charged at $134.10 per hour above 182hours; not to exceed $54,908.82
*** Correction: revised fees correct a typographical error to reflect the actual Board approved 10% fee increase for FY 08-09**

SUMMARY OF ERC PROCESSING RATES, BANKING, CHANGE OF TITLE, ALTERATION/MODIFICATION, and CONVERSION TO SHORT TERM CREDITS

Schedule	Banking Application	Change of Title	Alteration/ Modification	Conversion to Short Term Credits	Re-issuance of Short Term Credits
FY 06-07 I	$2745.06	$484.90	$484.90	$484.90	$484.90
FY 07-08 I	$3,019.57	$533.39	$533.39	$533.39	$533.39
FY 08-09 I	$3,321.52	$586.73	$586.73	$586.73	$586.73

SACQMD Permit Fee Calculation
Landfill Treatment System

Schedule E Fee	$5,148.93
Expedite Fee	$2,574.47
Total Fee	$7,723.40

THE BOULEVARDS AT SOUTH BAY, LLC

ATTACHMENT 1

GAS BLOWER PERFORMANCE CURVE

Houston Service Industries, Inc.
7901 Hansen Rd • Houston, TX 77061
Phone: 713-947-1623 • 800-725-2291 • Fax: 713-947-6409
Web: www.hsiblowers.com • E-mail: hsi@hsiblowers.com

Blower / Exhauster Design Datasheet

Customer : John Zink

Datasheet No.: 22856
Design Date: 3/25/2008
Quote/Job No.:

Project :

Design Data

Inlet Conditions

Volume :
Bar Pressure: 14.677 PSIA
Inlet Press. : 11.068 PSIA
Inlet Temp. : 100.00 °F
Humidity : 100.0 %

Design Point

Volume (Inlet) :
Differential Press.:
Discharge Press. :
Inlet Vacuum :

Other Information

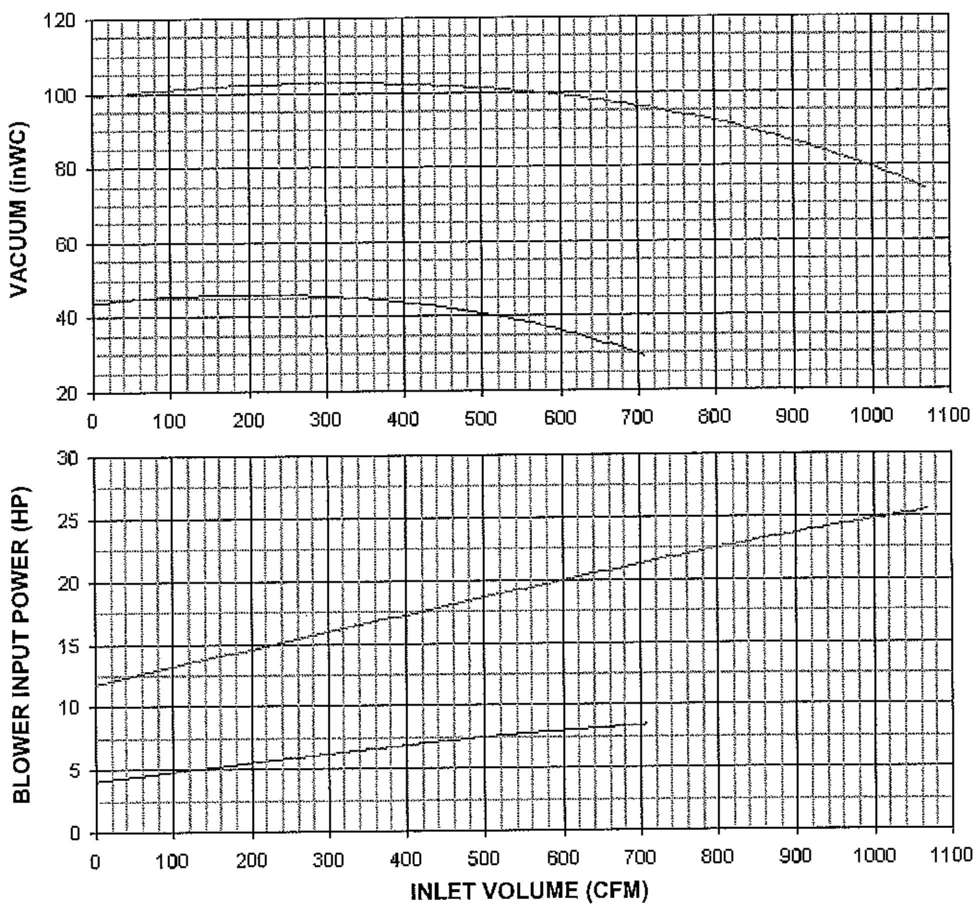
Mol Weight : 28.9948012
(k-1)/k Factor : 0.2159067
EAP (std) :
Isentropic Pwr :
Op. Speed : 3775 RPM

Exhauster Data

Model : HSI 5105
Impeller 1 : (5) 5012

Alt. Speed : 2500 RPM

Performance Curves



Gas Data

Gas	Pct	MW	Cp
Carbon Dioxide (CO_2)	50.000	44.0100	0.2050
Methane (CH_4)	50.000	16.0420	0.5933

Gas	Pct	MW	Cp

THE BOULEVARDS AT SOUTH BAY, LLC

ATTACHMENT 2

FLARE SPECIFICATIONS

ULTRA-LOW EMISSION ENCLOSED LANDFILL GAS FLARE

-A Full Scale Factory Test-

JOHN ZINK®
A KOCH INDUSTRIES COMPANY

Presented at SWANA 21st Annual
Landfill Gas Symposium
Austin, Texas
March 1998

ULTRA-LOW EMISSION ENCLOSED LANDFILL GAS FLARE

- A Full Scale Factory Test -

Tim W. Locke
Biogas Flare Group
John Zink Company
Tulsa, Oklahoma

ABSTRACT

In our increasingly environmentally-conscious society, landfill gas flare emission requirements are continuing to become more and more stringent as people (and government) become more aware of the environmental and health detriments of these emissions. This paper discusses the baseline emission results from a full scale test on a typical enclosed landfill gas flare being fired with a simulated landfill gas. In addition, a full scale test has been completed on a newly developed Ultra-Low emission enclosed landfill gas flare, and those results are discussed in detail and compared to the emission results of the baseline flare previously tested. The enclosed flares ("typical" and Ultra-Low emission) were rated for 1500 scfm of landfill gas and were tested at the John Zink Company Research and Development Facility in Tulsa, Oklahoma. The testing comprised firing a natural gas and carbon dioxide mixture while measuring NOx, CO, O_2, and flame length on both the "typical" flare and on the Ultra-Low emission flare.

The baseline "typical" flare testing comprised varying the flow rate, methane concentration, and operating temperature as well as introducing ammonia into the gas stream to simulate nitrogen-bound compounds that convert directly to NOx when oxidized. The results indicate drastic fluctuations in the emissions due to the varying methane concentrations and operating temperatures tested.

The Ultra-Low emission flare testing comprised varying the flow rate, methane concentration, and operating temperature. The results indicate reductions in NOx in excess of 60% and CO in excess of 80% (based on 1400°F operating temperature) as well as substantially shorter flame lengths.

The results from the "typical" flare test are used as a baseline for all comparisons with the Ultra-Low emission flare in order to demonstrate the significance of the improvement.

TEST ARRANGEMENT - PHASE I

The initial Phase I testing to determine the "baseline" emissions information on a typical John Zink enclosed landfill flare utilized an 8'-0" O.D. x 45' OAH stack. The testing took place at the John Zink International Research and Development Facility in Tulsa, Oklahoma starting in November, 1996 with completion of the Phase II testing in September, 1997.

Since large volumes of landfill gas with varying compositions were not readily available, a mixture of Tulsa Natural Gas (TNG) and carbon dioxide (CO_2) was used to simulate the landfill gas.

COMPOSITION OF TULSA NATURAL GAS (TNG)

Compound	Vol%
CH_4	93.4
C_2H_6	2.7
C_3H_8	0.6
C_4H_{10}	0.2
N_2	2.4
CO_2	0.7

LHV - 914
HHV - 1013

With a methane concentration in the TNG of 93.4% and an overall heating value in the TNG of 914 (as opposed to the 910 of methane), TNG is considered an acceptable substitute for methane in the landfill gas simulation. The TNG was metered through ASME designed orifice runs and then mixed with CO_2 before it entered the flare.

A 40,000 lb liquid CO_2 tank provided the second component source for the simulated landfill gas. The liquid CO_2 was vaporized utilizing a steam vaporizer, then metered through ASME designed orifice runs, and then mixed with TNG before it entered the flare. A sketch of the test setup is shown in Figure I-1.

Several feet downstream of the orifice runs is a rotometer used to monitor the flow rate of ammonia into the fuel stream. The purpose of the ammonia injection is to determine the effects of fuel-bound nitrogen on emissions.

The enclosed flare used was 8'-0" O.D. with approximately 2" of ceramic fiber insulation on the inside. The stack overall height was 45', with 40' of stack height above the burner tips. The Phase I test comprised John Zink's standard landfill gas enclosed flare burners, floor arrangement, and inlet damper openings. The only difference between the unit tested and a standard 8'-0" O.D. flare was the additional 5' of stack height, which had no effect on the emissions data taken.

The flare stack was equipped with thirteen (13) type "K" thermocouple assemblies. Each thermocouple was attached to a digital read out that read in degrees F. The thermocouples were placed at three elevations above the burner assemblies: 15'-0", 26'-0", and 36'-0". At each elevation, four (4) thermocouples placed 90° apart protruded into the stack approximately 14"-16". At the top elevation of 36'-0" above the burner assembly, one (1) additional thermocouple was attached to the stack protruded 4'-0" into the stack to sample the temperature in the center of the unit. A sketch of the thermocouple placement is shown in Figure I-2.

A cross-type sample probe is located one-half stack diameter down from the top of the stack. Figure I-3 is a sketch of the design of the sample probe. The probe was made from ½" diameter schedule 40, inconel 600 pipe. A carbon steel or stainless steel probe would not have been adequate because of the presence of carbon within the steel that could give erroneous carbon monoxide (CO) readings. The probe ports are drilled to 1/8" diameter. The positions of the ports are located in accordance with 40 CFR Pt. 60, App. A, Method 1. The flue gas is pulled from the probe to a data shack where it is cooled to drop out all liquids.

TEST ARRANGEMENT

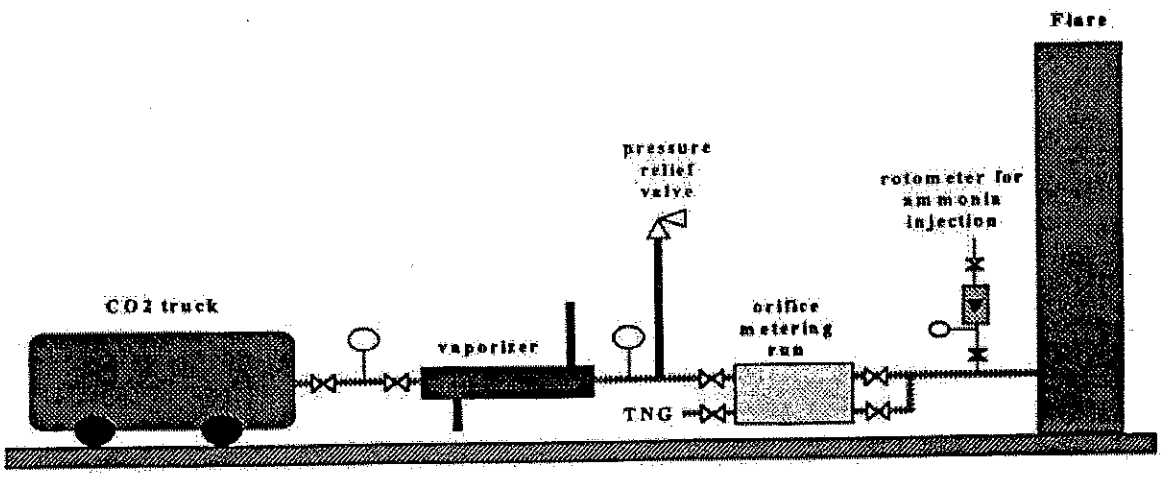


Figure I-1

THERMOCOUPLE POSITIONS

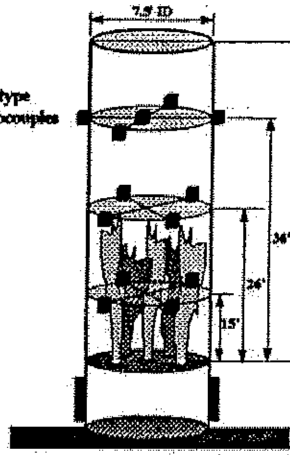


Figure I-2

DESCRIPTION OF SAMPLE PROBE

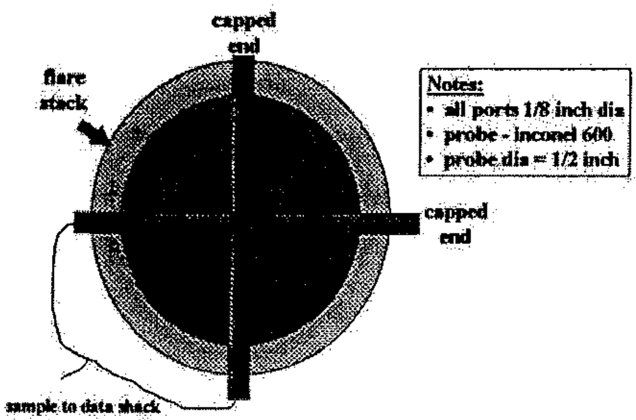


Figure I-3

The parts per million on a dry volume basis of CO and NOx were measured as well as percent oxygen (O_2).

TEST DESCRIPTION - PHASE I

Phase I of the testing was to determine the baseline emission factors and flame characteristics on a standard John Zink enclosed landfill gas flare. These factors and flare characteristics were used in comparison to Phase II testing of the Ultra Low Emission Flare. By comparing the results, step change improvements could be documented.

Test Series A1 - Standard Flare Performance

A total of twelve (12) different flow conditions was tested with the standard flare design. Each flow condition consisted of collecting emissions at four (4) different stack temperatures. The NOx, CO, and O_2 data was collected every 5 seconds for approximately 3 to 5 minutes. The data was collected both manually and using a data acquisition system. In addition, the flame length was measured through sight ports on the stack. Following are the flow conditions tested:

- **Flow rates (scfm):** 1500, 1000, 500

At each flow rate, the following compositions were tested:

- **%TNG/%CO_2:** 65/35, 55/45, 45/55, 30/70

At each flow composition, emissions were taken at the following temperatures:

- **Stack Temperature (°F):** 1400, 1500, 1600, 1800

Due to capacity limitations of the enclosed flare, measurements were taken only at 1800°F on the 65% TNG case and measurements were not taken at 1800°F on the 55% TNG case. With these four cases not included, the total number of test points was 44. At each test point, average NOx, CO, and O_2 readings were taken over a 3 to 5 minute interval, based on the digital recorder on the data acquisition system. In addition, 13 temperature readings were taken for a total of 572 temperatures.

Test Series A2 - Effects of Fuel Bound Nitrogen on NOx Production

Since fuel-bound nitrogen can have a drastic effect on the NOx production in the combustion process, two (2) tests that included injection of ammonia into the fuel stream were completed. At each flow condition, between 0 and 200 ppm of ammonia was injected for this analysis. Below is a description of the flow conditions tested:

- **Flow Rates (scfm):** 1500 and 1000

At each flow rate, the following compositions were tested:

- **%TNG/%CO_2:** 65/35, 55/45, 30/70

At each flow condition, emissions were taken at the following temperatures:

- **Stack Temperature (°F):** 1400, 1600

THERMOCOUPLE POSITIONS

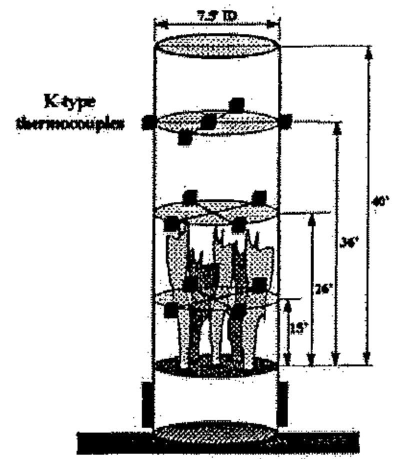


Figure I-2

DESCRIPTION OF SAMPLE PROBE

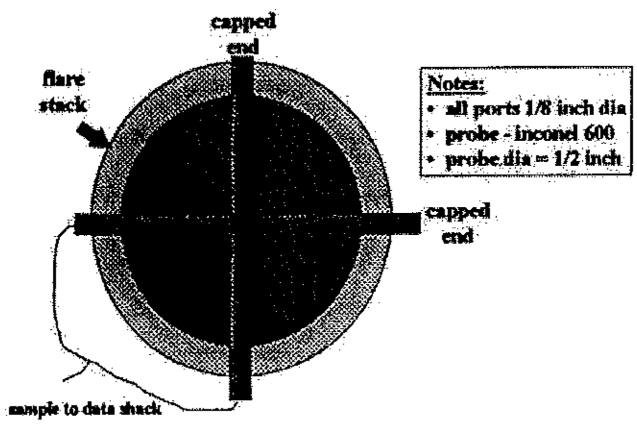


Figure I-3

The parts per million on a dry volume basis of CO and NOx were measured as well as percent oxygen (O_2).

TEST DESCRIPTION - PHASE I

Phase I of the testing was to determine the baseline emission factors and flame characteristics on a standard John Zink enclosed landfill gas flare. These factors and flare characteristics were used in comparison to Phase II testing of the Ultra Low Emission Flare. By comparing the results, step change improvements could be documented.

Test Series A1 - Standard Flare Performance

A total of twelve (12) different flow conditions was tested with the standard flare design. Each flow condition consisted of collecting emissions at four (4) different stack temperatures. The NOx, CO, and O_2 data was collected every 5 seconds for approximately 3 to 5 minutes. The data was collected both manually and using a data acquisition system. In addition, the flame length was measured through sight ports on the stack. Following are the flow conditions tested:

- **Flow rates (scfm):** 1500, 1000, 500

At each flow rate, the following compositions were tested:

- **%TNG/%CO_2:** 65/35, 55/45, 45/55, 30/70

At each flow composition, emissions were taken at the following temperatures:

- **Stack Temperature (°F):** 1400, 1500, 1600, 1800

Due to capacity limitations of the enclosed flare, measurements were taken only at 1800°F on the 65% TNG case and measurements were not taken at 1800°F on the 55% TNG case. With these four cases not included, the total number of test points was 44. At each test point, average NOx, CO, and O_2 readings were taken over a 3 to 5 minute interval, based on the digital recorder on the data acquisition system. In addition, 13 temperature readings were taken for a total of 572 temperatures.

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Since fuel-bound nitrogen can have a drastic effect on the NOx production in the combustion process, two (2) tests that included injection of ammonia into the fuel stream were completed. At each flow condition, between 0 and 200 ppm of ammonia was injected for this analysis. Below is a description of the flow conditions tested:

- **Flow Rates (scfm):** 1500 and 1000

At each flow rate, the following compositions were tested:

- **%TNG/%CO_2:** 65/35, 55/45, 30/70

At each flow condition, emissions were taken at the following temperatures:

- **Stack Temperature (°F):** 1400, 1600

STANDARD FLARE PERFORMANCE - PHASE I

Stack Temperatures

Temperatures in the standard John Zink enclosed flare were taken with thirteen (13) different type K thermocouples. Four (4) thermocouples were placed 90 degrees apart at three elevations: 15', 26', and 36' above the burner tips. One additional thermocouple was placed to measure the center of the flare at the 36' level. The 572 temperatures taken indicated a wide temperature variance within the enclosed flare at each elevation. In fact, temperature differentials of over 200°F were common at the same elevation as well as from elevation to elevation. For example, with a TNG concentration of 55% and a flow rate of 1000 scfm, the temperature at the 15' elevation varied from 1550°F to 1740°F with an average operating stack temperature of 1606°F as measured at the 36' elevation (sample port level). A temperature differential between elevations is noted at virtually every test point. These differentials range from 50°F to more than 200°F from the lower thermocouple elevation to the top elevation. Examples of these temperature ranges are given in Appendix A as Stack Temperature vs. Stack Height graphs.

NOx and CO

NOx and CO were measured at flow rates of 1500 scfm, 1000 scfm, and 500 scfm of a simulated landfill gas in a standard John Zink enclosed flare. At each flow rate, the composition changed from 65% TNG to 55% to 45% to 30% TNG (balance CO_2) and the temperature was varied between 1400°F to 1800°F+. Appendix A has a summary of these emissions in a graph form. The NOx emissions were plotted and compared to the industry standard limitation of 0.06 lb/mmbtu fired. The CO emissions were plotted and compared to the industry standard limitation of 0.20 lb/mmbtu fired. From these graphs, we can note the following trends:

NOx Emissions

- For a given fuel flow rate, increasing the volume percentage of TNG in the TNG/CO_2 fuel composition increases the pounds of NOx per mmBtu fired.
- For a given fuel composition and flow rate, increasing the stack temperature increases the pounds of NOx per mmBtu fired.
- For a given fuel composition and stack temperature, increasing the fuel flow rate decreases the pounds of NOx per mmBtu fired.

CO Emissions

- For a given fuel composition and stack temperature, increasing the stack temperature decreases the pounds of CO per mmBtu fired.

Flame Length

A total of 44 different flow conditions was tested. The flame length was measured by observing the flame through sight ports (located approximately every five feet) on the flare stack. At times, the flame length would flicker approximately +/- 3 feet in height. Here, the flame length is defined as the length from the burner outlet to the maximum height of the flame during flickering. Appendix A includes a plot of the flame length versus local average stack temperature and percent volumetric flow rate of TNG/heat release.

The data in the flame length graph shows that the flame length increases with stack temperature for a given fuel composition and flow rate. This trend is expected since increasing the stack temperature reduces the percent excess oxygen in the stack. A reduction in excess oxygen in the stack requires more time for the fuel to find the remaining oxygen resulting in a longer flame.

This data also shows that the flame length increases with an increase in the heat release for fuel compositions greater than 55% TNG by volume. However, for fuel compositions less than approximately 55% TNG by volume, the general trend of the flame length appears to be that it decreases with an increase in the heat release.

The overall general trend, as shown in Appendix A, shows that the flame length also increases with an increase in the percent of TNG in the fuel stream. One data point, however, appears to deviate from the general trend. This data point occurs at 30% TNG, 1500 scfm, and a stack temperature of 1800°F. The reason for this anomaly is not clear.

The overall test data suggest an interesting phenomenon, that for a given flare stack temperature, there exists a fuel composition and heat release that will produce a minimum flame length. At this minimum flame length at a given temperature and composition, any increase or decrease in the flow rate will lengthen the flame.

EFFECTS OF FUEL BOUND NITROGEN ON NOx PRODUCTION

A total of twelve (12) different flow conditions were tested in an effort to determine the effects of fuel-bound nitrogen on NOx production in enclosed landfill flares. Tests consisted of injecting ammonia into the fuel stream at ammonia concentrations ranging form 0 to 200 ppmv. Tests were performed at 65%, 55% and 45% TNG (balance CO_2) at flow rates of 1500 scfm and 1000 scfm and at stack temperatures of approximately 1400°F and 1600°F. See Figure II-1 for a graph of the results shown as a percentage increase in NOx production versus ppmv ammonia. This graph is typical for all flow rates.

EFFECTS OF FUEL-BOUND NITROGEN
total fuel flow rate = 1000 scfm

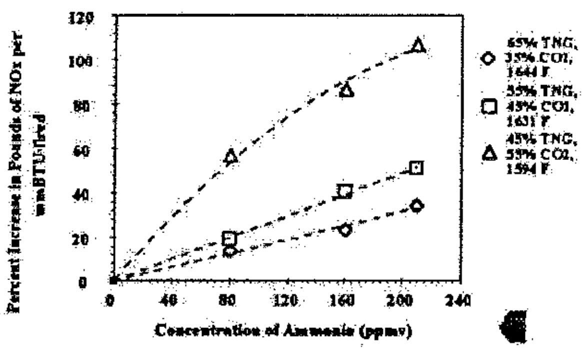


Figure II-1

The data shows, for all cases tested, that as the concentration of ammonia in the fuel stream increases, the NOx level also increases. The data appears to show that the NOx level increases linearly with ammonia concentration and that the slope of the line is not significantly dependent on stack temperature.

Ammonia Injection Conclusions

- The presence of a fuel-bound nitrogen in a landfill gas stream can dramatically increase NOx emissions. In some instances, 100 ppmv of ammonia in the landfill gas stream can increase the pounds of NOx per million BTU fired by as much as 100%.
- The data shows that the percent increase in NOx due to the presence of a fuel bound-nitrogen is more dramatic as the concentration of CO_2 in the fuel mixture increases.

ULTRA-LOW EMISSION FLARE - PHASE II

The goal of the Ultra-Low Emission Flare testing was to successfully develop an enclosed landfill flare that could achieve the following:

- NOx emissions less than 0.03 lb/mmbtu throughout a range of 30% to 55% methane at varying flow rates.
- Lower CO emissions than the standard John Zink enclosed flare system.
- Shorter flame lengths
- Reduction in flame radiation
- Higher destruction efficiency

Before the initial design of the Ultra-Low Emission Flare could be developed, it was necessary to understand the components and mechanisms of NOx formation. The components of NOx are:

- NO (90%)
- NO_2 (9%)
- N_2O (1%)

The mechanisms of NOx are:

- Thermal NOx
- Fuel NOx
- Prompt NOx

Thermal NOx is defined as that NOx produced from the combustion air which contains atmospheric nitrogen and oxygen. For example, N2 and O2 in the combustion air are further broken down into N and O radicals with the addition of high heat. These N and O radicals can produce NO as follows:

$$\mathbf{O + N_2 \rightarrow NO + N}$$
$$\mathbf{N + O_2 \rightarrow NO + O}$$
$$\mathbf{N + OH \rightarrow NO + H}$$

Ways to reduce Thermal NOx production:

- Reduce peak flame temperature

It should be noted that Thermal NOx is the largest contributor to NOx formation in the combustion process.

Fuel NOx is defined as that NOx produced from nitrogen that is chemically or organically bound in the fuel, such as ammonia (NH_3). When the nitrogen-bound compound is exposed to high heat, the N radical is broken from the molecule and readily attaches to an O radical. Once NO is formed, it is also possible to combine with an N radical to form N_2 at low O_2 concentrations in the flue gas.

Fuel N + O_2 → NO + O
Fuel N + NO → N_2 + O

Conversion to NO:
- Dominant at high O_2 concentrations

Conversion to N_2:
- Dominant at low O_2 concentrations

Ways to reduce Fuel NOx:
- Maintain low O_2 concentrations

Since fuel-bound nitrogen compounds are not typically in high concentrations in landfill gas, it is not practical or cost effective to operate enclosed flares at low O_2 levels in an effort to reduce Fuel NOx formation.

Prompt NOx is defined as that NOx formed in the initial portion of the flame zone when fuel and air react. For example, when methane (CH_4) is exposed to high heat, it is initially broken into CH/CH_2 plus some H radicals. This CH and CH_2 now combine with N_2 to form HCN and NH, which now acts as fuel-bound nitrogen.

N2 + CH → HCN + N
N2 + CH2 → HCN + NH

Ways to reduce NO formation:
- Reduce CH and CH2 concentrations, i.e., burn fuel lean (air rich)

With an understanding of the three (3) mechanisms of NOx formation, it is apparent that the critical factor in NOx reduction is reduction of peak flame temperature, thus reducing the reactivity of the molecules involved, allowing them to more readily convert directly to CO_2 and H_2O as follows:

$$CH_4 + O_2 + N_2 \rightarrow CO_2 + H_2O + N_2$$

Test Arrangement for Phase II Testing

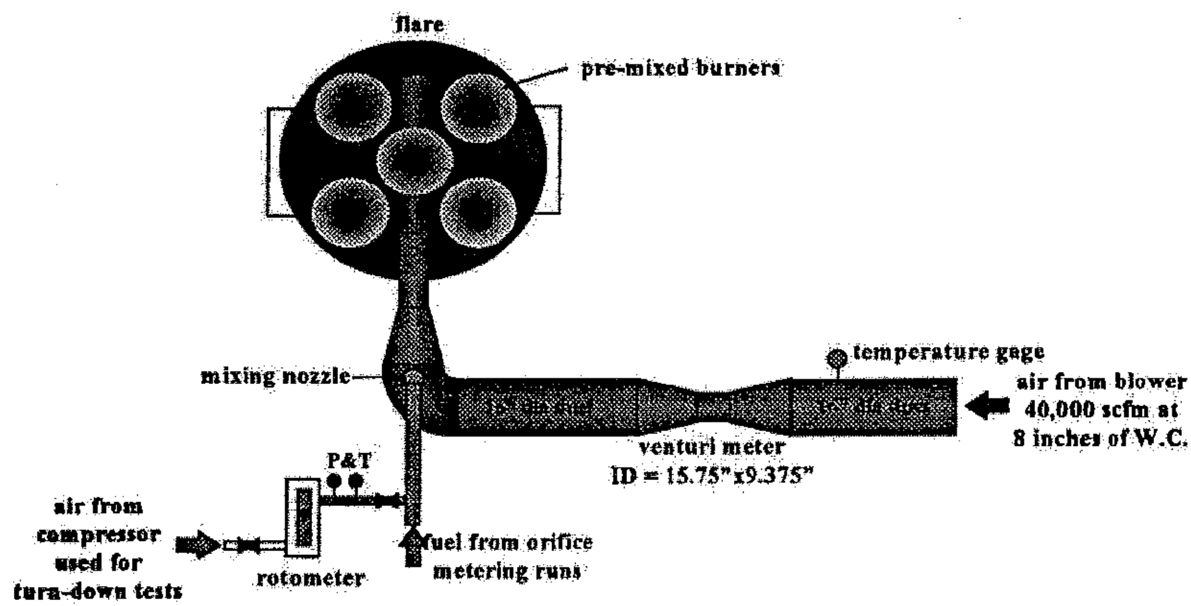


Figure III-1

Reducing peak flame temperatures can be accomplished several ways. The most common are:

- Staged fuel (fuel lean)
- Staged air (low O_2)
- Dilution

With the three (3) NOx formation mechanisms outlined above, we can formulate the following table:

NOx Reduction			
	Thermal NOx	Prompt NOx	Fuel NOx
Staged Fuel	↓	↓	↑
Staged Air	↓	↑	↓
Dilution	↓	↓	–

Table III - 1

Based on Table III - 1 above and the fact that fuel staging and air staging will lengthen the flame on a standard burner while dilution shortens the flame length by promoting mixing, Phase II testing utilized a dilution process mixing an air stream with the TNG/CO_2 mixture.

TEST ARRANGEMENT - PHASE II

Phase II testing was the development of an Ultra-Low Emission enclosed landfill flare. The flare tested was the same size as the baseline or standard flare, which was 8'-0" O.D. x 45' OAH. The same fuel mixing setup was utilized in Phase II as in the original baseline test. The fuel gas/CO_2 mixture then mixed with an air stream near the shell of the enclosed flare as illustrated in Figure III-1.

The flow rate of air was measured using a venturi meter designed according to ASME specifications. Approximately 15 duct diameters upstream of the venturi meter and 5 duct diameters downstream are allowed. The air was supplied from a blower capable of supplying 40,000 scfm at a pressure of 8 inches of water column.

Again, a total of 13 type K thermocouples were located in the stack for measurement of the flue gas temperatures and the same cross-type inconel sample probe was used.

TEST DESCRIPTION - PHASE II

Phase II of the testing was for an Ultra-Low Emission landfill flare configuration utilizing a pre-mixture of air and simulated landfill gas (TNG/CO_2). This testing is designated as Test Series B.

Test Series B1 - Single Burner Stability and Turn-down Performance

Test Series B was completed in two steps. Step one was to determine the best burner design to be utilized for the completion of the testing. A single burner was used in this procedure in an effort to minimize redundant and tedious changes during the performance testing. The criteria utilized to determine the overall burner design was flame stabilization and turndown capability. Flame stability was determined with 30% TNG and 70% CO_2 and the turndown tests were performed with 65% TNG and 35% CO_2.

Test Series B2 - Multiple Burner Performance

Once the single burner design was completed, five (5) of these burners were utilized in the enclosed flare for the maximum capacity requirement of 1500 scfm flow rate. A total of eleven (11) different flow conditions were tested in the Phase II program. At each flow condition, NOx, CO, and O_2 data were collected. The flow conditions tested are as listed below in Table IV-1.

Flow (SCFM)	%TNG	%CO2	%XS Air
500	55	45	48
500	55	45	33
1500	45	55	38
1500	45	55	11
1500	45	55	53
500	45	55	31
500	30	70	30
1000	30	70	30
1000	30	70	43
500	30	70	30
300	55	45	47

Table IV-1

ULTRA-LOW EMISSION FLARE PERFORMANCE - PHASE II

The purpose of these tests was to determine the emissions (NOx and CO) emitted from the new Ultra-Low Emission Flare design and compare these results with the standard enclosed landfill flare design.

NOx and CO

NOx and CO were measured at each condition as outlined in Table IV-1. The NOx emissions were plotted and compared to the baseline standard landfill gas enclosed flare as tested in Phase I and is shown on graphs in Appendix B. The CO emissions were plotted and compared to the baseline standard landfill gas enclosed flare as tested in Phase I and is shown on graphs in Appendix B also. From these graphs, we can note the following:

NOx Emissions

- For a given fuel flow rate, increasing the volume percentage of TNG in the TNG/CO_2 fuel composition increases the pounds of NOx per mmBtu fired.
- For a given fuel composition and flow rate, increasing the stack temperature increases the pounds of NOx per mmBtu fired.
- For a given fuel composition and stack temperature, increasing the fuel flow rate decreases the pounds of NOx per mmBtu fired.
- For a given fuel composition and stack temperature, increasing the amount of air that is premixed with the fuel decreases the pounds of NOx per mmBtu fired.
- The NOx emissions on the Ultra-Low Emission Flare were a minimum of 60% less than the standard enclosed landfill gas flare at high excess air mixture rates.

CO Emissions

- For a given fuel composition and stack temperature, increasing the stack temperature decreases the pounds of CO per mmBtu fired.
- At low TNG concentrations, the CO increased as the temperature decreased and the flow rate decreased.
- At high TNG concentrations, the CO increased only slightly as the temperature decreased down to 1200°F.

SUMMARY AND CONCLUSIONS

In the Phase I testing of the standard John Zink enclosed landfill gas flare, several key factors are to be noted including the wide variation of temperatures between thermocouples at the same elevation in the flare stack. Typically, if a temperature measurement were taken at a given elevation, that temperature was believed to be a good indicator at that particular elevation. However, the fact is that the temperature could be as much as 200° hotter or cooler at the same elevation in the stack.

The next major item of note is that for a given fuel composition and stack temperature, increasing the fuel flow rate actually decreases the pounds of NOx per mmBtu fired. Flame length is another item that is seldom mentioned in flare designs. It should be noted from this testing that the flame length in the standard enclosed flare increases approximately 10 feet when the TNG increased from 55% to 65% in the fuel gas. Otherwise, the flame lengths tended to trend as expected.

It is widely known that fuel-bound nitrogen increases NOx, but this testing now confirms the drastic effects that take place. In some instances, as little as 100 ppmv of ammonia can increase the pounds of NOx per mmBtu fired by 100%.

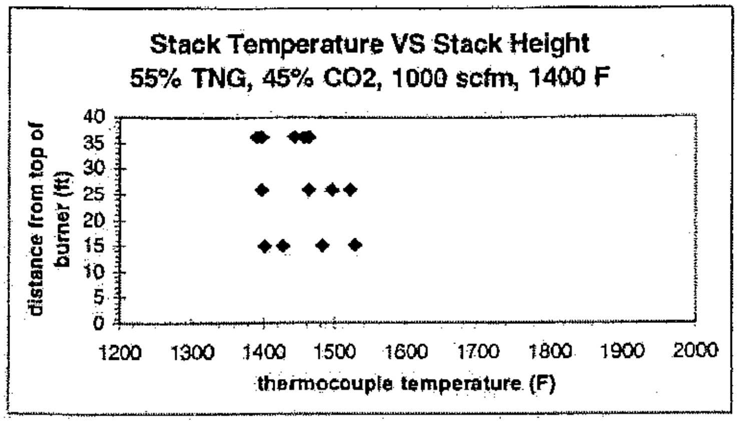
Phase II testing of the Low Emission Flare resulted in drastic reductions in NOx and CO, especially when compared to the generally accepted emission rates of 0.06 lbs/mmBtu fired of NOx and 0.20 lbs/mmBtu fired of CO. Even the reductions in NOx emissions from the standard John Zink enclosed landfill gas flare ranged from 60% to over 80%.

With the low CO emissions obtained (especially down to 1200°F), it is expected that the destruction efficiency on NMOC's will also be greater than the industry standard of 98%.

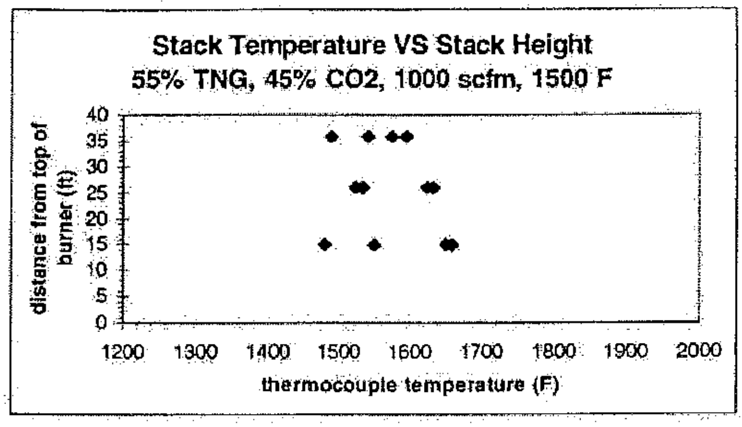
Finally, low CO emissions down to 1200°F, mean that lower operating temperatures can be maintained on the Ultra-Low Emission Flare, thus lowering the NOx even further than the numbers stated in this paper.

APPENDIX A

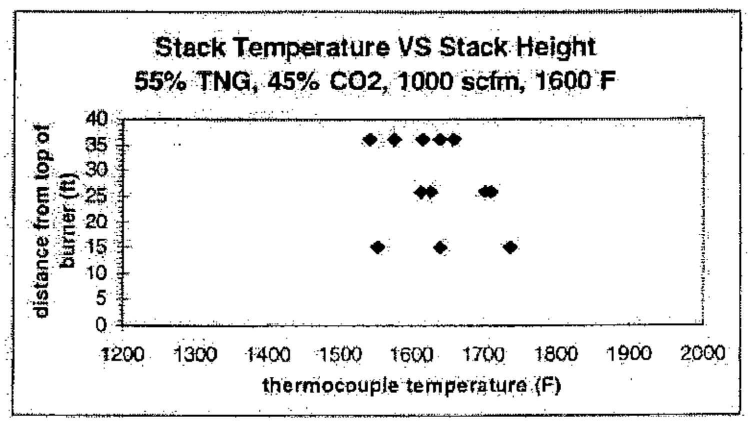
Standard Flare Performance



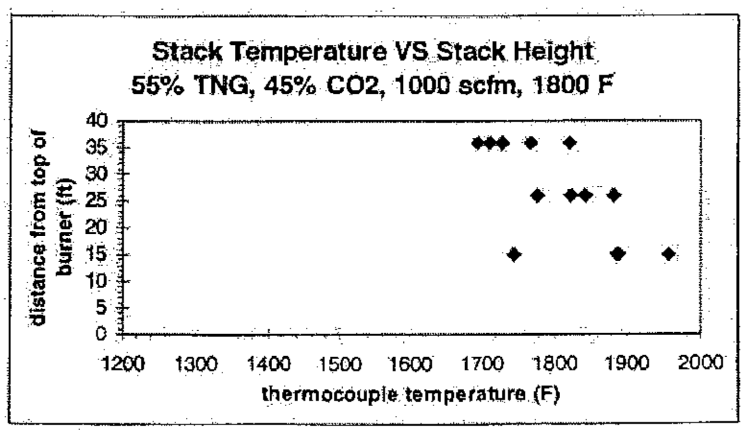
Stack Temperature VS Stack Height
55% TNG, 45% CO2, 1000 scfm, 1400 F
distance from top of burner (ft)
thermocouple temperature (F)



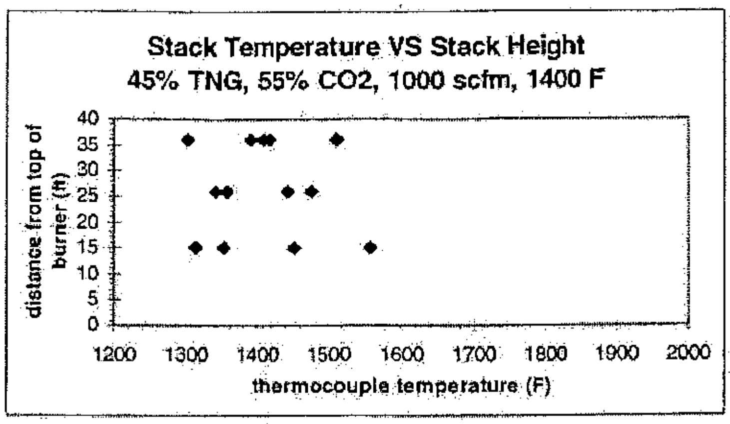
Stack Temperature VS Stack Height
55% TNG, 45% CO2, 1000 scfm, 1500 F
distance from top of burner (ft)
thermocouple temperature (F)

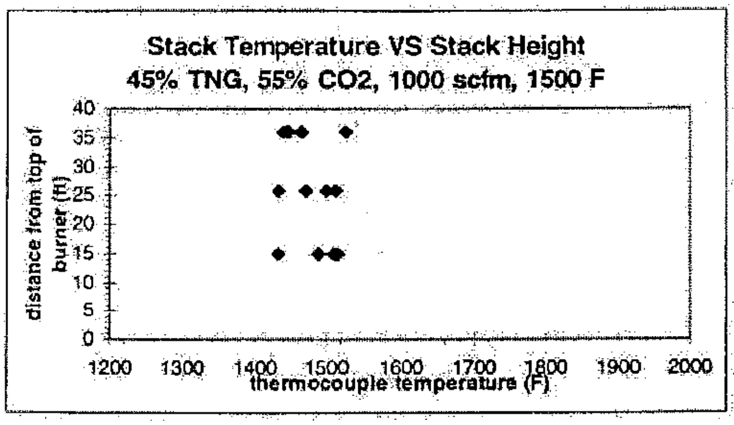


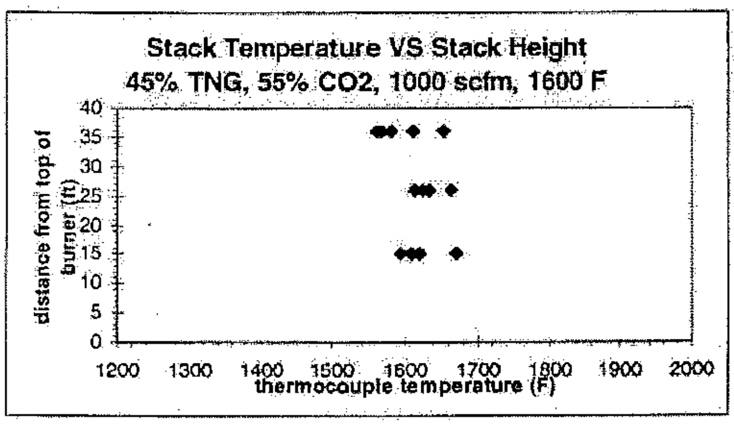
Stack Temperature VS Stack Height
55% TNG, 45% CO2, 1000 scfm, 1600 F
distance from top of burner (ft)
thermocouple temperature (F)

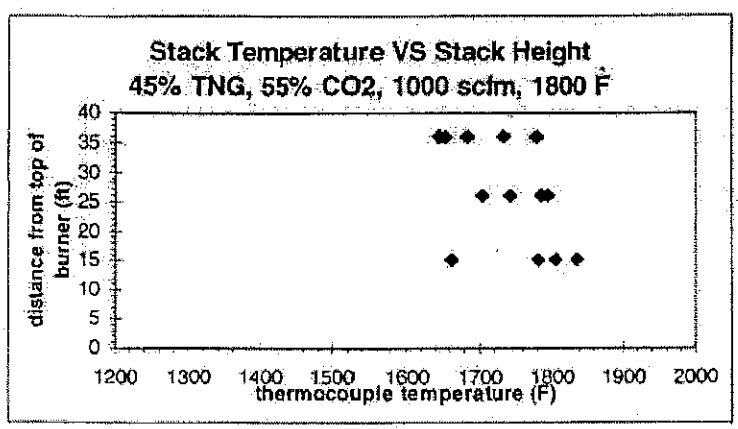


Stack Temperature VS Stack Height
55% TNG, 45% CO2, 1000 scfm, 1800 F
distance from top of burner (ft)
thermocouple temperature (F)

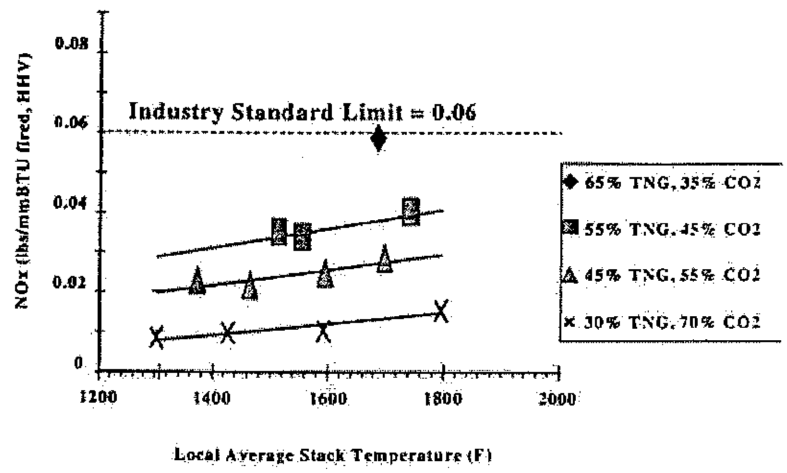

Stack Temperature VS Stack Height
45% TNG, 55% CO2, 1000 scfm, 1400 F
distance from top of burner (ft)
thermocouple temperature (F)


Stack Temperature VS Stack Height
45% TNG, 55% CO2, 1000 scfm, 1500 F
distance from top of burner (ft)
thermocouple temperature (F)

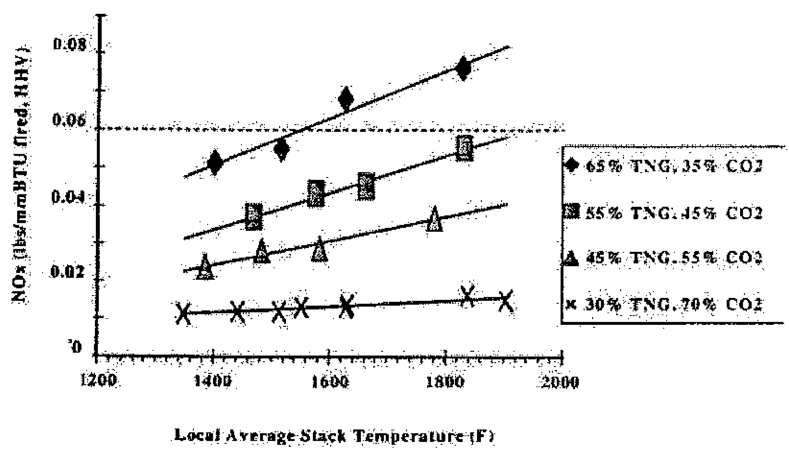

Stack Temperature VS Stack Height
45% TNG, 55% CO2, 1000 scfm, 1600 F
distance from top of burner (ft)
thermocouple temperature (F)


Stack Temperature VS Stack Height
45% TNG, 55% CO2, 1000 scfm, 1800 F
distance from top of burner (ft)
thermocouple temperature (F)

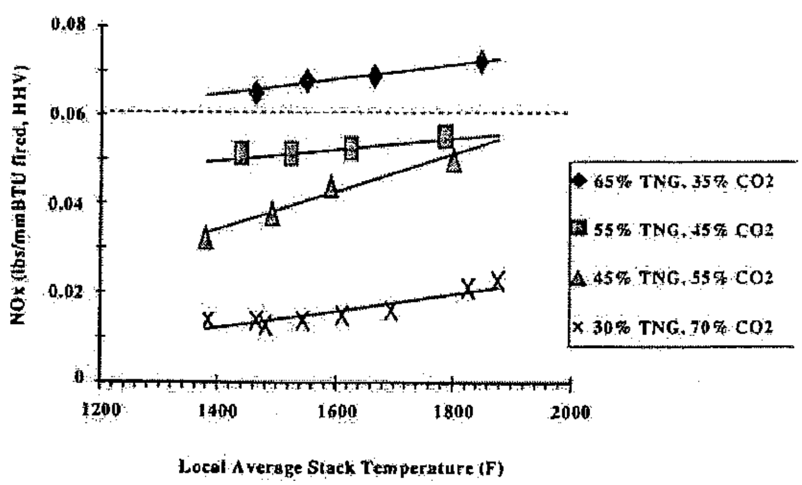
NOx Level VS Local Average Stack Temperature, 1500 scfm



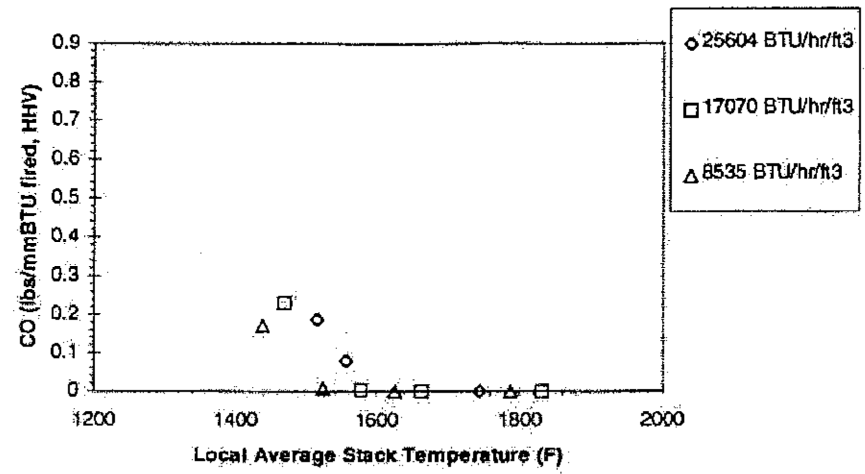
NOx Level VS Local Average Stack Temperature, 1000 scfm



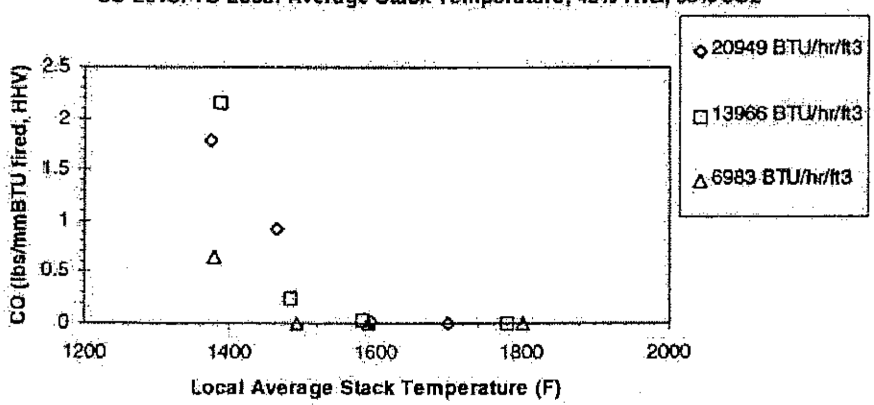
NOx Level VS Local Average Stack Temperature, 500 scfm



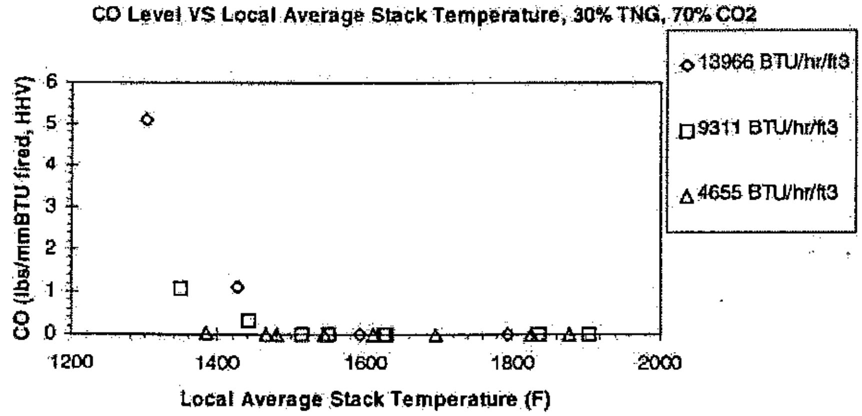
CO Level VS Local Average Stack Temperature, 55% TNG, 45% CO2



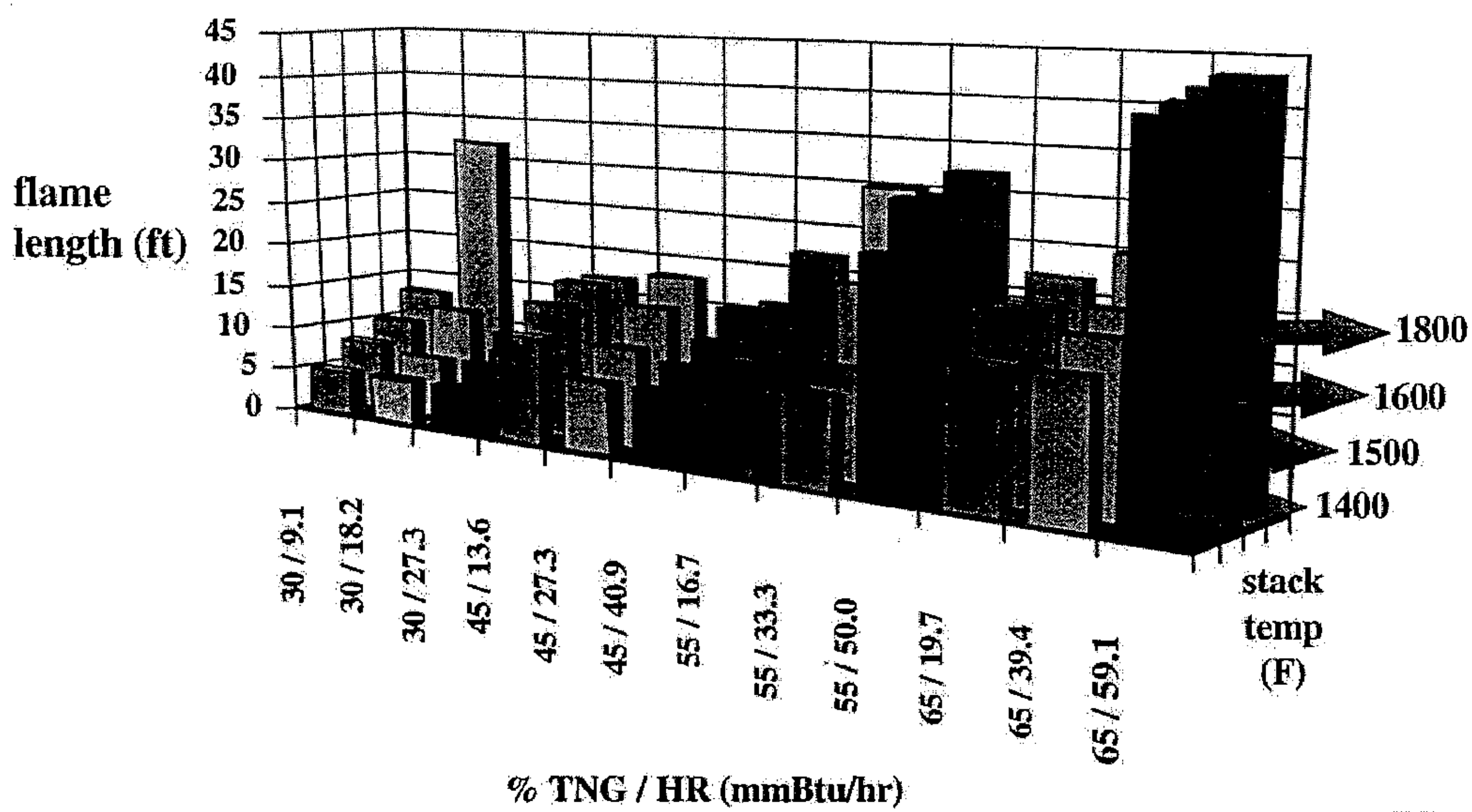
CO Level VS Local Average Stack Temperature, 45% TNG, 55% CO2



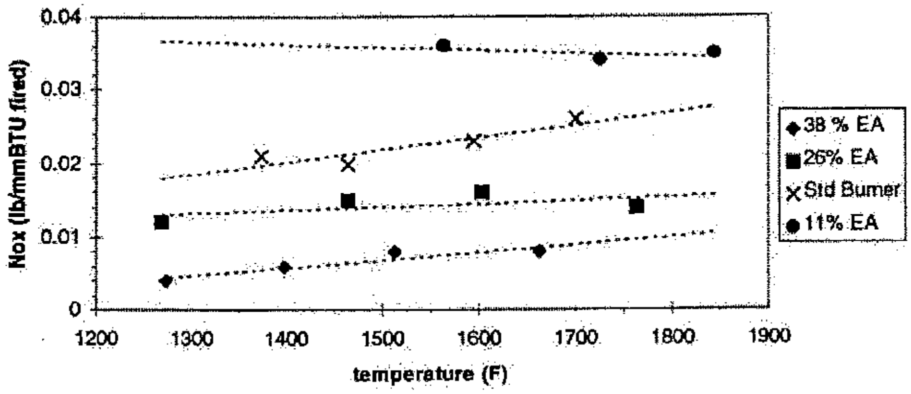
CO Level VS Local Average Stack Temperature, 30% TNG, 70% CO2



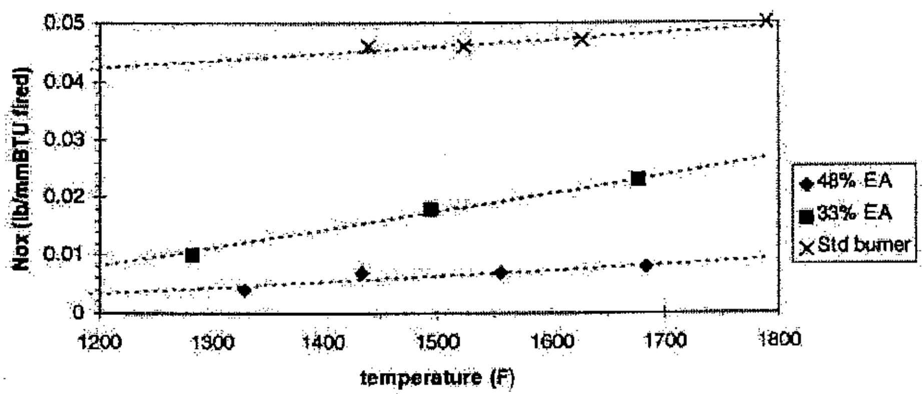
FLAME LENGTH AS A FUNCTION OF HR (MMBTU/HR) % TNG AND LOCAL AVERAGE STACK TEMPERATURE



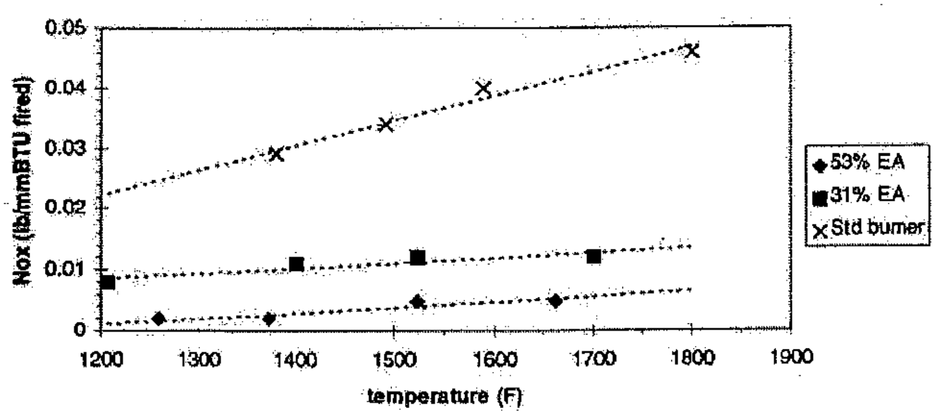
45% TNG, 55% CO2, 1500 scfm



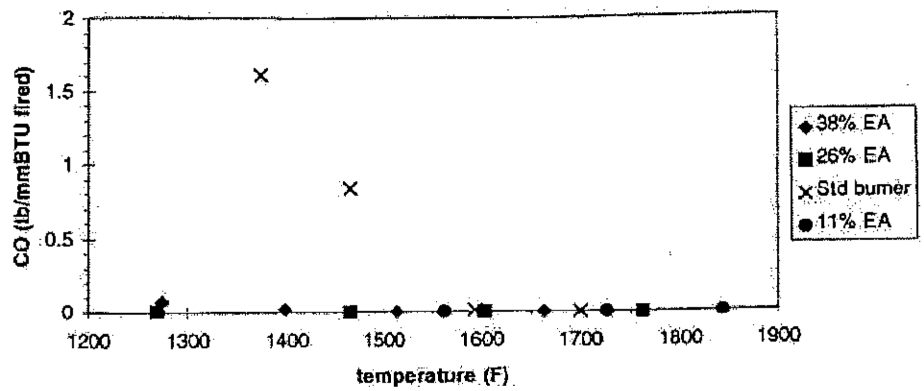
55% TNG, 45% CO2, 500 scfm



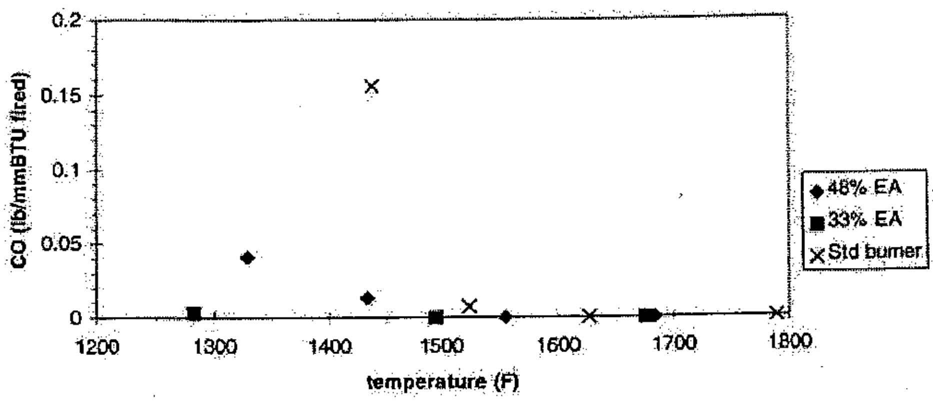
45% TNG, 55% CO2, 500 scfm



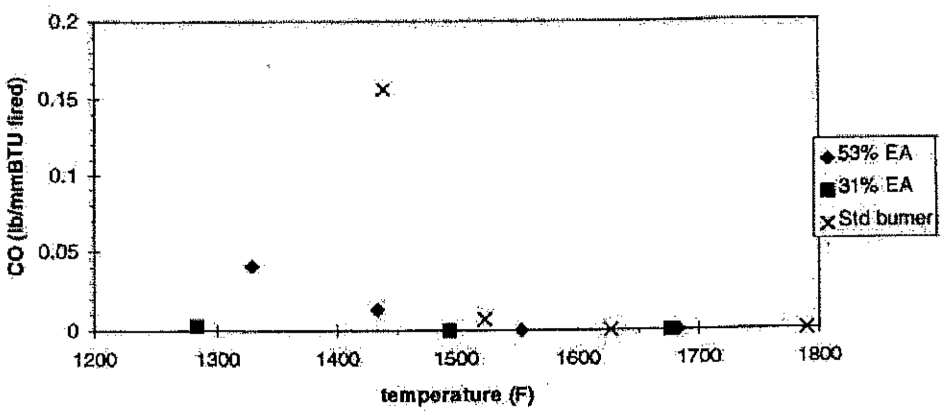
45% TNG, 55% CO2, 1500 scfm



55% TNG, 45% CO2, 500 scfm



45% TNG, 55% CO2, 500 scfm



ZULE: LANDFILL GAS ULTRA LOW EMISSION FLARE SYSTEM

Part 1. General

1.01 Description

A. Information within this specification describes an enclosed flare system designed specifically for emitting low NOx, low CO, and having high destruction efficiencies when combusting landfill gas. The flare system shall exhibit industrial quality and shall be completely manufactured, including the control system, by the flare supplier. The supplier shall have a minimum 10 years experience in the design and manufacture of flare equipment and shall have a minimum of 100 landfill gas flares operating successfully in the United States.

B. The flare system supplied shall be complete and operable as specified within.

1.02 Design Criteria

A. The enclosed flare shall be designed to operate continuously with landfill gas as the primary fuel source.

B. The landfill gas stream is characterized by the following parameters.

Flow Rate:	________ SCFM (maximum)
Composition:	30% to 50% CH_4 remainder CO_2, air, and inert gases
Lower Heating Value (LHV):	________ BTU/SCF (maximum)
Temperature:	100 °F
Moisture Content:	saturated
Heat Release:	________ BTU/hr (maximum)

C. The flare system shall satisfy the following site conditions.

Wind Speed:	110 mph (maximum)
Seismic Classification:	Zone 4
Site Elevation:	________ ft above sea level
Electrical Area Classification:	non-hazardous (unclassified)

D. The enclosed flare shall satisfy the following process conditions.

Smokeless Capacity:	100%
Operating Temperature:	1200 °F to 1800 °F (2000 °F shutdown)
Retention Time:	0.7 seconds (minimum) at 1800 °F
Inlet Pressure:	15" H_2O

E. The following utilities are required to support operation of the flare system.

Pilot Gas (intermittent):	22 SCFH of propane at 10 psig 50 SCFH of natural gas at 15 psig
Electricity:	480 V, three phase, 60 Hz

1.03 Performance Requirements

A. The enclosed flare must be capable of achieving the following performance requirements.

1. The flare shall sustain stable combustion with 10% to 50% methane concentrations at the maximum flow rate, while maintaining the operating temperature, without requiring any burner adjustment.
2. Considering a 50% methane concentration, all flares designed for flow rates of 1500 SCFM or greater must achieve a 5:1 instantaneous heat release turndown minimum. Flares designed for flow rates less than 1500 SCFM, must achieve a 3,500,000 BTU/hr heat release minimum. Achieving the specified turndown must not require any burner adjustment or flare modification.
3. The flare shall sustain stable combustion with methane concentrations of at least 10% without any burner adjustments or flare modification.
4. The pressure loss through the flare, from the inlet flange through the flare enclosure, shall be less than 15" H_2O.
5. The flare shall operate free of pulsation and vibration with at most 5% oxygen concentration in the landfill gas stream.
6. Emissions from the flare shall not exceed the following.

Nitrogen Oxide (NOx):	0.025 lb per million BTU fired
Carbon Monoxide (CO):	0.06 lb. per million BTU fired

7. The flare system shall achieve a destruction efficiency greater than 99% of total non-methane organic compounds (NMOC) throughout the entire flare operating range, without any burner adjustments or flare modification.

Part 2. Products

2.01 General

A. All equipment shall be designed and shall perform in accordance with these specifications, as a minimum.
B. The content of these specifications is intended to describe an enclosed flare requiring no burner adjustment to accommodate varying flow rates or gas concentrations.
C. Three (3) operation and maintenance manuals with essential instructions, appropriate vendor literature, and submittal drawings shall be supplied.

2.02 Equipment

A. The flare system shall include the following items, as a minimum.

1. Anti-flashback burners
2. Flare stack
3. Externally removable spark ignited pilot
4. Ignition and control station
5. Ancillary equipment

B. The equipment provided shall be manufactured by the flare supplier at the supplier's own fabrication facility. All components directly supporting combustion, such as burners and pilots, must be manufactured by the flare supplier. Only ancillary equipment, such as gas blowers, flame arrestors, and instrumentation shall be manufactured by others.

C. The control system shall be completely assembled and tested prior to shipment by the flare supplier at the supplier's own fabrication facility.

2.03 Equipment Description

A. Anti-flashback burners

1. All burners furnished within the enclosed flare shall be anti-flashback type, with an internal flame arresting seal, a flame stabilization device, and no adjustable, or moving, parts.
2. All burners shall be individually flanged for removal through the damper opening.
3. All burner material within 6" of the burner flame zone shall be made of high temperature material.

B. Flare stack

1. Stacks 7'-0" diameter and smaller shall be constructed of carbon steel with a 1/4" minimum thickness.
2. Stacks between 8'-0" diameter and 11'-0" diameter shall be constructed of carbon steel with a 3/8" minimum thickness.
3. Stacks 11'-0" diameter and larger shall be constructed of carbon steel with a 1/2" minimum thickness.
4. The internal portion of the stack requires a 2" thickness minimum of ceramic fiber blanket refractory. The surface layer, exposed to flame, shall be 1" thick, 8 lb density backed by 1" thick, 6 lb density, both with a 2400 °F temperature rating minimum. The surface layer shall be overlapped horizontally for additional heat protection.
5. Refractory shall be attached using Inconel 601 pins and keepers, with 8-3/4" horizontal spacing maximum and 10-1/2" vertical spacing maximum.

6. The stack shall contain a burner manifold with flanged inlet connection, and individual flanged burner connections, allowing proper gas distribution.
7. The external portion of the stack requires SSPC-SP-6 surface preparation and one coat of Sherwin Williams "Zinc Clad II" coating system, or equal, 3-4 mils DFT, gray-green color.
8. Two (2) 4" diameter FNPT sample ports and plugs minimum shall be located 90° apart and one-half stack diameter from the stack top for emissions testing. Each of the 4" diameter plugs shall be insulated with ceramic fiber refractory.
9. Connections for combustion air dampers shall be supplied on the stack.
10. Three (3) connections minimum shall be supplied on the stack for installing temperature control thermocouples.
11. One (1) connection shall be located in the lower one-third of the stack for installing the high temperature thermocouple.
12. The stack shall contain thermocouple conduit mounting brackets.
13. A stainless steel rain guard shall be provided at the stack top, covering the exposed edge of refractory, to prevent water damage. This rain guard shall consist of overlapping segments and not a continuous ring, to minimize thermal expansion affects.
14. The stack shall include an AISC designed, continuous baseplate for mounting and high wind stability.
15. Two (2) lifting lugs shall be located 180° apart for use during installation.

C. Externally removable spark ignited pilot

1. The pilot shall be mounted to the outside of the stack such that the assembly is externally removable.
2. The pilot shall be spark ignited.
3. The pilot shall be capable of firing on either propane or natural gas at pressures ranging from 3 to 15 psig.

D. Ignition and control station

Provide a complete and functional control system designed for 480 V, three phase, 60 Hz incoming power, including transformer conversion as required for operating the flare system. The following items shall be completely mounted, assembled, and wired on a structural steel rack.

1. One (1) weatherproof single phase power transformer to convert electrical service from 480 V to 120 V.
2. One (1) weatherproof Flare Control Panel including the following instrumentation for safe, overall system operation and control.

    - General Electric 9030 programmable logic controller, or equal
    - Honeywell UDC 3300 temperature indicating control module
    - High temperature shutdown switch
    - Flame scanner amplifier and relay

- Honeywell DR 4500 Truline digital circular chart recorder, or equal
- Three position thermocouple selector switch
- Ammeter for each gas blower motor (200% scale)
- Hourmeter for each gas blower motor
- One (1) 10 A duplex outlet.

The following switches and pushbuttons are required, as a minimum.

- Panel power (On/Off) switch
- System control (Local/Off/Remote) switch
- Gas blower (Hand/Off/Automatic) switch(es)
- Reset pushbutton
- Lamp test pushbutton

The following indications are required, as a minimum.

- Panel power on
- Purging
- Ignition sequence
- Flame proved
- Gas blower(s) ON
- Gas blower(s) failure
- Purge failure
- Automatic block valve failure
- Flame failure
- Flare low temperature
- Flare high temperature
- Burner flashback
- Low combustion air flow

3. Weatherproof combination motor starters for each gas blower.
4. Variable frequency drive for the combustion air blower.
5. One (1) Pilot Gas Control System including pressure regulator, fail-closed shutdown valve, manual block valve, and pressure gauge.

The following components shall be installed on or mounted to the flare stack.

1. One (1) weatherproof Ignition Panel with 6000 V transformer mounted to the stack for intermittent pilot ignition.
2. One (1) self-checking, ultraviolet flame scanner to monitor the main flame.
3. Three (3) temperature control thermocouples.
4. One (1) high temperature thermocouple.
5. Combustion air dampers with opposed, bolted blade design, galvanized finish, and stainless steel press-fit bearings.

The control station and instrumentation shall be assembled and wired completely in a facility approved by Underwriters Laboratories and shall be functionally tested prior to shipment simulating actual operation.

E. Ancillary Equipment

1. An eccentric flame arrester with aluminum body and removable, internal aluminum element shall be installed at the flare inlet flange.
2. A mixing chamber with static mixer for landfill gas and combustion air.
3. An automatic block valve assembly consisting of a high performance butterfly valve with 316 stainless steel disc and Teflon seal, and a fail-closed pneumatic actuator shall be supplied.
4. Gas blowers with totally enclosed, fan cooled (TEFC) motors shall supply the enclosed flare with landfill gas.
5. A moisture separator vessel with flanged inlet and outlet connections, stainless steel demister element capable of removing 99% of water droplets 10 micron and larger from landfill gas, and level gauge shall be supplied.
6. A suitable amount of thermocouple and ignition wire shall be supplied.
7. A combustion air blower with totally enclosed, fan cooled (TEFC) motor shall supply the required combustion air for proper dilution.

Part 3. System Operation

3.01 General

A. The flare system shall operate with automatic temperature control and shall safely destroy organic compounds generated by solid waste.
B. The system shall be controlled by a programmable logic controller (PLC) which receives and transmits signals with respect to operating conditions. If an unacceptable operating condition occurs, the system shall either adjust the operating parameters to correct the problem or discontinue operation.
C. System operation shall include an initial purge cycle, timed ignition sequence, and fail-safe controls.
D. System shutdown shall result from low purge air flow, pilot flame failure, main flame failure, flare low temperature, flare high temperature, low combustion air flow, and burner flash back.
E. Both local and remote operating modes shall be available.
F. A self-checking flame scanner shall monitor the main flame.

3.02 System Control Selection

System operation shall begin automatically by selecting either local or remote system control. Local control requires interaction at the control panel to start and stop operation. Remote control allows starting and stopping operation without interaction at the control panel.

3.03 Operating Permissives

System operation shall be permitted only after confirming two safety conditions exist. The closed limit switch for the automatic block valve must be satisfied, proving a closed valve position. Additionally, the flame scanner must not detect the presence of flame inside the flare enclosure.

3.04 Purge Cycle

Prior to beginning the ignition sequence, the combustion chamber and flare enclosure must be purged with ambient air to ensure no potentially explosive gas mixture exists inside. To create a safe condition for pilot ignition, the combustion air blower operates and the air damper louvers shall be maintained fully open for five minutes prior to each ignition attempt and "Purging" will be indicated. If the blower operation fails, or the purge air is not satisfied, "Purge Failure" will be indicated and system operation discontinues.

3.05 Ignition Sequence

The ignition sequence shall begin immediately after the purge cycle is complete. The pilot gas solenoid valve opens automatically, supplying gas to the pilot, "Ignition Sequence" is indicated, and the ignition transformer energizes. The ignition transformer continues for ten seconds and then the pilot thermocouple verifies flame is present. "Flame Proved" is indicated and the pilot gas solenoid valve remains open.

3.06 Gas Supply

Once the thermocouple detects pilot flame, the combustion air flow increases to a pre-determined rate, the automatic block valve opens, operation of the selected gas blower begins, supplying gas to the flare. After the gas blower has been on for a pre-determined time, the combustion air flow will decrease to the corrected flow rate. While the flame scanner verifies the presence of flame, system operation continues. If the open limit switch for the automatic block valve is not achieved within twenty seconds, "Automatic Block Valve Failure" is indicated and system operation discontinues.

3.07 Automatic Temperature Control

The operating temperature, or temperature maintained inside the flare enclosure, is controlled by varying the ambient air available through the air damper louvers. The elevation of the temperature control thermocouple is selected depending on the gas flow rate and methane concentration. The operating temperature is maintained by adjusting automatically the position of the louvers. Closing the louvers reduces the amount of air available and increases the operating temperature, while opening the louvers increases the amount of air available and decreases the operating temperature. The louvers are maintained open initially, before beginning automatic temperature control modulation, which introduces air inside the flare enclosure while the enclosure is cold and lacking draft, to minimize smoke during initial operation.

Part 4. System Failure

4.01 Purge Failure

A purge air flow meter shall monitor positive pressure during the purge cycle. If enough flow is not detected during the purge cycle, "Purge Failure" will be indicated and system operation discontinues.

4.02 Automatic Block Valve Failure

If either the open or closed limit switch for the automatic block valve indicates improper valve position any moment during operation, the "Automatic Block Valve" light flashes and system operation discontinues.

4.03 Pilot Flame Failure

During the ignition sequence, pilot flame failure shall occur when the thermocouple is unable to detect the presence of flame inside the flare enclosure. If the thermocouple is unable to detect flame, the entire purge cycle and ignition sequence is repeated. "Flame Failure" is indicated and system operation discontinues only after three consecutive, unsuccessful attempts occur.

4.04 Main Flame Failure

Main Flame Failure occurs, once the ignition sequence is complete, when the flame scanner is unable to detect flame is present inside the flare enclosure. When Main Flame Failure occurs, system operation is interrupted momentarily. Then the entire purge cycle and ignition sequence are repeated automatically. A Shutdown occurs only after three consecutive Failures, or unsuccessful attempts. Once Main Flame Shutdown occurs, "Flame Failure" is indicated and system operation discontinues.

4.05 Flare Low Temperature

Flare low temperature shall occur when a temperature below 1200 °F is detected inside the flare enclosure by the selected controlling thermocouple and exists for ten minutes consecutively. The corresponding "Flare Low Temperature" is indicated and system operation discontinues. The low temperature timer resets the moment a temperature above 1200 °F is detected during normal operation.

4.06 Flare High Temperature

Flare high temperature shall occur the moment a 2000 °F temperature is detected inside the flare enclosure by a dedicated high temperature thermocouple. "Flare High

Temperature" is indicated and system operation discontinues immediately.

4.07 Low Combustion Air Flow

Low combustion air flow shall occur the moment the measured air flow is determined to be an incorrect flow ratio with the given landfill gas flow rate and methane concentration, as determined by the PLC. "Low Combustion Air Flow" will be indicated and system operation discontinues immediately.

4.08 Burner Flashback

Burner flashback shall occur when a temperature above the desired set point is detected on the burner thermocouples. "Burner Flashback" is indicated and system operation discontinues immediately.

THE BOULEVARDS AT SOUTH BAY, LLC

ATTACHMENT 3

DISPERSION MODELING AND HEALTH RISK ASSESSMENT (SEE SEPARATE BOUND DOCUMENTS)

Carson Market Place
Carson, California

DISPERSION MODELING
AND
HEALTH RISK ASSESSMENT

Landfill Gas Collection with Flare Systems

Final Report

July 2008

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Air Dispersion Modeling
and
Health Risk Assessment

Landfill Gas Flare System
Carson Market Place
Carson, California

Final Report
submitted by
W. Chung Lee
(909) 396-9210

CONFIDENTIAL

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1. Purpose

Tetra Tech proposes to construct and operate a landfill gas collection system located in Carson Marketplace, Carson, California. Bryan A, Stirrat and Associates designs the system. As part of permit application for permits from South Coast Air Quality Management District (SCAQMD), this report presents Rule 1401 health risk assessment (Tier 3) of air toxics and air quality impact analyses of criteria pollutants emitted from the proposed landfill gas collection facility. The facility will consist of a gas collection system and two flares which are designed with Lowest Achievable Emission Rate (LAER) and will be functioned as Best Available Control Technology for air toxics (T-BACT). The health risk assessment and air quality impact analyses are conducted based on two flares operating at a maximum process flow rate of 700 scfm combined (worst case) and a minimum process rate of 50 scfm of the smaller flare.

2. Facility Description

The project site is located on a closed landfill which is located at the southwest corner of San Diego Freeway (405) and Del Amo Blvd. in the City of Carson (Figure 1). All landfill operations are closed. The landfill will have a closed cap system constructed and landfill gases will be collected and controlled with two flares which function as T-BACT. The land will be developed mainly for commercial use, with small portion on the far north side for residential use (Figure 2).

As shown in Figure 2, the control element of the landfill gas collection and control system will be located in a small parcel at the southwest corner of the site, between two commercial buildings just north of a storm channel. The systems will operate 24 hours per day, 365 days per year. Figure 3 shows the close vicinity and Figure 4 shows the plot plan of the landfill gas operating facility.

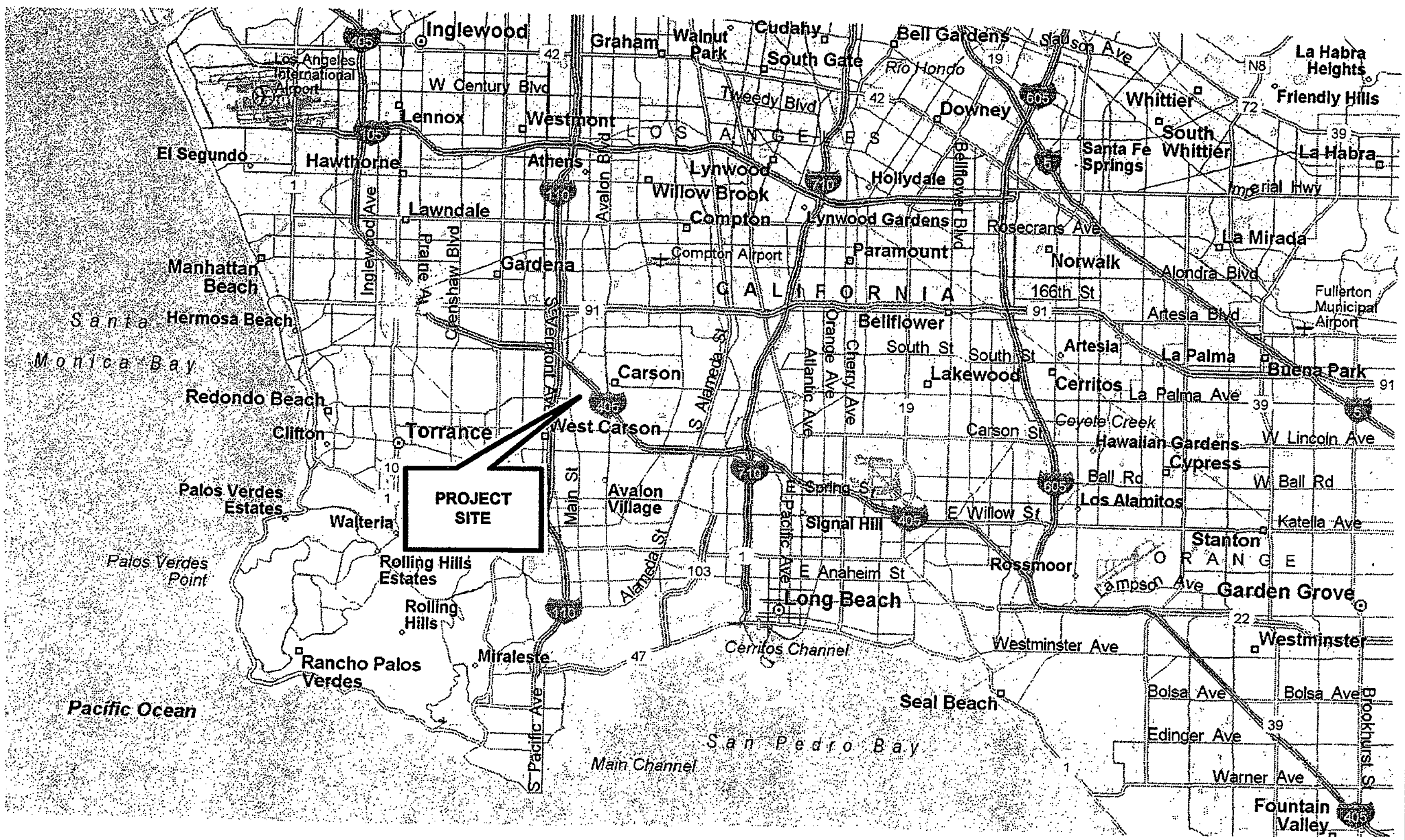

FIGURE 1. PROJECT LOCATION
BAS - CARSON MARKETPLACE
PROPOSED FLARE SYSTEM
CARSON, CALIFORNIA

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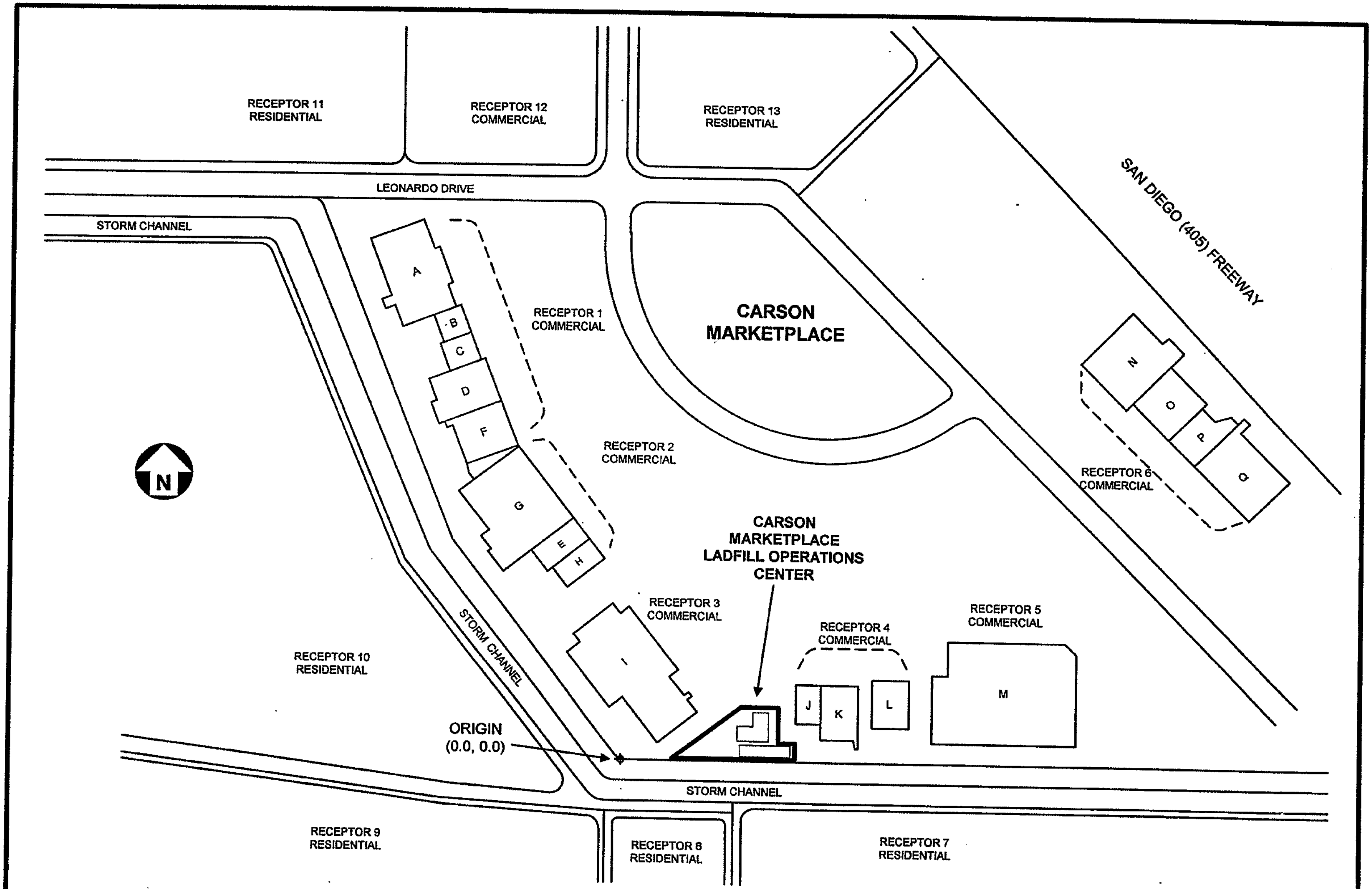

FIGURE 2. VICINITY MAP
BAS - CARSON MARKETPLACE
PROPOSED FLARE SYSTEM
CARSON, CALIFORNIA

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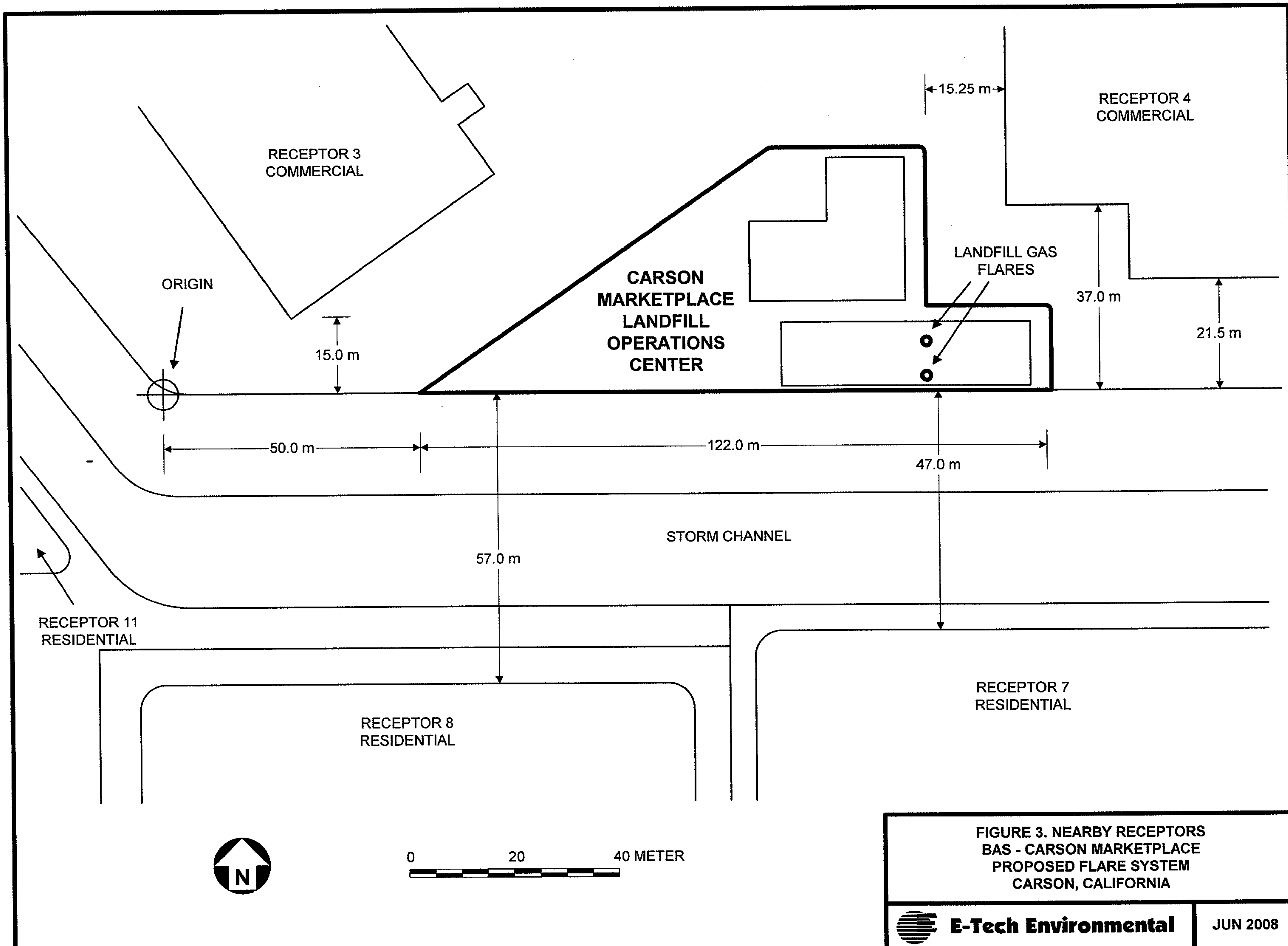

FIGURE 3. NEARBY RECEPTORS
BAS - CARSON MARKETPLACE
PROPOSED FLARE SYSTEM
CARSON, CALIFORNIA

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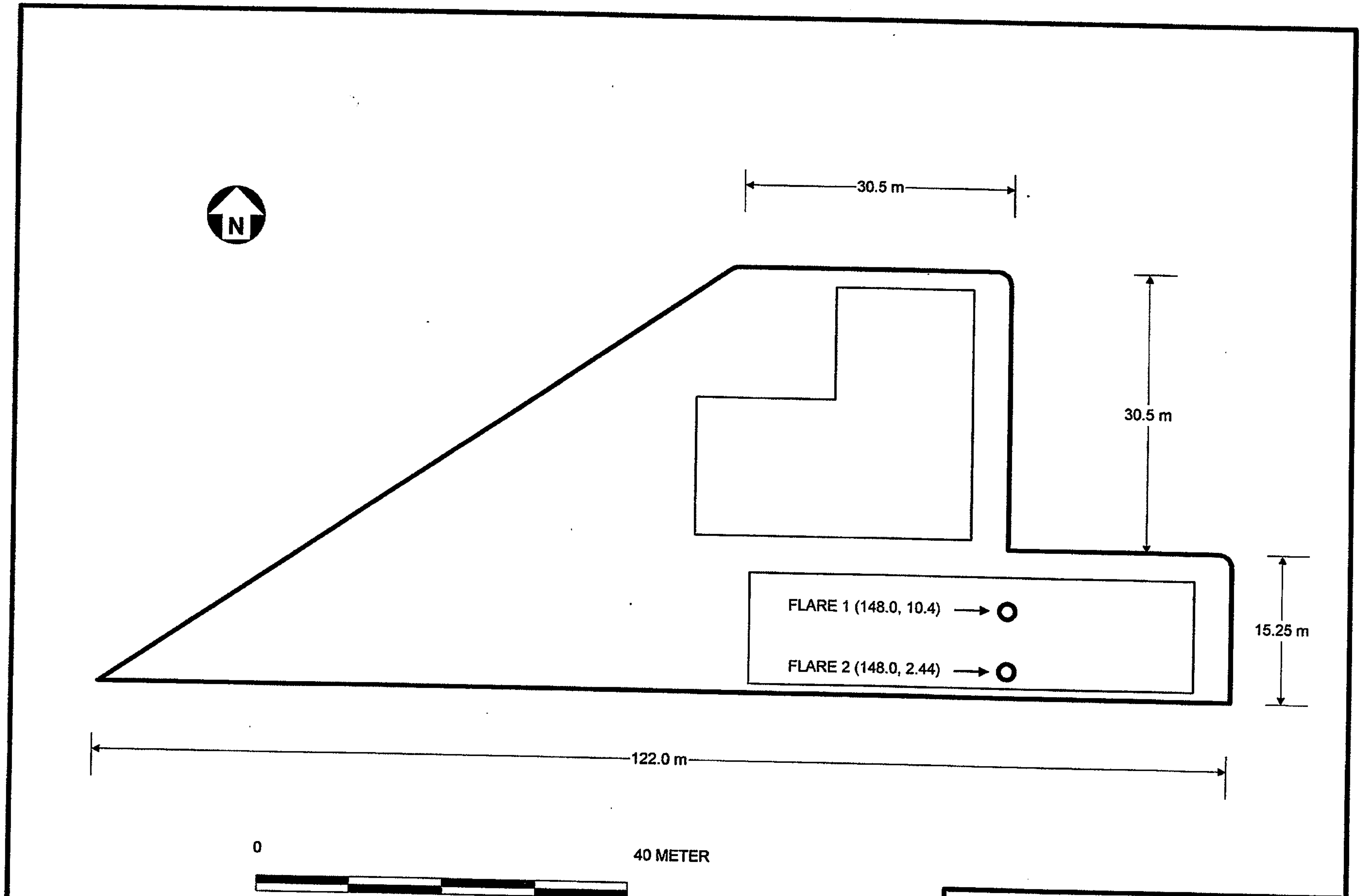

FIGURE 4. PLOT PLAN
BAS - CARSON MARKETPLACE
PROPOSED FLARE SYSTEM
CARSON, CALIFORNIA

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3. Flare Specifications

The proposed landfill gas collection will include two flares which functions as T-BACT and also as BACT for volatile organic compounds. Flare 1 is a smaller flare with 4 feet in diameter and 40 feet high and is rated at 250 scfm maximum. Flare 2 is larger with 5 feet in diameter and 40 feet high, rated at 450 scfm. Maximum process rate at the facility will be a combined rate of 700 scfm with both flares operating and minimum process rate at 50 scfm with Flare 1 operating. Control efficiency of each flare is 99%. Specifications for the flares are listed in Table 1.

4. Emission Rates

The two flares will be manufactured by John Zink Company with guaranteed maximum emission rates of criteria pollutants which include oxides of nitrogen (NO_x), carbon dioxide (CO), particulate matter (PM), and sulfur dioxide (SO_2). Emissions of particulate matter less than 10 microns were not available but is assumed to be 50% of particulate matter. The guaranteed maximum emission rates are:

Pollutant	Lb/MMBtu
NOx	2.50 x e-02
CO	6.00 x e-02
PM	4.20 x e-02
PM10*	2.10 x e-02
SO2	1.14 x e-02

Table 2 shows calculated emission rates of criteria pollutants at both maximum flow rate of 700 scfm combined and minimum flow rate of 50 scfm.

Representative emissions of the landfill gas were derived from a combination of sample gases collected from the subject landfill site. Eighteen carcinogenic and toxic contaminants were targeted and analyzed, including the list of contaminants listed in the Core Group as specified by SCAQMD Rule 1150.1. Among all, five air toxics (benzyl chloride, 1,2-dibromoethane, tetrachloromethane, 1,1,1-trichloroethane, and trichloromethane) were not detected. A copy of the landfill gas analysis is included in Appendix A.

Table 3 shows a list of the contaminants, including their corresponding CAS numbers and other chemical names commonly used. It also shows the maximum concentration of each air contaminant, uncontrolled emissions at maximum and minimum flow rates of each flare, and controlled emissions calculated based on control efficiency of 99%.

Table 1. Flare Modeling Scenarios

	Flare 1		Flare 1		Flare 2	
Flow Rate	At Minimum 50 scfm		At Maximum 250 scfm		At Maximum 450 scfm	
Heat Release	2.50 MMBtu/hr		6.830 MMBtu/hr		12.294 MMBtu/hr	
Control Efficiency	99%		99%		99%	
Height	40 ft	12.19 m	40 ft	12.19 m	40 ft	12.19 m
Diameter	4 ft	1.22 m	4 ft	1.22 m	5 ft	1.52 m
Exit Velocity	9.17 ft/sec	2.796 m/sec	27.93 ft/sec	8.518 m/sec	30.82 ft/sec	9.399 m/sec
Exit Temperature	1400 F	1033 K	1800 F	1256 K	1800 F	1256 K

Table 2. Exhaust Emissions of Critieria Pollutants

	Emission Rate lb/MMBtu	Emission Rate at 50 scfm gm/sec	Emission Rate at 250 scfm gm/sec	Emission Rate at 450 scfm gm/sec
NOx, lb/MMBtu	2.50E-02	7.8819E-03	2.1533E-02	3.8760E-02
CO, lb/MMBtu	6.00E-02	1.8917E-02	5.1680E-02	9.3025E-02
PM, lb/MMBtu	4.20E-02	1.3242E-02	3.6176E-02	6.5117E-02
PM10, lb/MMBtu *	2.10E-02	6.6208E-03	1.8088E-02	3.2559E-02
SO2, MMBtu/hr **	1.14E-03	3.6005E-04	9.8365E-04	1.7706E-03

* PM10 assumed to be 50% of calculated PM

** SO2 emissions calculated based on 3.18 ppm of H2S tested and 100% converted to SO2

Table 3. Air Toxic Emissions from Flare Operation

Contaminant	CAS #	Other Chemical Name Listed	Molecular Weight	Emission Data: Max Inlet Concentration ppm	Emission Data: Uncontrolled Emissioins mg/m^3	Emission Data: 99% Controlled Emissions mg/m^3	Controlled Emission Rate per Flare Operation: Minimum Flare 1 at 50 scfm gm/sec	Controlled Emission Rate per Flare Operation: Maximum Flare 1 at 250 scfm gm/sec	Controlled Emission Rate per Flare Operation: Maximum Flare 2 at 450 scfm gm/sec	Controlled Emission Rate per Flare Operation: Total Max Flares 1 & 2 at 700 scfm gm/sec
Benzene	71-43-2		78.11	8.33	26.6103	0.26610	6.2800E-06	3.1400E-05	5.6520E-05	8.7920E-05
1,4 - Dichlorobenzene	106-46-7	p-Dichlorobenzene	147.01	0.72	4.3289	0.04329	1.0216E-06	5.1081E-06	9.1946E-06	1.4303E-05
1,2 - Dichloroethane	107-06-2	Ethylene Dichloride	147.01	0.432	2.5973	0.02597	6.1297E-07	3.0649E-06	5.5168E-06	8.5816E-06
1,1 - Dichloroethylene	75-35-4	Vinylidene Chloride	96.95	0.329	1.3045	0.01304	3.0786E-07	1.5393E-06	2.7707E-06	4.3100E-06
Tetrachloroethylene	127-18-4	Perchloroethylene	165.85	5.77	39.1372	0.39137	9.2364E-06	4.6182E-05	8.3127E-05	1.2931E-04
Toluene	108-88-3	Methyl Benzene	92.13	14.2	53.5042	0.53504	1.2627E-05	6.3135E-05	1.1364E-04	1.7678E-04
Trichloroethylene	79-01-6		131.40	6.252	33.5979	0.33598	7.9291E-06	3.9646E-05	7.1362E-05	1.1101E-04
Vinyl Chloride	75-01-4		62.50	5.4	13.8030	0.13803	3.2575E-06	1.6287E-05	2.9317E-05	4.5605E-05
Xylenes	1330-20-7		106.16	21	91.1756	0.91176	2.1517E-05	1.0759E-04	1.9366E-04	3.0124E-04
Benzyl Chloride *	100-44-7		126.58	ND						
Chlorobenzene	108-90-7		112.56	14.7	67.6706	0.67671	1.5970E-05	7.9851E-05	1.4373E-04	2.2358E-04
1,2 - Dibromoethane *	106-93-4	Ethylene Dibromide	187.88	ND						
1,1 - Dichloroethane	75-34-3		98.97	0.0736	0.2979	0.00298	7.0306E-08	3.5153E-07	6.3275E-07	9.8428E-07
Dichloromethane	75-09-2	Methylene Chloride	84.94	2.67	9.2752	0.09275	2.1889E-06	1.0945E-05	1.9700E-05	3.0645E-05
Hydrogen Sulfide	7783064		34.08	3.18	4.4323	0.04432	1.0460E-06	5.2301E-06	9.4141E-06	1.4644E-05
Tetrachloromethane *	56-23-5	Carbon Tetrachloride	153.84	ND						
1,1,1 - Trichloroethane *	71-55-6	Methyl Chloroform	133.42	ND						
Trichloromethane *	67-66-3	Chloroform	119.39	ND						
Total Contaminants							8.2065E-05	4.1033E-04	7.3859E-04	1.1489E-03

Notes:
* Contaminant not detected.
Maximum Operating Rates: Flare 1 and Flare 2 combined 700scfm at 1800 deg F.
Minimum Operating Rate: Flare 1 operating at 50 scfm at 1400 deg F.

K:\BAS5\Bas5\Emissions

5. Air Dispersion Modeling and Health Risk Assessment Approaches

U.S. EPA-approved ISCST3 model was used in this assessment. SCAQMD recommends the use of the model, along with a full year of meteorological data, to estimate the maximum annual average ground-level concentrations that could occur at any point outside the property lines of the landfill operations center. The results of this analysis are considered as conservative and tend to over-estimate the exposure to the population.

Approaches used for the health risk assessment were based on algorithms developed by Office of Environmental Health Hazard Assessment (OEHHA) and health risk calculation methodology established by SCAQMD. Cancer risk caused by each carcinogenic contaminant was calculated using cancer potency, dose through inhalation, and daily breathing rate. Different exposure value factors, exposure frequencies, and exposure durations were also used for commercial and sensitive/residential receptors.

Maximum Individual Cancer Risks (MICR) were calculated by the cumulative risks of all carcinogenic contaminants detected. Table 4 shows the essential health risk assessment factors such as cancer potency factors through inhalation, chronic reference exposure levels, and acute reference exposure levels developed and published by OEHHA. Table 5 shows cancer potency and dose through inhalation assessment parameters adopted by SCAQMD. As recommended by SCAQMD health risk assessment guidelines, daily breathing rate (DBR) was assumed to be 149 liters per kg body weight per day for offsite worker receptors and 302 liters per kg body weight per day for sensitive residential receptors. Also, exposure value factors(EVF) used for off-site worker receptor was 0.38 based on 245 days per year of exposure duration and that used for residential receptors was 0.96 based on 350 days per year of exposure duration. Exposure duration of 40 years was used for offsite worker receptors and 70 years for residential receptors.

6. Dispersion Modeling and Air Toxic Assessment Results

The latest version of USEPA Industrial Source Complex - Short Term (ISCST3) Air Dispersion Model was used for estimating maximum ground level concentrations of air toxics. BPIP model was also used to calculate downwash effects caused by nearby building structures. Both maximum operation at 700 scfm combined flow rate (Flare 1 and Flare 2) at maximum temperature of 1800 °F and minimum operation at 50 scfm flow rate (Flare 1) at minimum temperature of 1400 °F were modeled.

Table 6A shows the modeled results for air toxics impacts at affected commercial and residential receptors at maximum combined flow rate of 700 scfm. It also shows the maximum-hourly concentration at an offsite site receptor. Table 6B shows the highest ground level concentrations modeled based on minimum operation of 50 scfm. Output printout for the modeling of air toxics at maximum and minimum flow rates are presented in Appendix B and Appendix C, respectively.

Table 4. Health Risk Assessment Factors

Contaminant	CAS #	Other Chemical Name Listed	Cancer Risk			Chroinc Impact			Acute Impact	
			Inhalation Cancer Potency	MPr	MPw	Chronic REL	MPr	MPw	Acute REL	Time Avg
Benzene	71-43-2		1.00E-01	1.00	1.00	6.00E+01	1.00	1.00	1.30E+03	6
1,4 - Dichlorobenzene	106-46-7	p-Dichlorobenzene	4.00E-02	1.00	1.00	8.00E+02	1.00	1.00		
1,2 - Dichloroethane	107-06-2	Ethylene Dichloride	7.20E-02	1.00	1.00	4.00E+02	1.00	1.00		
1,1 - Dichloroethylene	75-35-4	Vinylidene Chloride				7.00E+01	1.00	1.00		
Tetrachloroethylene	127-18-4	Perchloroethylene	2.10E-02	1.00	1.00	3.50E+01	1.00	1.00	2.00E+04	1
Toluene	108-88-3	Methyl Benzene				3.00E+02	1.00	1.00	3.70E+04	1
Trichloroethylene	79-01-6		7.00E-03	1.00	1.00	6.00E+02	1.00	1.00		
Vinyl Chloride	75-01-4		2.70E-01	1.00	1.00				1.80E+05	1
Xylenes	1330-20-7					7.00E+02	1.00	1.00	2.20E+04	1
Benzyl Chloride *	100-44-7		1.70E-01	1.00	1.00				2.40E+02	1
Chlorobenzene	108-90-7					1.00E+03	1.00	1.00		
1,2 - Dibromoethane *	106-93-4	Ethylene Dibromide	2.50E-01	1.00	1.00	8.00E-01	1.00	1.00		
1,1 - Dichloroethane	75-34-3		5.70E-03	1.00	1.00					
Dichloromethane	75-09-2	Methylene Chloride	3.50E-03	1.00	1.00	4.00E+02	1.00	1.00	1.40E+04	1
Hydrogen Sulfide	7783064					1.00E+01	1.00	1.00	4.20E+01	1
Tetrachloromethane *	56-23-5	Carbon Tetrachloride	1.50E-01	1.00	1.00	4.00E+01	1.00	1.00	1.90E+03	7
1,1,1 - Trichloroethane *	71-55-6	Methyl Chloroform				1.00E+03	1.00	1.00	6.80E+04	1
Trichloromethane *	67-66-3	Chloroform	1.90E-02	1.00	1.00	3.00E+02	1.00	1.00	1.50E+02	7

Note:
* Contaminant not detected
Shaded area has no published cancer potency inhalation, chronic, or acute reference exposure value.
MPr, MPw - Multiplier factors for residential and worker receptors, respectively.
REL - Reference Esposure Level.

Table 5. Cancer Risk and Health Index Assessment Parameters

	Parameter	Off-Site Worker	Residence
Daily Breathing Rate, l/kg-day	DBR	149	302
Exposure Value Factor	EVF	0.38	0.96
Inhalation Absorption *	A	1	1
Exposure Frequency, days/yr	EF	245	350
Exposure Duration, year	ED	40	70
Averaging Time Period, day	AT	25,550	25,550
Multiple Pathway	MP	1	1

Source: Health risk parameters and assessment algorithm used were based on published guidelines developed by Office of Environmental Health Hazard Assessment of Cal EPA and adopted by South Coast Air Quality Management Ditrict, July 2005.
* (OEHHA guideline, A = 1)

Table 6A. Modeled Maximum Concentrations with Flare 1 and Flare 2 at Maximum 700 scfm

	Two Flares at Total Flow Rate of 700 scfm		
	Commercial Receptor	Residential Receptor	Offsite Receptor
Annual Concentration, ug/m^3	0.00954	0.00168	
Location	(224.0, 22.0)	(450.0, -47.0)	
Max Hourly Concentration, ug/m^3	0.18290	0.14002	0.18123
Location	(192.0, 22.0)	(150.0, -47.0)	(152.0, 52.0)
Calculated Dose, Inhalation (DI)	**5.4522E-07**	**4.8651E-07**	

Table 6B. Modeled Maximum Concentrations with Flare 1 at Minimum 50 scfm

	Flare 1 at Minimum Flow Rate of 50 scfm		
	Commercial Receptor	Residential Receptor	Offsite Receptor
Annual Concentration, ug/m3	0.00197	0.00037	
Location	(224.0, 22.0)	(400.0, -47.0)	
Max Hourly Concentration, ug/m^3	0.02545	0.01018	0.02467
Location	(168.0, 37.0)	(150.0, -47.0)	(152.0, 52.0)
Calculated Dose, Inhalation (DI)	**1.1259E-07**	**1.0715E-07**	

Tables 7A and 7B show the health risk assessment results based on maximum operating rate of 700 scfm combined. Table 7A tabulates the calculated results of maximum individual cancer risks (MICR). Based on controlled emissions calculated, modeled concentrations, health risk assessment factors developed by OEHHA, and health risk calculation methodology adopted by SCAQMD, the MICRs are calculated to be:

Recptor	MICR
Nearest Commercial Recptor	1.23×10^{-8}
Nearest Residential Recptor	1.10×10^{-8}

Table 7B tabulates the health impact indices to the offsite and residential receptors based on maximum flow rate. The resulting health impact indices are:

Receptor	HIC	HIA
Nearest Commercial Recptor	6.83×10^{-5}	7.06×10^{-5}
Nearest Residential Receptor	1.20×10^{-5}	5.41×10^{-5}
Nearest Offsite Receptor	N/A	7.00×10^{-5}

*N/A - Not Applicable

Tables 8A and 8B show the health risk assessment results based on minimum operating rate of 50 scfm. Table 8A tabulates the calculated results of maximum individual cancer risks (MICR). Based on controlled emissions calculated, modeled concentrations, health risk assessment factors developed by OEHHA, and health risk calculation methodology established by SCAQMD, the MICRs are calculated to be:

Recptor	MICR
Nearest Commercial Recptor	2.54×10^{-9}
Nearest Residential Recptor	2.42×10^{-9}

Table 8B tabulates the health impact indices to the offsite and residential receptors based on minimum flow rate. The resulting health impact indices are:

Receptor	HIC	HIA
Nearest Commercial Recptor	1.41×10^{-5}	9.83×10^{-6}
Nearest Residential Receptor	2.65×10^{-6}	3.93×10^{-6}
Nearest Offsite Receptor	N/A	9.53×10^{-6}

*N/A - Not Applicable

Table 7A. Cancer Risks Based on Two Flares at Maximum Rates of 700 scfm

Contaminant	CAS #	Other Chemical Name Listed	Cancer Potency Inhalation	Commercial Dose Inhalation	Commercial Cancer Risk	Residential Dose Inhalation	Residential Cancer Risk
					0.00954		0.00168
Benzene	71-43-2		1.00E-01	4.17E-08	4.17E-09	3.72E-08	3.72E-09
1,4 - Dichlorobenzene	106-46-7	p-Dichlorobenzene	4.00E-02	6.79E-09	2.71E-10	6.06E-09	2.42E-10
1,2 - Dichloroethane	107-06-2	Ethylene Dichloride	7.20E-02	4.07E-09	2.93E-10	3.63E-09	2.62E-10
1,1 - Dichloroethylene	75-35-4	Vinylidene Chloride					
Tetrachloroethylene	127-18-4	Perchloroethylene	2.10E-02	6.14E-08	1.29E-09	5.48E-08	1.15E-09
Toluene	108-88-3	Methyl Benzene					
Trichloroethylene	79-01-6		7.00E-03	5.27E-08	3.69E-10	4.70E-08	3.29E-10
Vinyl Chloride	75-01-4		2.70E-01	2.16E-08	5.84E-09	1.93E-08	5.21E-09
Xylenes	1330-20-7						
Benzyl Chloride *	100-44-7		1.70E-01				
Chlorobenzene	108-90-7						
1,2 - Dibromoethane *	106-93-4	Ethylene Dibromide	2.50E-01				
1,1 - Dichloroethane	75-34-3		5.70E-03	4.67E-10	2.66E-12	4.17E-10	2.38E-12
Dichloromethane	75-09-2	Methylene Chloride	3.50E-03	1.45E-08	5.09E-11	1.30E-08	4.54E-11
Hydrogen Sulfide	7783064						
Tetrachloromethane *	56-23-5	Carbon Tetrachloride	1.50E-01				
1,1,1 - Trichloroethane *	71-55-6	Methyl Chloroform					
Trichloromethane *	67-66-3	Chloroform	1.90E-02				
Total Cancer Risk, MICR (at Maximum Rates)					1.23E-08		1.10E-08

Note: * Contaminant not detected
Otherwise shaded area has no published cancer potency inhalation value.

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Table 7B. Non Cancer Health Impacts Based on Two Flares at Maximum Rates

Contaminant	CAS #	Other Chemical Name Listed	Commercial HIC Chronic	Residential HIC Chronic	Commercial HIA Acute	Residential HIA Acute	Offsite HIA Acute
Benzene	71-43-2		1.22E-05	2.14E-06	1.08E-05	8.24E-06	1.07E-05
1,4 - Dichlorobenzene	106-46-7	p-Dichlorobenzene	1.48E-07	2.61E-08			
1,2 - Dichloroethane	107-06-2	Ethylene Dichloride	1.78E-07	3.14E-08			
1,1 - Dichloroethylene	75-35-4	Vinylidene Chloride	5.11E-07	9.00E-08			
Tetrachloroethylene	127-18-4	Perchloroethylene	3.07E-05	5.40E-06	1.03E-06	7.88E-07	1.02E-06
Toluene	108-88-3	Methyl Benzene	4.89E-06	8.62E-07	7.61E-07	5.82E-07	7.54E-07
Trichloroethylene	79-01-6		1.54E-06	2.71E-07			
Vinyl Chloride	75-01-4				4.03E-08	3.09E-08	4.00E-08
Xylenes	1330-20-7		3.57E-06	6.29E-07	2.18E-06	1.67E-06	2.16E-06
Benzyl Chloride *	100-44-7						
Chlorobenzene	108-90-7		1.86E-06	3.27E-07			
1,2 - Dibromoethane *	106-93-4	Ethylene Dibromide					
1,1 - Dichloroethane	75-34-3						
Dichloromethane	75-09-2	Methylene Chloride	6.36E-07	1.12E-07	3.48E-07	2.67E-07	3.45E-07
Hydrogen Sulfide	7783064		1.22E-05	2.14E-06	5.55E-05	4.25E-05	5.50E-05
Tetrachloromethane *	56-23-5	Carbon Tetrachloride					
1,1,1 - Trichloroethane *	71-55-6	Methyl Chloroform					
Trichloromethane *	67-66-3	Chloroform					
Total Non Cancer Health Impact (at Maximum Rates)			**6.83E-05**	**1.20E-05**	**7.06E-05**	**5.41E-05**	**7.00E-05**

Note: * Contaminant not detected
Otherwise shaded area has no published chronic or acute reference exposure value.

Table 8A. Cancer Risks Based on Flare 1 at Minimum Rate

Contaminant	CAS #	Other Chemical Name Listed	Cancer Potency Inhalation	Commercial Dose Inhalation	Commercial Cancer Risk	Residential Dose Inhalation	Residential Cancer Risk
					0.00197		0.00037
Benzene	71-43-2		1.00E-01	8.62E-09	8.62E-10	8.20E-09	8.20E-10
1,4 - Dichlorobenzene	106-46-7	p-Dichlorobenzene	4.00E-02	1.40E-09	5.61E-11	1.33E-09	5.34E-11
1,2 - Dichloroethane	107-06-2	Ethylene Dichloride	7.20E-02	8.41E-10	6.05E-11	8.00E-10	5.76E-11
1,1 - Dichloroethylene	75-35-4	Vinylidene Chloride					
Tetrachloroethylene	127-18-4	Perchloroethylene	2.10E-02	1.27E-08	2.66E-10	1.21E-08	2.53E-10
Toluene	108-88-3	Methyl Benzene					
Trichloroethylene	79-01-6		7.00E-03	1.09E-08	7.61E-11	1.04E-08	7.25E-11
Vinyl Chloride	75-01-4		2.70E-01	4.47E-09	1.21E-09	4.25E-09	1.15E-09
Xylenes	1330-20-7						
Benzyl Chloride *	100-44-7		1.70E-01				
Chlorobenzene	108-90-7						
1,2 - Dibromoethane *	106-93-4	Ethylene Dibromide	2.50E-01				
1,1 - Dichloroethane	75-34-3		5.70E-03	9.65E-11	5.50E-13	9.18E-11	5.23E-13
Dichloromethane	75-09-2	Methylene Chloride	3.50E-03	3.00E-09	1.05E-11	2.86E-09	1.00E-11
Hydrogen Sulfide	7783064						
Tetrachloromethane *	56-23-5	Carbon Tetrachloride					
1,1,1 - Trichloroethane *	71-55-6	Methyl Chloroform					
Trichloromethane *	67-66-3	Chloroform					
Total Cancer Risk, MICR (at Minimum Rate)					**2.54E-09**		**2.42E-09**

Note: * Contaminant not detected
Otherwise shaded area has no published cancer potency inhalation value.

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Table 8B. Non Cancer Health Impacts Based on Flare 1 at Minimum Rate

Contaminant	CAS #	Other Chemical Name Listed	Commercial HIC Chronic	Residential HIC Chronic	Commercial HIA Acute	Residential HIA Acute	Offsite HIA Acute
Benzene	71-43-2		2.51E-06	4.72E-07	1.50E-06	5.99E-07	1.45E-06
1,4 - Dichlorobenzene	106-46-7	p-Dichlorobenzene	3.07E-08	5.76E-09			
1,2 - Dichloroethane	107-06-2	Ethylene Dichloride	3.68E-08	6.91E-09			
1,1 - Dichloroethylene	75-35-4	Vinylidene Chloride	1.06E-07	1.98E-08			
Tetrachloroethylene	127-18-4	Perchloroethylene	6.33E-06	1.19E-06	1.43E-07	5.73E-08	1.39E-07
Toluene	108-88-3	Methyl Benzene	1.01E-06	1.90E-07	1.06E-07	4.23E-08	1.03E-07
Trichloroethylene	79-01-6		3.17E-07	5.96E-08			
Vinyl Chloride	75-01-4				5.61E-09	2.24E-09	5.44E-09
Xylenes	1330-20-7		7.38E-07	1.39E-07	3.03E-07	1.21E-07	2.94E-07
Benzyl Chloride *	100-44-7						
Chlorobenzene	108-90-7		3.83E-07	7.20E-08			
1,2 - Dibromoethane *	106-93-4	Ethylene Dibromide					
1,1 - Dichloroethane	75-34-3						
Dichloromethane	75-09-2	Methylene Chloride	1.31E-07	2.47E-08	4.85E-08	1.94E-08	4.70E-08
Hydrogen Sulfide	7783064		2.51E-06	4.72E-07	7.72E-06	3.09E-06	7.49E-06
Tetrachloromethane *	56-23-5	Carbon Tetrachloride					
1,1,1 - Trichloroethane *	71-55-6	Methyl Chloroform					
Trichloromethane *	67-66-3	Chloroform					
Total Non Cancer Health Impact (at Minimum Rate)			**1.41E-05**	**2.65E-06**	**9.83E-06**	**3.93E-06**	**9.53E-06**

Note: * Not Detected
Otherwise shaded area has no published chronic or acute reference exposure value.

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7. Results of Air Quality Impact Analyses of Criteria Pollutants

The latest version of USEPA ISCST3 Air Dispersion Model was also used for estimating maximum ground level concentrations of criteria pollutants which include oxides of nitrogen (NO_x), carbon dioxide (CO), particulate matter at 10 microns (PM_{10}), and sulfur dioxide (SO_2). USEPA BPIP model was also used to calculate downwash effects caused by nearby building structures. Both maximum (worst-case) operation at 700 scfm combined flow rate and minimum operation at 50 scfm flow rate were modeled. The resulting modeled highest onsite concentrations caused by the maximum operation of the facility are listed as follows:

Criteria Pollutant	Annual (ug/m^3)	24-Hour (ug/m^3)	8-Hour (ug/m^3)	3-Hour (ug/m^3)	1-Hour (ug/m^3)
No_x	0.57460	N/A	N/A	N/A	10.87306
CO	N/A	N/A	15.58957	N/A	26.09567
PM_{10}	0.48267	2.28776	N/A	N/A	N/A
SO_2	0.02625	0.12441	N/A	0.43008	0.49669

*N/A - Not Applicable

Table 9 shows the comparison of modeled results of criteria pollutants at various averaging time and the air quality standards established by California and Federal EPA. As shown in the table, the highest air quality impacts modeled for all criteria pollutants are orders of magnitude better than the regulated air quality impact thresholds. Output printout for the modeling of criteria pollutants of NO_x, CO, PM_{10}, and SO_2 at maximum and minimum flow rates are presented in Appendix D and Appendix E, respectively.

8. Conclusions

The proposed facility is equipped with two flares as emission control systems which are best available control technology for toxics (T-BACT) for landfill gas collection facilities. The results of the ISCST3 modeling and health risk assessment indicated that the MICRs at the nearest commercial and residential building are less than the ten in a million (< 10×10^{-6}) threshold and the highest non cancer health indices less than 1. The modeled results and risk assessment show that emissions from the landfill gas facility will not cause significant cancer risks to the closest receptors and operation of the facility will be in compliance with SCAQMD Rule 1401.

In addition, emissions of criteria pollutants of NO_x, CO, PM_{10}, and SO_2 were modeled and analyzed for air quality impact. Modeled results of maximum concentrations of each of the criteria pollutants are well below the regulated thresholds as specified by both California and Federal EPA. This shows that there will be no air quality impacts caused by the operation of the proposed facility.

Table 9. Comparison of Air Quality Standards for Critieria Pollutants

		Ambient Air Quality Standard		Highest AQ Impact Flares 1&2 at Max 700 scfm Combined		Highest AQ Impact Flare 1 at Minimum 50 scfm	
Criteria Pollutants	Averaging Time	State ug/m^3	Federal ug/m^3	Onsite Impact ug/m^3	Offsite Impact ug/m^3	Onsite Impact ug/m^3	Offsite Impact ug/m^3
NOx	Annual	57	100	0.57460	0.07106	0.22897	0.03769
NOx	1 Hour	399		10.87306	9.51053	2.47205	2.36907
CO	8 Hour	10000	10000	15.58957	12.20908	4.57660	3.86941
CO	1 Hour	23000	40000	26.09567	22.82557	5.93307	5.68590
PM10	Annual	50	150	0.48267	0.05969	0.19233	0.03166
PM10	24 Hour	20		2.28776	1.42442	0.70679	0.45214
SO2	Annual		80	0.02625	0.00325	0.01046	0.00172
SO2	24 Hour	105	365	0.12441	0.07746	0.03844	0.02459
SO3	3 Hour		1300	0.43008	0.28665	0.10196	0.10069
SO2	1 Hour	655		0.49669	0.43445	0.11292	0.10822

Note: Shaded area has no regulated air quality standard.

CARSON MARKETPLACE

ADDENDUM
to the
Final Environmental Impact Report

SCH No. 2005051059

JULY 2009

Appendix B: Application for Permit to Construct and Permit to Operate Landfill Gas Treatment System -- GAC/KMN, February 2009

matrix environmental

Application for Permit to Construct and Permit to Operate Landfill Gas Treatment System--GAC/KMN

The Boulevards at South Bay, LLC

February 2009

Submitted To:

South Coast Air Quality Management District
21865 East Copley Drive
Diamond Bar, California 91765

Prepared For and Submitted By:

The Boulevards at South Bay, LLC
c/o LNR Properties
4350 Von Karman Avenue, Suite 2000
Newport Beach, California 92660

Prepared By:

BAS

BRYAN A. STIRRAT & ASSOCIATES
1360 Valley Vista Drive
Diamond Bar, California 91765
(909) 860-7777

THE BOULEVARDS AT SOUTH BAY, LLC

TABLE OF CONTENTS

THE BOULEVARDS AT SOUTH BAY, LLC
(FORMER CAL COMPACT LANDFILL)
APPLICATION FOR PERMIT TO CONSTRUCT AND PERMIT TO OPERATE LANDFILL GAS TREATMENT SYSTEM—GAC/KMN

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

THE BOULEVARDS AT SOUTH BAY, LLC
(FORMER CAL COMPACT LANDFILL)
APPLICATION FOR PERMIT TO CONSTRUCT AND PERMIT TO OPERATE
LANDFILL GAS TREATMENT SYSTEM—GAC/KMN

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF ATTACHMENTS

THE BOULEVARDS AT SOUTH BAY, LLC

SECTION 1.0

APPLICATION

1.0 APPLICATION FOR PERMIT TO CONSTRUCT AND PERMIT TO OPERATE LANDFILL GAS TREATMENT SYSTEM

1.1 APPLICANT

The Boulevards at South Bay, LLC
c/o LNR Properties
4350 Von Karman Avenue, #2000
Newport Beach, California 92660

1.2 CONSULTANT

Bryan A. Stirrat & Associates (BAS)
1360 Valley Vista Drive
Diamond Bar, California 91765
Contact: G.E. Andraos
Phone: (909) 860-7777, ext. 251

1.3 BACKGROUND

The former Cal Compact Landfill (Figure 1) was operated from its opening in April 1959 through its closure in February 1965. The 157 acre Class II landfill accepted both municipal solid waste and specified industrial liquid wastes. Available records indicate that over 90 percent of the liquid wastes were drilling fluids which consisted primarily of water and clay mixtures, with minor heavy metal additives and oily residue. Other wastes received included solvents, oils, sludges, heavy metals, paint sludges, and inorganic salts. The landfill operations consisted of excavation of trenches and the placement and covering of wastes in the trenches. A total of five cells were constructed in the landfill. An interim soil cap overlies all five cells that comprise the entire landfill area. The interim landfill soil cap varies in thickness from approximately 2 feet to over 30 feet and averages approximately 11 feet in thickness across the Site.

The site has been approved for development by the California Environmental Protection Agency's Department of Toxic Substance Control to become the "The Boulevards of South Bay", with requirement of several remedial measures to protect the public and future users. One of these remedial systems is a landfill gas collection and treatment system. The purpose of proposed temporary extraction system is to develop landfill gas generation and composition data in order to design the required permanent collection system. The landfill gas collection and treatment system will be comprised of vertical and horizontal gas wells connected to a header circumscribing the site (Figure 2). The header will terminate at the gas treatment station where the gas will be initially treated for non-methane organics by carbon adsorption.

1.4 EQUIPMENT LOCATION

Former Cal-Compact Landfill
20300 Main Street
Carson, California 90745
Contact: Javier Weckmann, VP, TetraTech, Inc.
See Figures 1 and 2

1.5 DESCRIPTION OF GAS TREATMENT EQUIPMENT

This is an application to install a Landfill Gas Treatment Equipment system that is designed to process up to a maximum flow of 350 standard cubic feet per minute (scfm) of landfill gas at The Boulevards of South Bay site. The system is a granular activated and potassium permanganate system intended to provide landfill gas treatment in the interim until the flares that have been designed and purchased can be installed.

The proposed Treatment System will consist of the following major equipment:

- **Centrifugal Gas Blowers (B–103, B-104):** Mfr.: Houston Service Industries, Inc. HSI-5105 driven by a 40 HP TEFC motor equipped with VFD. A blower performance curve is included in Attachment 1. Tests have been performed to demonstrate no overheating when operating at 50 scfm flow. Also, space is provided on the blower skid for a third smaller blower, e.g., 25-50 scfm operating range. This small blower would either be rented or purchased and installed if the flows from the initial gas extraction area are consistently below 50 scfm.

- **Carbon Adsorption Vessels (V-2 A/B/C/D Primary, Secondary, Tertiary and Backup):** Baker Filtration, Model TSU-2000S, 4 canisters each containing 2,000 lbs. of activated carbon (Primary, Secondary, Tertiary and backup) to adsorb the non-methane contaminants in the LFG.

- **Potassium Permanganate (KMN) Primary and Backup (V-3A/B):** For treatment of specific non methane organics. Baker Filtration, Model TSU-1000S, or equal, vessels, 2 canisters each containing 2,000 lbs. of potassium permanganate (primary, and backup).

- **Exhaust Vent Stack:** 50' tall 10" diameter exhaust vent stack.

- **Flame Arrestor (FA-1):** Mfr.: Groth, vertical type.

- **Flow Element (FE-1):** Mfr.: Kurz, hot wire anemometer.

1.6 OPERATION AND PROCESS CONTROL

GAC treatment of LFG has proved to be a cost effective method for removal of toxic air contaminants (TAC), especially on older, inactive landfills where higher British thermal unit (BTU) LFG and flow rates are not possible. Also, due to the phasing of development of the site and build-out of the gas extraction system the GAC system is suited for treatment of the low volume of LFG expected to be extracted from the initial phases of the system. The LFG Treatment facility is located as shown on the LFG Control System Plan, Figure 2. The phasing plan for site development and build-out of the gas extraction system is shown on Figure 3. Cell 1 and 2 are expected to have the gas extraction system installed and operating by fall of 2009. Operation of the municipal waste landfill ceased over 40 years ago and the gas generation rate is on the downside of the "bell shaped" decay curve. The gas generation projected for these two cells is conservatively estimated at 175-250 scfm, based on the gas generation projections included in the LFG Extraction System permit application submitted to SCAQMD in August, 2008 and pro-rated for Cells 1 and 2 only, but may be lower.

The treatment system will utilize the same LFG extraction and condensate handling systems basic elements as shown in those permit applications submitted August, 2008. The facilities layout is shown on Figure 4, which includes the future flaring systems only for reference.

The facility is designed to process a maximum of 350 SCFM of LFG. A Process Flow Diagram (Figure 5) and a Mechanical Assembly Plan (Figure 6) for the GAC system are included in the Figure section of this permit application. The PLC panel that has been designed for the future flaring system will have additional separate controls for operating and monitoring the GAC system. Also, the condensate generated from the gas extraction system would be stored in the tank shown on Figure 4 and the tank would be emptied as needed and the condensate hauled to a facility for proper treatment and disposal until the Liquids Treatment Plant to be constructed at the landfill is up and running.

The inlet of the treatment facility will be equipped with a knockout vessel rated for removal of particulates and free liquids and is designed to operate with one blower in operation, and one blower as 100% backup. These blowers will be designed for operational capacity of 500 SCFM of LFG each as they would also be used for the future flares or expansion of the GAC as the LFG flow increases with gas extraction system additions. A VFD will be provided to reduce the Treatment System's electric consumption at the lower flow-rates and provide a greater turn down ratio. Both LFG temperature and pressure are measured via a pressure and temperature indicator on the discharge of the blower. The control system will incorporate an automatically controlled telephone "auto-dialer" to inform designated personnel if a shut down and or an alarm condition occurs.

After the LFG enters the suction side of the operating blower, it is discharged under positive pressure into a series of two 2000 pound GAC vessels. One 2000 pound GAC vessel will serve as a standby and be utilized when the primary GAC vessel is saturated and requires servicing. By use of valves, the LFG can be routed to any or each of these vessels. During normal operation the LFG is routed into the primary vessel, out of the primary and into the secondary and tertiary vessels then through a flame arrestor with differential pressure indicator and discharged through a vent stack. In compliance with the Health Risk Assessment, the outlet LFG will be routed through a 25' high supported vent stack. At this point, the process temperature of the LFG is expected to be near ambient temperatures. A Mechanical Assembly Plan (Figure 6) shows the layout of the system.

During operations, monitoring of Total Gaseous Non-Methane Non-Ethane Organic Compounds (TGNMNEOCs) will be performed at the inlet and outlet of the GAC and recorded on a routine basis using a Photo Ionization Detector (PID). When the monitoring indicates the primary vessels are approaching saturation with VOCs, the gas stream will be routed to the backup vessel while the primary vessel is being replenished.

THE BOULEVARDS AT SOUTH BAY, LLC

SECTION 2.0

ROG EMISSIONS AND HEALTH RISK SCREENING ASSESSMENT

2.0 ROG EMISSIONS AND HEALTH RISK SCREENING ASSESSMENT

2.1 ROG EMISSIONS CALCULATION AND EXEMPTION FROM MORATORIUM ON ERCS

Using the laboratory data on samples collected from the GAC system vent stack outlet during the Pilot Test we calculated the lbs/day for each non-attainment air pollutant. The GAC/KMN system produces no NOx, SO2, CO or measurable PM10. The calculation for total VOCs or Total Gaseous Non Methane Non Ethane Organics (TGNMNEO) is included as Attachment 5 and indicates less than 0.5 lbs/day of TGNMNEO emissions from the vent stack for the system operating at 350 scfm.

2.2 HEALTH RISK SCREENING

In compliance with SCAQMD Rule 212 and 1401, a screening risk assessment analysis using SCAQMD guidelines was conducted for air toxics to evaluate compliance with SCAQMD standards.

The toxic compounds evaluated in the screening analysis are those listed in the SCAQMD Rule 1150.1 Toxic Air Contaminant Core Group and also listed in SCAQMD Rule 1401.

The health risk screening analysis was conducted in compliance with the guidelines presented in SCAQMD's "Risk Assessment Procedures for Rules 1401 and 212" - Version 7.0, July 2005.

In an effort to characterize the landfill gas as necessary for the Health Risk Assessment, BAS utilized the sample test results for the inlet gas stream collected during the Pilot Test conducted under SCAQMD permits at the site in 2007. The collected samples were each tested by a Certified Laboratory for total gaseous non methane non ethane organic compounds (TGNMNEOCs), TO-15 and sulfur compounds, as well as permanent gases which include methane, carbon dioxide, oxygen and nitrogen.

The results of the screening risk assessment analysis which includes the Maximum Individual Cancer Risk (MICR) screening, and both the chronic and acute toxic screening show that the health risks associated with the emissions from the proposed treatment facility with 350 scfm landfill gas flow and a 50 foot stack height are in compliance with SCAQMD's Rules 1401 and 212 (see Tables 1A, 1B, 2A, 2B and 3).

THE BOULEVARDS AT SOUTH BAY, LLC

TABLES 1A & 1B

SCAQMD TIER2 SCREENING RISK ASSESSMENT
GAC TREATMENT SYSTEM
MAXIMUM INDIVIDUAL CANCER RISK (MICR)

TABLE 1A

TIER 2 SCREENING RISK ASSESSMENT: THE BOULEVARDS AT SOUTH BAY GAC TREATMENT SYSTEM--NEAREST COMMERCIAL RECEPTOR

MAXIMUM INDIVIDUAL CANCER RISK (MICR)

			@ % CH4	Total CH4 Flow, SCFM	Stack Ht. (ft.)	Fence line (m)
Total Flow	350	SCFM	54.30%	190.05	50	50
Exhaust Flow (total)	350	SCFM				

CP	Inhalation Cancer Potency
REL	Reference Exposure Level
MP	Multi Pathway Adjustment Factor
MICR	Maximum Individual Cancer Risk

Fixed Gases	Est. Conc. In LFG	Units
Methane	54.30	%
Carbon dioxide	29.50	%
Oxygen	0.43	%
Nitrogen	9.95	%
TGNMO	4,840.00	ppmv
SOX (as SO2)	NA	ppmn
PM10	NA	Grains/DSCF
DRE	99	%

$MICR = CP * Q_{tons} * X/Q * A_{fann} * MET * DBR * EVF * 10^{-6} * MP$

Requires input decision

									Table 8a									
									Cancer		Chronic		Acute					
Toxics	Conc. , ppb	MW	Lb/hr into Facility	Lb/hr out of Treatment Facility	Tons/yr out of Treatment Facility	X/Q Tbl 3A 50' Stack at 50 m ONE IN A MILLION AND CHRONIC	MET Table 3B	Afann Table 3C	CP	MP (R for residential - W for work)	REL	MP(R for residential - W for work)	REL	DBR Table 9A	EVF Table 9B	Tier 2 MICR		Pounds removed based on DRE
Hydrogen Sulfide	3180.00	34.08	6.00E-03	6.00E-05	2.63E-04	2.38	0.6	1	0	1	1	1	4.20E+01	149	0.38	0.00E+00	Hydrogen Sulfide	0.005937
1,2-Dibromoethane (ethylene dibromide)	0.09	173.83	8.66E-07	8.66E-09	3.79E-08	2.38	0.6	1	2.50E-01	1	8.00E-01	1	1	149	0.38	7.66E-13	1,2-Dibromoethane (ethylene dibromide)	0.000001
Benzene	8330.00	78.12	3.60E-02	3.60E-04	1.58E-03	2.38	0.6	1	1.00E-01	1	6.00E+01	1	1.30E+03	149	0.38	1.28E-08	Benzene	0.035649
Benzyl chloride	0.13	126.59	8.76E-07	8.76E-09	3.84E-08	2.38	0.6	1	1.70E-01	1	1	1	2.40E+02	149	0.38	5.27E-13	Benzyl chloride	0.000001
Carbon tetrachloride	0.10	153.82	8.09E-07	8.09E-09	3.54E-08	2.38	0.6	1	1.50E-01	1	4.00E+01	1	1.90E+03	149	0.38	4.30E-13	Carbon tetrachloride	0.000001
Chlorobenzene	14700.00	112.56	9.16E-02	9.16E-04	4.01E-03	2.38	0.6	1	0	1	1.00E+03	1	1	149	0.38	0.00E+00	Chlorobenzene	0.090645
Chloroform (trichloromethane)	0.12	119.38	7.60E-07	7.60E-09	3.33E-08	2.38	0.6	1	1.90E-02	1	3.00E+02	1	1.50E+02	149	0.38	5.11E-14	Chloroform (trichloromethane)	0.000001
1,3-Dichlorobenzene	720.00	147.01	5.86E-03	5.86E-05	2.57E-04	2.38	0.6	1	4.00E-02	1	8.00E+02	1	1	149	0.38	8.30E-10	1,3-Dichlorobenzene	0.005799
1,4-Dichlorobenzene	0	147.01	0.00E+00	0.00E+00	0.00E+00	2.38	0.6	1	0	1	1	1	1	149	0.38	0.00E+00	1,4-Dichlorobenzene	0.000000
1,2-Dichlorobenzene	0	147.01	0.00E+00	0.00E+00	0.00E+00	2.38	0.6	1	0	1	1	1	1	149	0.38	0.00E+00	1,2-Dichlorobenzene	0.000000
1,1-Dichloroethane (ethylidene chloride)	0.11	98.96	5.75E-07	5.75E-09	2.52E-08	2.38	0.6	1	5.73E-03	1	1	1	1	149	0.38	1.17E-14	1,1-Dichloroethane (ethylidene chloride)	0.000001
1,2-Dichloroethane (ethylene dichloride)	432.00	98.96	2.37E-03	2.37E-05	1.04E-04	2.38	0.6	1	7.20E-02	1	4.00E+02	1	1	149	0.38	6.03E-10	1,2-Dichloroethane (ethylene dichloride)	0.002342
1,1-Dichloroethene (vinylidene chloride)	329.00	96.94	1.76E-03	1.76E-05	7.73E-05	2.38	0.6	1	0.00E+00	1	1	1	1	149	0.38	0.00E+00	1,1-Dichloroethene (vinylidene chloride)	0.001747
Methylene chloride (dichloromethane)	2870.00	84.93	1.35E-02	1.35E-04	5.91E-04	2.38	0.6	1	3.50E-03	1	4.00E+02	1	1.40E+04	149	0.38	1.67E-10	Methylene chloride (dichloromethane)	0.013353
Tetrachloroethene (perchloroethylene)	577.00	165.8	5.29E-03	5.29E-05	2.32E-04	2.38	0.6	1	2.10E-02	1	3.50E+01	1	2.00E+04	149	0.38	3.94E-10	Tetrachloroethene (perchloroethylene)	0.005241
Toluene	16000.00	92.15	8.16E-02	8.16E-04	3.57E-03	2.38	0.6	1	0	1	3.00E+02	1	3.70E+04	149	0.38	0.00E+00	Toluene	0.080771
1,1,1-Trichloroethane (methyl chloroform)	0.11	133.41	7.75E-07	7.75E-09	3.40E-08	2.38	0.6	1	0	1	1.00E+03	1	6.80E+04	149	0.38	0.00E+00	1,1,1-Trichloroethane (methyl chloroform)	0.000001
Trichloroethene	6252.00	131.39	4.55E-02	4.55E-04	1.99E-03	2.38	0.6	1	7.00E-03	1	6.00E+02	1	1	149	0.38	1.13E-09	Trichloroethene	0.045001
Vinyl chloride	5400.0	62.5	1.87E-02	1.87E-04	8.18E-04	2.38	0.6	1	2.70E-01	1	1	1	1.80E+05	149	0.38	1.79E-08	Vinyl chloride	0.018489
Total xylenes	21000.00	106.17	1.23E-01	1.23E-03	5.40E-03	2.38	0.6	1	0	1	7.00E+02	1	2.20E+04	149	0.38	0.00E+00	Total xylenes	0.122142
						50' stack at 50 meters downwind distance	Compton	Used for 24/7		Work and residential values same for core group		Work and residential values same for core group		Using offsite worker	Using offsite worker			
															RISK PER MILLION =	0.03	(Must be less than 1)	

TABLE 1B

TIER 2 SCREENING RISK ASSESSMENT: THE BOULEVARDS AT SOUTH BAY GAC TREATMENT SYSTEM

NEAREST RESIDENTIAL RECEPTOR--MAXIMUM INDIVIDUAL CANCER RISK (MICR)

			@ % CH4	Total CH4 Flow, SCFM	Stack Ht. (ft.)	Fence line (m)
Total Flow	350	SCFM	54.30%	190.05	50	50
Exhaust Flow (total)	350	SCFM				

CP	Inhalation Cancer Potency
REL	Reference Exposure Level
MP	Multi Pathway Adjustment Factor
MICR	Maximum Individual Cancer Risk
	Requires input decision

Fixed Gases	Est. Conc. in LFG	Units
Methane	54.30	%
Carbon dioxide	29.50	%
Oxygen	0.43	%
Nitrogen	9.95	%
TGNMO	4,840.00	ppmv
SOX (as SO2)	NA	ppmn
PM10	NA	Grains/DSCF
DRE	99	%

$MICR = CP * Q_{tons} * X/Q * A_{fann} * MET * DBR * EVF * 10^{-6} * MP$

									Table 8a									
									Cancer		Chronic		Acute					
Toxics	Conc., ppb	MW	Lb/hr Into Facility	Lb/hr out of Treatment Facility	Tons/yr out of Treatment Facility	X/Q Tbl 3A 50' Stack at 50 m ONE IN A MILLION AND CHRONIC	MET Table 3B	Afann Table 3C	CP	MP (R for residential - W for work)	REL	MP(R for residential - W for work)	REL	DBR Table 9A	EVF Table 9B	Tier 2 MICR		Pounds removed based on DRE
Hydrogen Sulfide	3180.00	34.08	6.00E-03	6.00E-05	2.63E-04	2.38	0.6	1	0	1	1	1	4.20E+01	302	0.96	0.00E+00	Hydrogen Sulfide	0.005937
1,2-Dibromoethane (ethylene dibromide)	0.09	173.83	8.66E-07	8.66E-09	3.79E-08	2.38	0.6	1	2.50E-01	1	8.00E-01	1	1	302	0.96	3.92E-12	1,2-Dibromoethane (ethylene dibromide)	0.000001
Benzene	8330.00	78.12	3.60E-02	3.60E-04	1.58E-03	2.38	0.6	1	1.00E-01	1	6.00E+01	1	1.30E+03	302	0.96	6.53E-08	Benzene	0.035649
Benzyl chloride	0.13	126.59	8.76E-07	8.76E-09	3.84E-08	2.38	0.6	1	1.70E-01	1	1	1	2.40E+02	302	0.96	2.70E-12	Benzyl chloride	0.000001
Carbon tetrachloride	0.10	153.82	8.09E-07	8.09E-09	3.54E-08	2.38	0.6	1	1.50E-01	1	4.00E+01	1	1.90E+03	302	0.96	2.20E-12	Carbon tetrachloride	0.000001
Chlorobenzene	14700.00	112.56	9.16E-02	9.16E-04	4.01E-03	2.38	0.6	1	0	1	1.00E+03	1	1	302	0.96	0.00E+00	Chlorobenzene	0.090645
Chloroform (trichloromethane)	0.12	119.38	7.60E-07	7.60E-09	3.33E-08	2.38	0.6	1	1.90E-02	1	3.00E+02	1	1.50E+02	302	0.96	2.62E-13	Chloroform (trichloromethane)	0.000001
1,3-Dichlorobenzene	720.00	147.01	5.86E-03	5.86E-05	2.57E-04	2.38	0.6	1	4.00E-02	1	8.00E+02	1	1	302	0.96	4.25E-09	1,3-Dichlorobenzene	0.005799
1,4-Dichlorobenzene	0	147.01	0.00E+00	0.00E+00	0.00E+00	2.38	0.6	1	0	1	1	1	1	302	0.96	0.00E+00	1,4-Dichlorobenzene	0.000000
1,2-Dichlorobenzene	0	147.01	0.00E+00	0.00E+00	0.00E+00	2.38	0.6	1	0	1	1	1	1	302	0.96	0.00E+00	1,2-Dichlorobenzene	0.000000
1,1-Dichloroethane (ethylidene chloride)	0.11	98.96	5.75E-07	5.75E-09	2.52E-08	2.38	0.6	1	5.73E-03	1	1	1	1	302	0.96	5.97E-14	1,1-Dichloroethane (ethylidene chloride)	0.000001
1,2-Dichloroethane (ethylene dichloride)	432.00	98.96	2.37E-03	2.37E-05	1.04E-04	2.38	0.6	1	7.20E-02	1	4.00E+02	1	1	302	0.96	3.09E-09	1,2-Dichloroethane (ethylene dichloride)	0.002342
1,1-Dichloroethene (vinylidene chloride)	329.00	96.94	1.76E-03	1.76E-05	7.73E-05	2.38	0.6	1	0.00E+00	1	1	1	1	302	0.96	0.00E+00	1,1-Dichloroethene (vinylidene chloride)	0.001747
Methylene chloride (dichloromethane)	2870.00	84.93	1.35E-02	1.35E-04	5.91E-04	2.38	0.6	1	3.50E-03	1	4.00E+02	1	1.40E+04	302	0.96	8.56E-10	Methylene chloride (dichloromethane)	0.013353
Tetrachloroethene (perchloroethylene)	577.00	165.8	5.29E-03	5.29E-05	2.32E-04	2.38	0.6	1	2.10E-02	1	3.50E+01	1	2.00E+04	302	0.96	2.02E-09	Tetrachloroethene (perchloroethylene)	0.005241
Toluene	16000.00	92.15	8.16E-02	8.16E-04	3.57E-03	2.38	0.6	1	0	1	3.00E+02	1	3.70E+04	302	0.96	0.00E+00	Toluene	0.080771
1,1,1-Trichloroethane (methyl chloroform)	0.11	133.41	7.75E-07	7.75E-09	3.40E-08	2.38	0.6	1	0	1	1.00E+03	1	6.80E+04	302	0.96	0.00E+00	1,1,1-Trichloroethane (methyl chloroform)	0.000001
Trichloroethene	6252.00	131.39	4.55E-02	4.55E-04	1.99E-03	2.38	0.6	1	7.00E-03	1	6.00E+02	1	1	302	0.96	5.77E-09	Trichloroethene	0.045001
Vinyl chloride	5400.0	62.5	1.87E-02	1.87E-04	8.18E-04	2.38	0.6	1	2.70E-01	1	1	1	1.80E+05	302	0.96	9.14E-08	Vinyl chloride	0.018489
Total xylenes	21000.00	106.17	1.23E-01	1.23E-03	5.40E-03	2.38	0.6	1	0	1	7.00E+02	1	2.20E+04	302	0.96	0.00E+00	Total xylenes	0.122142
						50' stack at 50 meters distance	Compton	Used for 24/7		Work and residential values same for core group		Work and residential values same for core group		Using Residential	Using Residential			

RISK PER MILLION = 0.17 (Must be less than 1)

THE BOULEVARDS AT SOUTH BAY, LLC

TABLES 2A & 2B

SCAQMD TIER2 SCREENING RISK ASSESSMENT
GAC TREATMENT SYSTEM
CHRONIC AND ACUTE TOXICITY

TABLE 2A

TIER 2 SCREENING RISK ASSESSMENT: THE BOULEVARDS AT SOUTH BAY GAC TREATMENT SYSTEM--NEAREST COMMERCIAL RECEPTOR CHRONIC AND ACUTE TOXICITY

			@ % CH4	Total CH4 Flow, SCFM	Stack Ht. (ft,)	Fence line (m)
Total Flow	350	SCFM	0.54	190.05	50	50
Exhaust Flow (total)	350	SCFM				

Fixed Gases	Est. Conc. in LFG	Units	
Methane	54.3	%	
Carbon dioxide	29.5	%	
Oxygen	0.4	%	
Nitrogen	10.0	%	
TGNMO	4,840.0	ppm	
SOX (as SO2)	NA	ppm	
PM10	NA	Grains/DSCF	
DRE	99.0	%	Using 0% because on discharge of canister

ACUTE AND CHRONIC HEALTH RISK INDICES CALCULATIONS

Toxics	Conc. , ppb	MW	Lb/hr Into Treatment Facility	Lb/hr out of Facility	Tons/yr out of Treatment Facility	REL (chron.) Reference Exposure Level Table 8A	X/Q Tbl 3A 50' Stack 100 m downwind for ONE IN A MILLION AND CHRONIC	MET Table 3B	MP (Chronic) Table 8A (R for residential and W for work)	HIC	REL (Acute) Reference Exposure Level Table 8A	X/Q Tbl 6, 50' Stack for ACUTE	Adjustment Factor (AF) Table 8b	HIA	
Hydrogen Sulfide	3180	34	6.0E-03	6.00E-05	2.63E-04	1.0E+00	2.38	0.6	1	3.75E-04	4.2E+01	110.1	1	1.57E-04	Hydrogen Sulfide
1,2-Dibromoethane (ethylene dibromide)	0.09	173.83	8.7E-07	8.66E-09	3.79E-08	8.0E-01	2.38	0.6	1	6.77E-08	1.0E+00	110.1	1	9.53E-07	1,2-Dibromoethane (ethylene dibromide)
Benzene	8330	78.12	3.6E-02	3.60E-04	1.58E-03	6.0E+01	2.38	0.6	1	3.75E-05	1.3E+03	110.1	0.67	2.04E-05	Benzene
Benzyl chloride	0.125	126.59	8.8E-07	8.76E-09	3.84E-08	1.0E+00	2.38	0.6	1	5.48E-08	2.4E+02	110.1	1	4.02E-09	Benzyl chloride
Carbon tetrachloride	0.095	153.82	8.1E-07	8.09E-09	3.54E-08	4.0E+01	2.38	0.6	1	1.26E-09	1.9E+03	110.1	0.67	3.14E-10	Carbon tetrachloride
Chlorobenzene	14700	112.56	9.2E-02	9.16E-04	4.01E-03	1.0E+03	2.38	0.6	1	5.73E-06	1.0E+00	110.1	1	1.01E-01	Chlorobenzene
Chloroform (trichloromethane)	0.115	119.38	7.6E-07	7.60E-09	3.33E-08	3.0E+02	2.38	0.6	1	1.58E-10	1.5E+02	110.1	0.67	3.74E-09	Chloroform (trichloromethane)
1,3-Dichlorobenzene	720	147.01	5.9E-03	5.86E-05	2.57E-04	8.0E+02	2.38	0.6	1	4.58E-07	1.0E+00	110.1	1	6.45E-03	1,3-Dichlorobenzene
1,4-Dichlorobenzene	0	147.01	0.0E+00	0.00E+00	0.00E+00	1.0E+00	2.38	0.6	1	0.00E+00	1.0E+00	110.1	1	0.00E+00	1,4-Dichlorobenzene
1,2-Dichlorobenzene	0	147.01	0.0E+00	0.00E+00	0.00E+00	1.0E+00	2.38	0.6	1	0.00E+00	1.0E+00	110.1	1	0.00E+00	1,2-Dichlorobenzene
1,1-Dichloroethane (ethylidene chloride)	0.105	98.96	5.7E-07	5.75E-09	2.52E-08	1.0E+00	2.38	0.6	1	3.60E-08	1.0E+00	110.1	1	6.33E-07	1,1-Dichloroethane (ethylidene chloride)
1,2-Dichloroethane (ethylene dichloride)	432	98.96	2.4E-03	2.37E-05	1.04E-04	4.0E+02	2.38	0.6	1	3.70E-07	1.0E+00	110.1	1	2.60E-03	1,2-Dichloroethane (ethylene dichloride)
1,1-Dichloroethene (vinylidene chloride)	329	96.94	1.8E-03	1.76E-05	7.73E-05	1.0E+00	2.38	0.6	1	1.10E-04	1.0E+00	110.1	1	1.94E-03	1,1-Dichloroethene (vinylidene chloride)
Methylene chloride (dichloromethane)	2870	84.93	1.3E-02	1.35E-04	5.91E-04	4.0E+02	2.38	0.6	1	2.11E-06	1.4E+04	110.1	1	1.06E-06	Methylene chloride (dichloromethane)
Tetrachloroethene (perchloroethylene)	577	165.8	5.3E-03	5.29E-05	2.32E-04	3.5E+01	2.38	0.6	1	9.46E-06	2.0E+04	110.1	1	2.91E-07	Tetrachloroethene (perchloroethylene)
Toluene	16000	92.15	8.2E-02	8.16E-04	3.57E-03	3.0E+02	2.38	0.6	1	1.70E-05	3.7E+04	110.1	1	2.43E-06	Toluene
1,1,1-Trichloroethane (methyl chloroform)	0.105	133.41	7.8E-07	7.75E-09	3.40E-08	1.0E+03	2.38	0.6	1	4.85E-11	6.8E+04	110.1	1	1.26E-11	1,1,1-Trichloroethane (methyl chloroform)
Trichloroethene	6252	131.39	4.5E-02	4.55E-04	1.99E-03	6.0E+02	2.38	0.6	1	4.74E-06	1.0E+00	110.1	1	5.00E-02	Trichloroethene
Vinyl chloride	5400	62.5	1.9E-02	1.87E-04	8.18E-04	1.0E+00	2.38	0.6	1	1.17E-03	1.8E+05	110.1	1	1.14E-07	Vinyl chloride
Total xylenes	21000	106.17	1.2E-01	1.23E-03	5.40E-03	7.0E+02	2.38	0.6	1	1.10E-05	2.2E+04	110.1	1	6.17E-06	Total xylenes
												using 50' stack at 50 meters			

ACUTE AND CHRONIC TOXICITY SCREENING

Target Organs Affected By Toxic Air Contanminants (Chronic Toxicity)

Toxics	AL	BN	CV	DEV	END	EYE	HEM	IMM	KID	NS	REP	RESP	SKIN
Hydrogen Sulfide												3.75E-04	
1,2-Dibromoethane (ethylene dibromide)												6.77E-08	
Benzene				3.75E-05			3.75E-05			3.75E-05			
Benzyl chloride													
Carbon tetrachloride	1.26E-09			1.26E-09						1.26E-09			
Chlorobenzene	5.73E-06								5.73E-06		5.73E-06		
Chloroform (trichloromethane)	1.58E-10			1.58E-10					1.58E-10				
1,3-Dichlorobenzene	4.58E-07								4.58E-07	4.58E-07		4.58E-07	
1,4-Dichlorobenzene													
1,2-Dichlorobenzene													
1,1-Dichloroethane (ethylidene chloride)													
1,2-Dichloroethane (ethylene dichloride)	3.70E-07												
1,1-Dichloroethene (vinylidene chloride)	1.10E-04												
Methylene chloride (dichloromethane)			2.11E-06							2.11E-06			
Tetrachloroethene (perchloroethylene)	9.46E-06			9.46E-06					9.46E-06				
Toluene				1.70E-05						1.70E-05		1.70E-05	
1,1,1-Trichloroethane (methyl chloroform)										4.85E-11			
Trichloroethene						1.94E-04				1.94E-04			
Vinyl chloride													
Total xylenes										1.10E-05		1.10E-05	
	1.3E-04	0.0E+00	2.1E-06	6.4E-05	0.0E+00	1.9E-04	3.8E-05	0.0E+00	1.6E-05	2.6E-04	5.7E-06	4.0E-04	0.0E+00

Total of each organ/system must be less than one

Chronic

Target Organs Affected By Toxic Air Contanminants (Acute Toxicity)

AL	CV	DEV	EYE	HEM	IMM	NS	REP	RESP	SKIN	Toxics
						1.57E-04				Hydrogen Sulfide
										1,2-Dibromoethane (ethylene dibromide)
		2.04E-05		2.04E-05	2.04E-05		2.04E-05			Benzene
			4.02E-09					4.02E-09		Benzyl chloride
3.14E-10		3.14E-10				3.14E-10	3.14E-10			Carbon tetrachloride
										Chlorobenzene
		3.74E-09				3.74E-09	3.74E-09			Chloroform (trichloromethane)
										1,3-Dichlorobenzene
										1,4-Dichlorobenzene
										1,2-Dichlorobenzene
										1,1-Dichloroethane (ethylidene chloride)
										1,2-Dichloroethane (ethylene dichloride)
										1,1-Dichloroethene (vinylidene chloride)
						1.06E-06				Methylene chloride (dichloromethane)
			2.91E-07			2.91E-07		2.91E-07		Tetrachloroethene (perchloroethylene)
		2.43E-06	2.43E-06			2.43E-06	2.43E-06	2.43E-06		Toluene
						1.26E-11				1,1,1-Trichloroethane (methyl chloroform)
										Trichloroethene
			1.14E-07			1.14E-07		1.14E-07		Vinyl chloride
			6.17E-06					6.17E-06		Total xylenes
3.1E-10	0.0E+00	2.3E-05	9.0E-06	2.0E-05	2.0E-05	1.6E-04	2.3E-05	9.0E-06	0.0E+00	

Total of each organ/system must be less than one

Acute

TABLE 2B

TIER 2 SCREENING RISK ASSESSMENT: THE BOULEVARDS AT SOUTH BAY GAC TREATMENT SYSTEM--NEAREST RESIDENTIAL RECEPTOR CHRONIC AND ACUTE TOXICITY

			@ % CH4	Total CH4 Flow, SCFM	Stack Ht. (ft,)	Fence line (m)
Total Flow	350	SCFM	0.54	190.05	50	50
Exhaust Flow (total)	350	SCFM				
Fixed Gases	Est. Conc. in LFG	Units				
Methane	54.3	%				
Carbon dioxide	29.5	%				
Oxygen	0.4	%				
Nitrogen	10.0	%				
TGNMO	4,840.0	ppm				
SOX (as SO2)	NA	ppm				
PM10	NA	Grains/DSCF				
DRE	99.0	%	Using 0% because on discharge of canister			

ACUTE AND CHRONIC HEALTH RISK INDICES CALCULATIONS

Toxics	Conc. , ppb	MW	Lb/hr Into Treatment Facility	Lb/hr out of Facility	Tons/yr out of Treatment Facility	REL (chron.) Reference Exposure Level Table 8A	X/Q Tbl 3A 50' Stack 50 m downwind for ONE IN A MILLION AND CHRONIC	MET Table 3B	MP (Chronic) Table 8A (R for residential and W for work)	HIC	REL (Acute) Reference Exposure Level Table 8A	X/Q Tbl 6, 50' Stack for ACUTE	Adjustment Factor (AF) Table 8b	HIA	
Hydrogen Sulfide	3180	34	6.0E-03	6.00E-05	2.63E-04	1.0E+00	2.38	0.6	1	3.75E-04	4.2E+01	110.1	1	1.57E-04	Hydrogen Sulfide
1,2-Dibromoethane (ethylene dibromide)	0.09	173.83	8.7E-07	8.66E-09	3.79E-08	8.0E-01	2.38	0.6	1	6.77E-08	1.0E+00	110.1	1	9.53E-07	1,2-Dibromoethane (ethylene dibromide)
Benzene	8330	78.12	3.6E-02	3.60E-04	1.58E-03	6.0E+01	2.38	0.6	1	3.75E-05	1.3E+03	110.1	0.67	2.04E-05	Benzene
Benzyl chloride	0.125	126.59	8.8E-07	8.76E-09	3.84E-08	1.0E+00	2.38	0.6	1	5.48E-08	2.4E+02	110.1	1	4.02E-09	Benzyl chloride
Carbon tetrachloride	0.095	153.82	8.1E-07	8.09E-09	3.54E-08	4.0E+01	2.38	0.6	1	1.26E-09	1.9E+03	110.1	0.67	3.14E-10	Carbon tetrachloride
Chlorobenzene	14700	112.56	9.2E-02	9.16E-04	4.01E-03	1.0E+03	2.38	0.6	1	5.73E-06	1.0E+00	110.1	1	1.01E-01	Chlorobenzene
Chloroform (trichloromethane)	0.115	119.38	7.6E-07	7.60E-09	3.33E-08	3.0E+02	2.38	0.6	1	1.58E-10	1.5E+02	110.1	0.67	3.74E-09	Chloroform (trichloromethane)
1,3-Dichlorobenzene	720	147.01	5.9E-03	5.86E-05	2.57E-04	8.0E+02	2.38	0.6	1	4.58E-07	1.0E+00	110.1	1	6.45E-03	1,3-Dichlorobenzene
1,4-Dichlorobenzene	0	147.01	0.0E+00	0.00E+00	0.00E+00	1.0E+00	2.38	0.6	1	0.00E+00	1.0E+00	110.1	1	0.00E+00	1,4-Dichlorobenzene
1,2-Dichlorobenzene	0	147.01	0.0E+00	0.00E+00	0.00E+00	1.0E+00	2.38	0.6	1	0.00E+00	1.0E+00	110.1	1	0.00E+00	1,2-Dichlorobenzene
1,1-Dichloroethane (ethylidene chloride)	0.105	98.96	5.7E-07	5.75E-09	2.52E-08	1.0E+00	2.38	0.6	1	3.60E-08	1.0E+00	110.1	1	6.33E-07	1,1-Dichloroethane (ethylidene chloride)
1,2-Dichloroethane (ethylene dichloride)	432	98.96	2.4E-03	2.37E-05	1.04E-04	4.0E+02	2.38	0.6	1	3.70E-07	1.0E+00	110.1	1	2.60E-03	1,2-Dichloroethane (ethylene dichloride)
1,1-Dichloroethene (vinylidene chloride)	329	96.94	1.8E-03	1.76E-05	7.73E-05	1.0E+00	2.38	0.6	1	1.10E-04	1.0E+00	110.1	1	1.94E-03	1,1-Dichloroethene (vinylidene chloride)
Methylene chloride (dichloromethane)	2870	84.93	1.3E-02	1.35E-04	5.91E-04	4.0E+02	2.38	0.6	1	2.11E-06	1.4E+04	110.1	1	1.06E-06	Methylene chloride (dichloromethane)
Tetrachloroethene (perchloroethylene)	577	165.8	5.3E-03	5.29E-05	2.32E-04	3.5E+01	2.38	0.6	1	9.46E-06	2.0E+04	110.1	1	2.91E-07	Tetrachloroethene (perchloroethylene)
Toluene	16000	92.15	8.2E-02	8.16E-04	3.57E-03	3.0E+02	2.38	0.6	1	1.70E-05	3.7E+04	110.1	1	2.43E-06	Toluene
1,1,1-Trichloroethane (methyl chloroform)	0.105	133.41	7.8E-07	7.75E-09	3.40E-08	1.0E+03	2.38	0.6	1	4.85E-11	6.8E+04	110.1	1	1.26E-11	1,1,1-Trichloroethane (methyl chloroform)
Trichloroethene	6252	131.39	4.5E-02	4.55E-04	1.99E-03	6.0E+02	2.38	0.6	1	4.74E-06	1.0E+00	110.1	1	5.00E-02	Trichloroethene
Vinyl chloride	5400	62.5	1.9E-02	1.87E-04	8.18E-04	1.0E+00	2.38	0.6	1	1.17E-03	1.8E+05	110.1	1	1.14E-07	Vinyl chloride
Total xylenes	21000	106.17	1.2E-01	1.23E-03	5.40E-03	7.0E+02	2.38	0.6	1	1.10E-05	2.2E+04	110.1	1	6.17E-06	Total xylenes
												using 50' stack at 50 meters			

ACUTE AND CHRONIC TOXICITY SCREENING

Target Organs Affected By Toxic Air Contanminants (Chronic Toxicity)

Toxics	AL	BN	CV	DEV	END	EYE	HEM	IMM	KID	NS	REP	RESP	SKIN
Hydrogen Sulfide												3.75E-04	
1,2-Dibromoethane (ethylene dibromide)												6.77E-08	
Benzene				3.75E-05			3.75E-05			3.75E-05			
Benzyl chloride													
Carbon tetrachloride	1.26E-09			1.26E-09						1.26E-09			
Chlorobenzene	5.73E-06								5.73E-06		5.73E-06		
Chloroform (trichloromethane)	1.58E-10			1.58E-10					1.58E-10				
1,3-Dichlorobenzene	4.58E-07								4.58E-07	4.58E-07		4.58E-07	
1,4-Dichlorobenzene													
1,2-Dichlorobenzene													
1,1-Dichloroethane (ethylidene chloride)													
1,2-Dichloroethane (ethylene dichloride)	3.70E-07												
1,1-Dichloroethene (vinylidene chloride)	1.10E-04												
Methylene chloride (dichloromethane)			2.11E-06							2.11E-06			
Tetrachloroethene (perchloroethylene)	9.46E-06			9.46E-06					9.46E-06				
Toluene				1.70E-05						1.70E-05		1.70E-05	
1,1,1-Trichloroethane (methyl chloroform)										4.85E-11			
Trichloroethene						1.94E-04				1.94E-04			
Vinyl chloride													
Total xylenes										1.10E-05		1.10E-05	
	1.3E-04	0.0E+00	2.1E-06	6.4E-05	0.0E+00	1.9E-04	3.8E-05	0.0E+00	1.6E-05	2.6E-04	5.7E-06	4.0E-04	0.0E+00

Total of each organ/system must be less than one

Chronic

Target Organs Affected By Toxic Air Contanminants (Acute Toxicity)

AL	CV	DEV	EYE	HEM	IMM	NS	REP	RESP	SKIN	
						1.57E-04				Hydrogen Sulfide
										1,2-Dibromoethane (ethylene dibromide)
		2.04E-05		2.04E-05	2.04E-05		2.04E-05			Benzene
			4.02E-09					4.02E-09		Benzyl chloride
3.14E-10		3.14E-10				3.14E-10	3.14E-10			Carbon tetrachloride
										Chlorobenzene
		3.74E-09				3.74E-09	3.74E-09			Chloroform (trichloromethane)
										1,3-Dichlorobenzene
										1,4-Dichlorobenzene
										1,2-Dichlorobenzene
										1,1-Dichloroethane (ethylidene chloride)
										1,2-Dichloroethane (ethylene dichloride)
										1,1-Dichloroethene (vinylidene chloride)
						1.06E-06				Methylene chloride (dichloromethane)
			2.91E-07			2.91E-07		2.91E-07		Tetrachloroethene (perchloroethylene)
		2.43E-06	2.43E-06			2.43E-06	2.43E-06	2.43E-06		Toluene
						1.26E-11				1,1,1-Trichloroethane (methyl chloroform)
										Trichloroethene
			1.14E-07			1.14E-07		1.14E-07		Vinyl chloride
			6.17E-06					6.17E-06		Total xylenes
3.1E-10	0.0E+00	2.3E-05	9.0E-06	2.0E-05	2.0E-05	1.6E-04	2.3E-05	9.0E-06	0.0E+00	

Total of each organ/system must be less than one

Acute

THE BOULEVARDS AT SOUTH BAY, LLC

TABLE 3

CORE GROUP--SCAQMD RULE 1150.1
SAMPLE RESULTS

TABLE 3 The Boulevards at South Bay Lab Summary Data–Pilot Test Inlet Highest Values

Core Group–SCAQMD Rule 1150.1

Analyte	Batch	MDL	1/2 MDL	Sample Result ppbv Inlet
Benzene	TO-15	0.17	0.085	8330.00
Benzyl Chloride	TO-15	0.25	0.125	0.13
Chlorobenzene	TO-15	0.29	0.145	14700.00
1,2-Dibromoethane (Ethylene Dibromide)	TO-15	0.18	0.090	0.09
Dichlorobenzenes (o,p &m-)	TO-15	0.38	0.190	720.00
1,1-Dichloroethane (Ethylidene Chloride)	TO-15	0.21	0.105	0.11
1,2-Dichloroethane (Ethylene Dichloride)	TO-15	0.19	0.095	432.00
1,1-Dichloroethene (Vinylidene Chloride)	TO-15	0.23	0.115	329.00
Dichloromethane (Methylene Chloride)	TO-15	0.16	0.080	2870.00
Hydrogen Sulfide	AQMD 307.91	2	1.000	3180.00
Tetrachloroethene (Perchloroethylene)	TO-15	0.21	0.105	577.00
Tetrachloromethane (Carbon tetrachloride)	TO-15	0.19	0.095	0.10
Toluene	TO-15	0.31	0.155	16000.00
1,1,1-Trichloroethane (Methyl Chloroform)	TO-15	0.21	0.105	0.11
Trichloroethene	TO-15	0.21	0.105	6252.00
Trichloromethane (Chloroform)	TO-15	0.23	0.115	0.12
Vinyl chloride	TO-15	0.17	0.085	5400.00
Xylenes (o.m,&p-)	TO-15	0.34	0.170	21000.00

Key: MDL = Method Detection Limit

checked vs lab

TGNMNEO (ppmv)	4840
CH_4 (%/v)	54.3
CO_2 (%/v)	29.5
O_2 (%/v)	0.43
N_2 (%/v)	9.95

Note 1: Volatile organic compounds by TO-15 method utilizing cryogenic GC/MS
Note 2: Hydrogen Sulfide by SCAQMD 307.91 method utilizing GC/Chemiluminence

AccuLabs, Inc.

THE BOULEVARDS AT SOUTH BAY, LLC

FIGURES

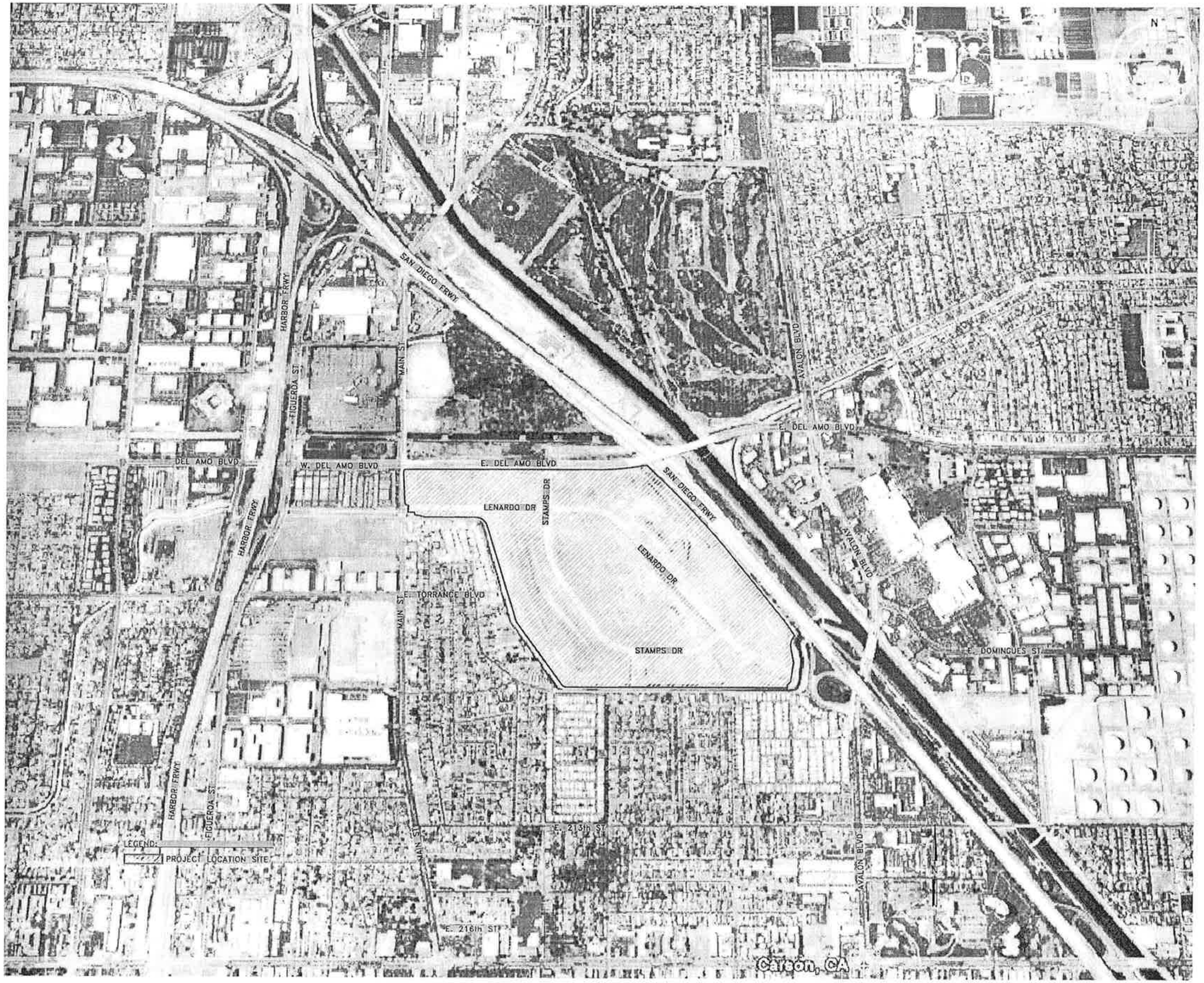

FIGURE 1

FOR PERMITTING PURPOSES ONLY

BAS
BRYAN A. STIRRAT & ASSOCIATES
CIVIL AND ENVIRONMENTAL ENGINEERS
1360 VALLEY VISTA DRIVE DIAMOND BAR, CA 91765
(909) 860-7777

THE BOULEVARDS AT SOUTH BAY (FORMER CAL COMPACT LANDFILL)

LANDFILL GAS TREATMENT FACILITY - GAC/KMN
SITE LOCATION MAP

JOB NO. 2008.0037-T3
DATE 02/2009
DRAWN BY FMR
FILE NAME: CARSON GAC-FIG1

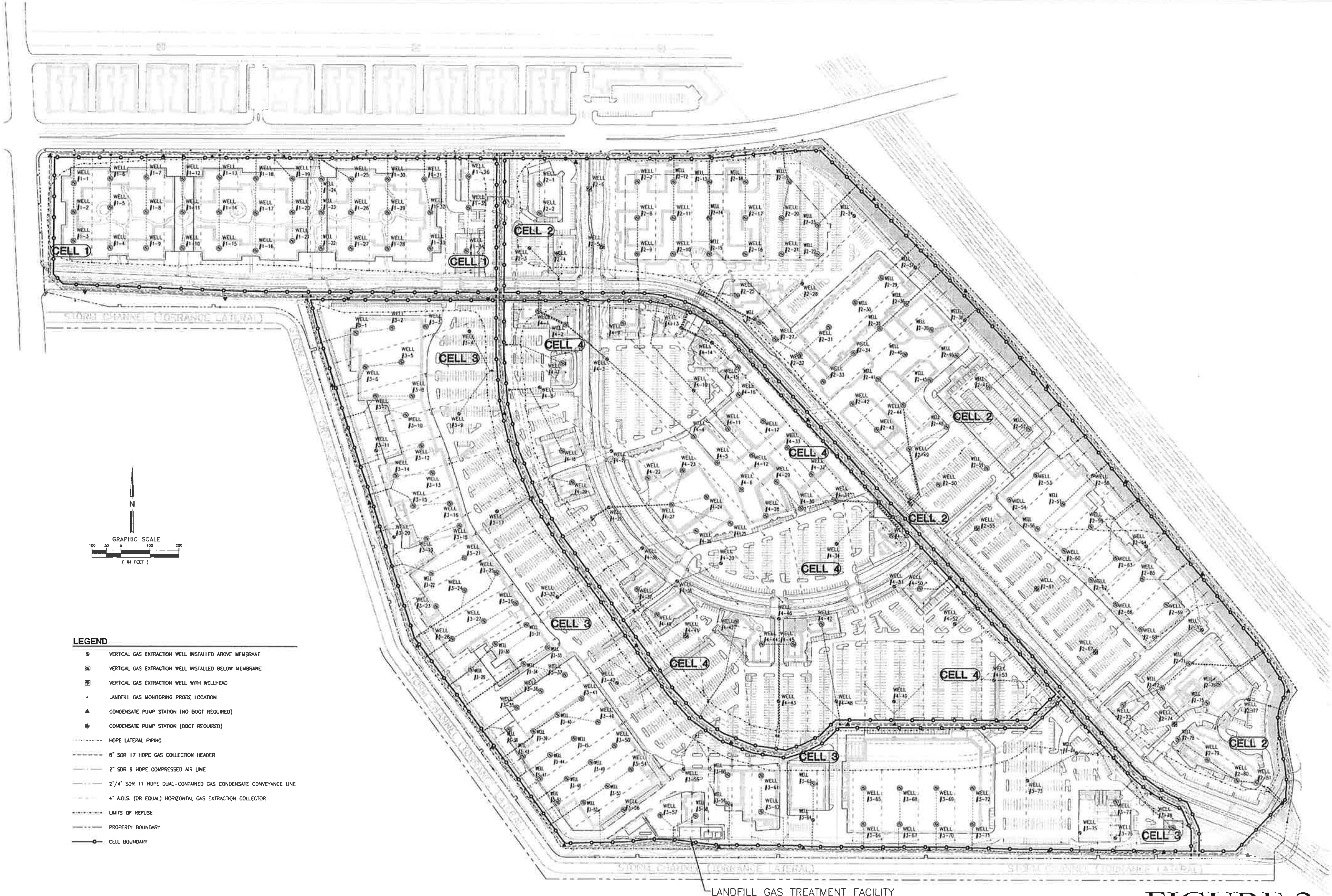

FIGURE 2

FOR PERMITTING PURPOSES ONLY

THE BOULEVARDS AT SOUTH BAY (FORMER CAL COMPACT LANDFILL)

LANDFILL GAS TREATMENT FACILITY - GAC/KMN
LFG EXTRACTION SYSTEM LAYOUT

JOB NO. 2008.0037-T3
DATE 02/2009
DRAWN BY JNR
FILE NAME: CARSON GAC-FIG2

BAS
BRYAN A. STIRRAT & ASSOCIATES
CIVIL AND ENVIRONMENTAL ENGINEERS
1360 VALLEY VISTA DRIVE DIAMOND BAR, CA 91765
(909) 860-7777

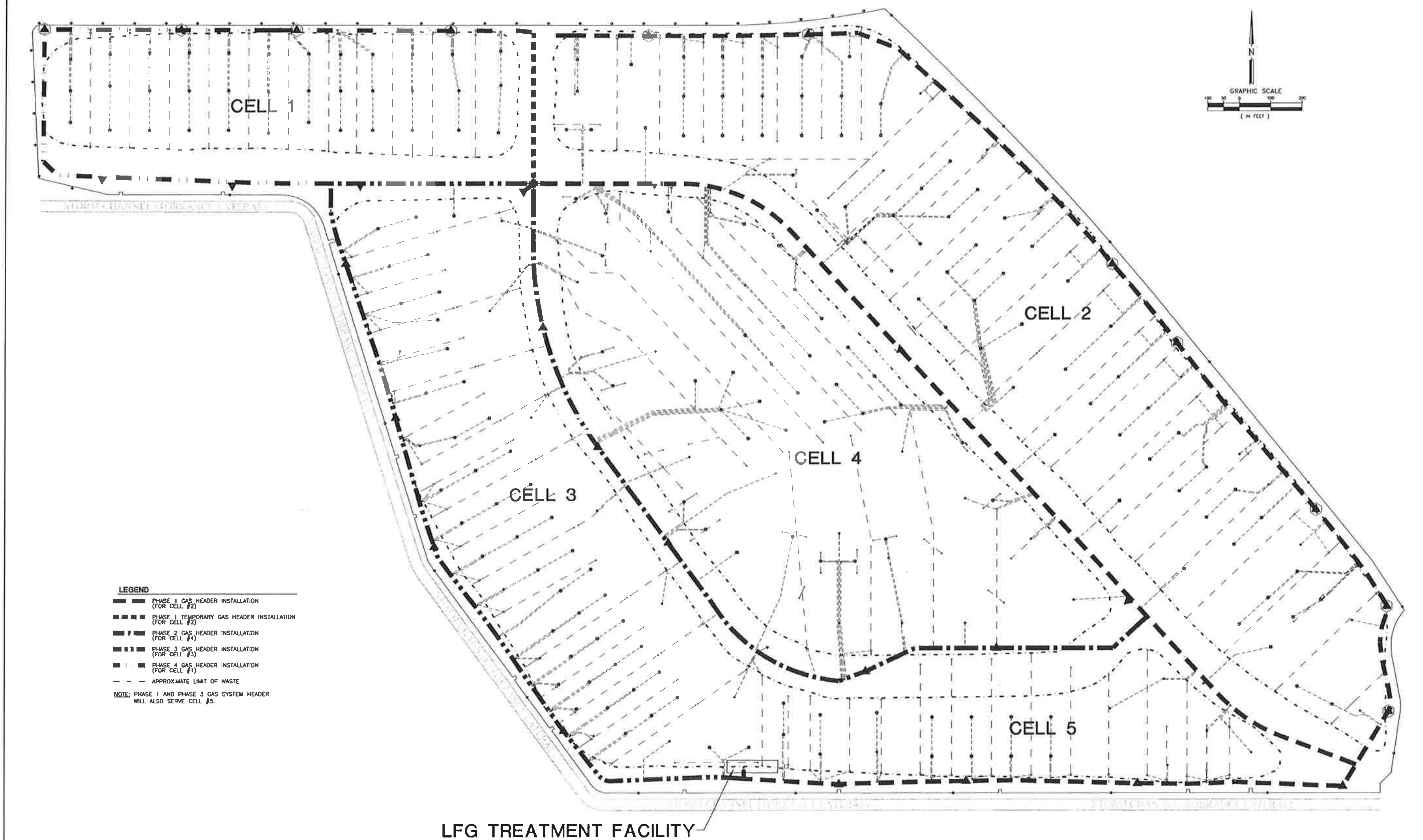

FIGURE 3

FOR PERMITTING PURPOSES ONLY

THE BOULEVARDS AT SOUTH BAY (FORMER CAL COMPACT LANDFILL)

LANDFILL GAS TREATMENT FACILITY - GAC/KMN
LFG EXTRACTION SYSTEM PHASING PLAN

(909) 860-7777
BRYAN A. STIRRAT & ASSOCIATES
CIVIL AND ENVIRONMENTAL ENGINEERS
1360 VALLEY VISTA DRIVE DIAMOND BAR, CA 91765

JOB NO. 2008.0037-T3
DATE 02/2009
DRAWN BY JNR
FILE NAME: CARSON GAC-FIG3

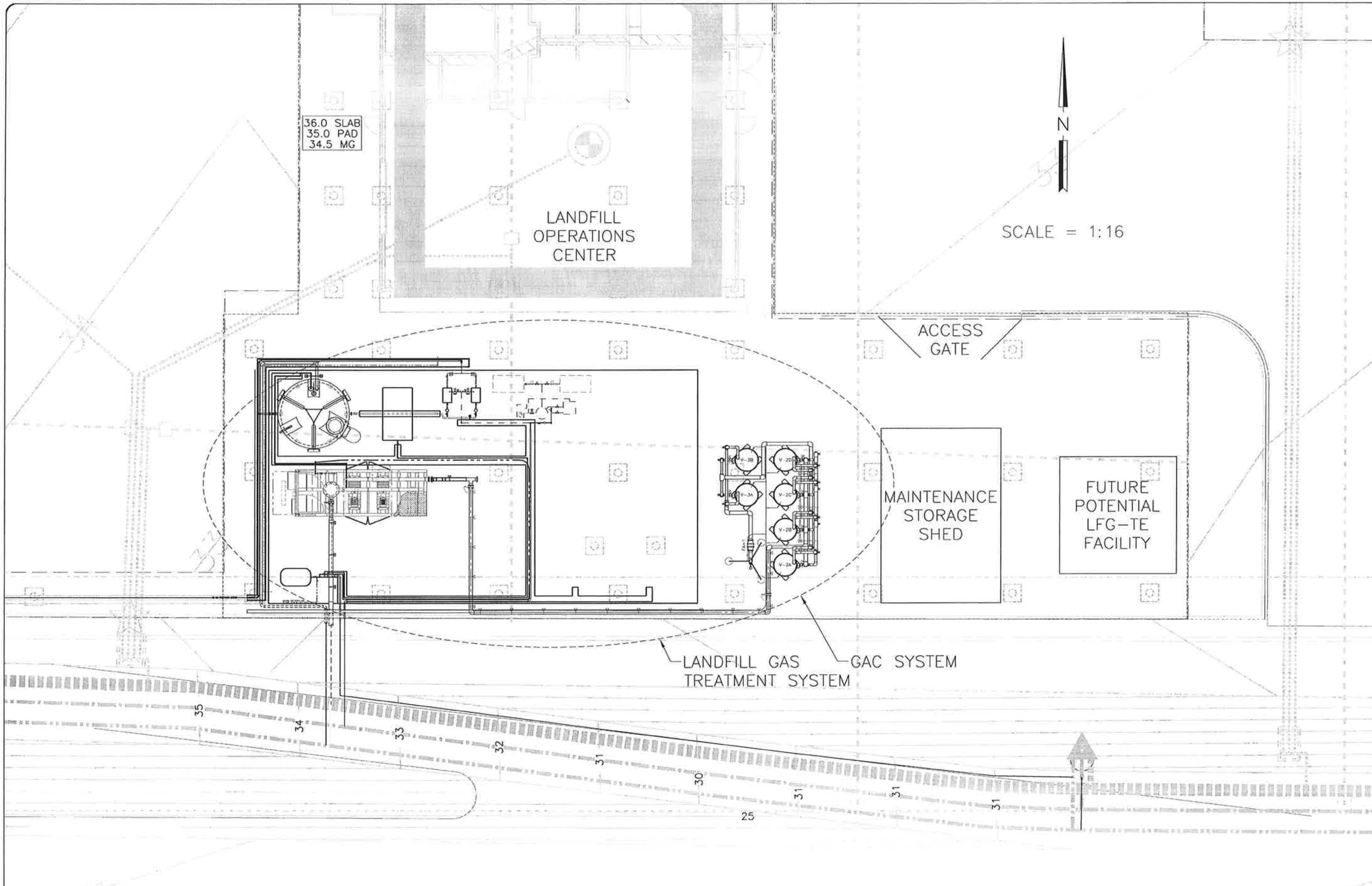

FIGURE 4

FOR PERMITTING PURPOSES ONLY

THE BOULEVARDS AT SOUTH BAY (FORMER CAL COMPACT LANDFILL)

LANDFILL GAS TREATMENT FACILITY - GAC/KMN

LAYOUT PLAN

(909) 860-7777

BAS

BRYAN A. STIRRAT & ASSOCIATES
CIVIL AND ENVIRONMENTAL ENGINEERS
1360 VALLEY VISTA DRIVE DIAMOND BAR, CA 91765

JOB NO.	2008.0037-T3
DATE	02/2009
DRAWN BY	FMR
FILE NAME:	CARSON GAC-FIG4

T-801A/B	V-101	BL-103/104	FE-1	V-2A/B/C/D	V-3A/B	FA-1
CONDENSATE HOLDING TANK MFR. POLY PROCESSING MODEL: 2005400A 5,400 GALLON DOUBLE-CONTAINMENT TANK CROSS LINKED POYETHYLENE DESIGN TEMP: AMBIENT	KNOCKOUT VESSEL MFR. JOHN ZONK MATERIAL: HDPE DESIGN FLOW: 700 scfm MAX.	LFG BLOWER w/SOUND ENCLOSURE MFR: HOUSTON SERVICE INDUSTRIES (HSI) MODEL SERIES 5105 FLOW RATE: 700 scfm LFG MAX. WITH VARIABLE FREQUENCY DRIVE (VFD)	FLOW ELEMENT MFR: KURZ INSTRUMENTS, INC. MODEL: SERIES 454FTB FLOW RATE: 0-200 scfm LFG	GRANULAR ACTIVATED CARBON (GAC) MFR: BAKER FILTRATION MODEL: KLEENAIR 2000S CAPACITY: 2,000 lbs. GAC	POTASSIUM PERMANGANATE (KMN) MFR: BAKER FILTRATION MODEL: KLEENAIR 1000S CAPACITY: 2,000 lbs. KMN	HORIZONTAL FLAME ARRESTOR MFR: GROTH EQUIPMENT CORP. (OR EQUAL) ALUMINUM HOUSING STAINLESS STEEL ELEMENT

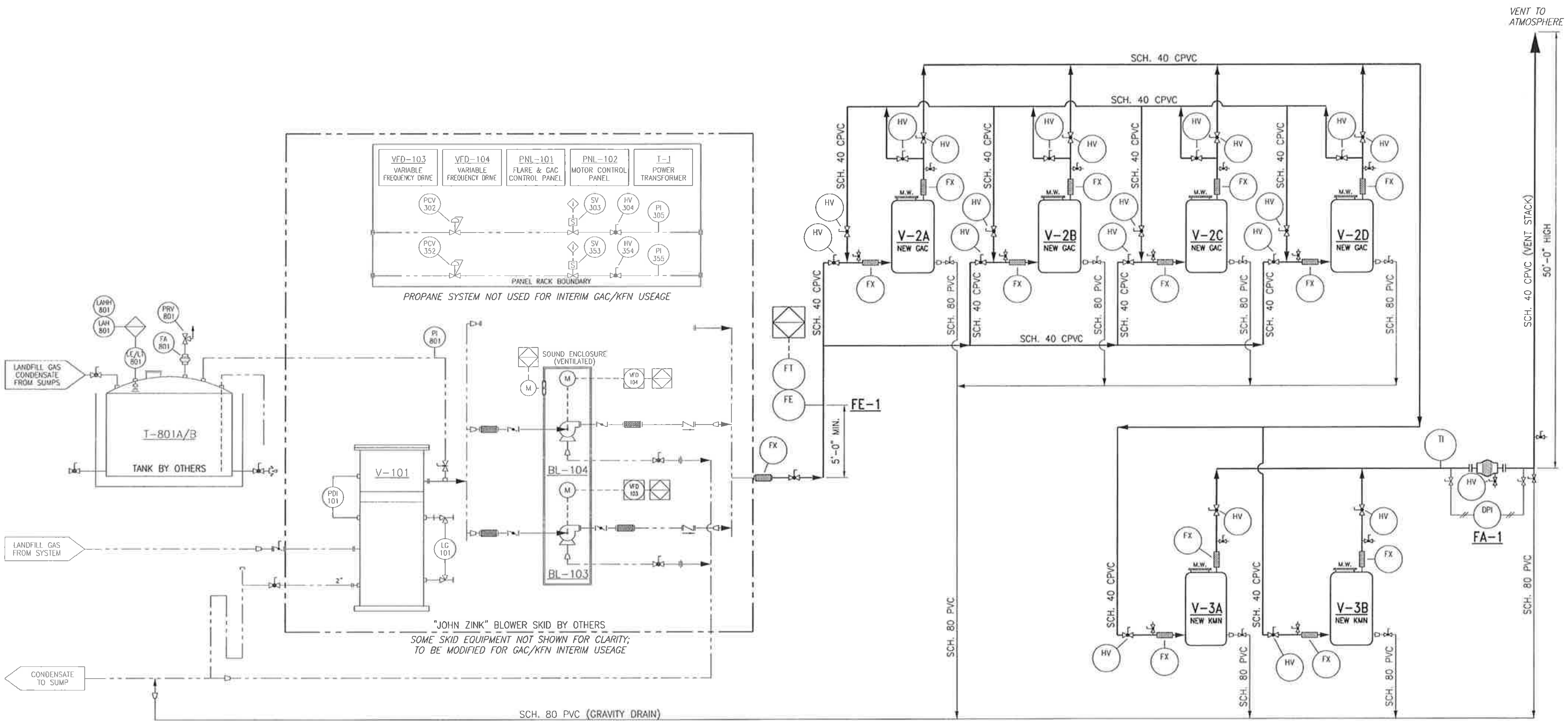

FIGURE 5

FOR PERMITTING PURPOSES ONLY

THE BOULEVARDS AT SOUTH BAY (FORMER CAL COMPACT LANDFILL)

LANDFILL GAS TREATMENT FACILITY - GAC/KMN PROCESS FLOW DIAGRAM

JOB NO. 2008.0037-T3
DATE 02/2009
DRAWN BY JNR
FILE NAME: CARSON GAC-FIG5

(909) 860-7777
BRYAN A. STIRRAT & ASSOCIATES
CIVIL AND ENVIRONMENTAL ENGINEERS
1360 VALLEY VISTA DRIVE DIAMOND BAR, CA 91765

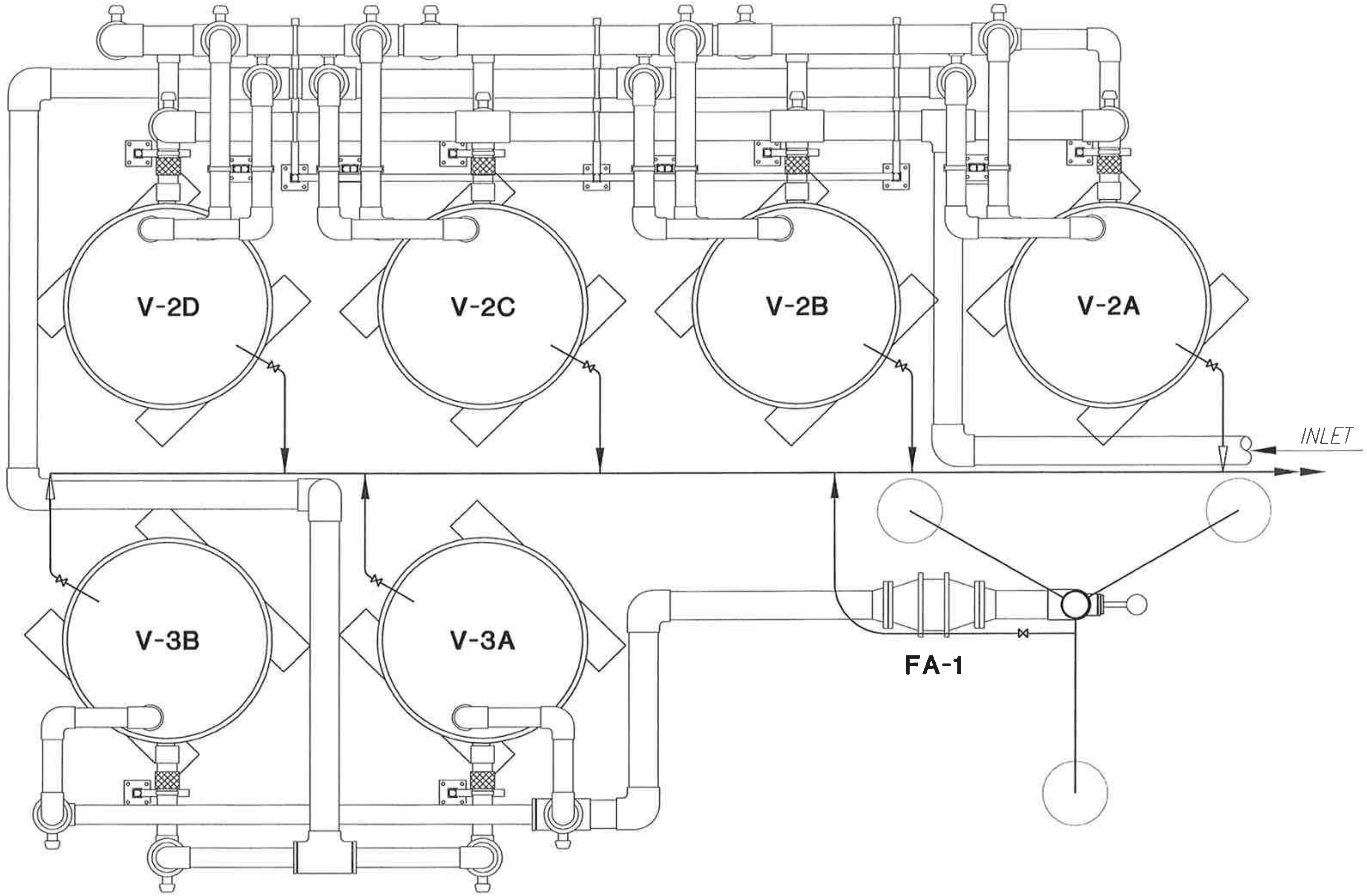

FIGURE 6

FOR PERMITTING PURPOSES ONLY

THE BOULEVARDS AT SOUTH BAY (FORMER CAL COMPACT LANDFILL)

LANDFILL GAS TREATMENT FACILITY - GAC/KMN
MECHANICAL ASSEMBLY LAYOUT

JOB NO.
2008.0037-T3

DATE
02/2009

DRAWN BY
JNR

FILE NAME:
CARSON GAC-FIG6

(909) 860-7777

BAS

BRYAN A. STIRRAT & ASSOCIATES
CIVIL AND ENVIRONMENTAL ENGINEERS
1360 VALLEY VISTA DRIVE DIAMOND BAR, CA 91765

THE BOULEVARDS AT SOUTH BAY, LLC

APPENDIX 1

SCAQMD FORM 400-A
APPLICATION FOR PERMIT TO CONSTRUCT
AND PERMIT TO OPERATE

South Coast Air Quality Management District

Form 400-A

Application For Permit To Construct and Permit To Operate

Mail Application To:
P.O. Box 4944
Diamond Bar, CA 91765

Tel: (909) 396-3385
www.aqmd.gov

Section A: Operator Information

1. Business Name of Operator To Appear On The Permit: Tetra Tech Inc.
2. Valid AQMD Facility ID (Available on Permit or Invoice issued by AQMD):
3. Owner's Business Name (only if different from Business Name of Operator):

Section B: Equipment Location

4. Equipment Location Address:
For equipment operated at various locations in AQMD's jurisdiction, provide address of initial site

20400 Main Street
Street Address

Carson, CA, 90745 -
City, State, Zip Code

County: (●) Los Angeles ( ) Orange ( ) San Bernardino ( ) Riverside

Contact Name: Javier Weckmann

Contact Title: Vice President Phone: (310) 965-0137

Fax: (310) 965-0273 E-Mail: javier.weckmann@tetratech

Section C: Permit Mailing Address

5. Permit and Correspondence Information:
[X] Check here if same as equipment location address

Street Address

City, State, Zip Code

Contact Name:

Contact Title: Phone:

Fax: E-Mail:

Section D: Application Type

The facility is in ( ) RECLAIM ( ) Title V ( ) RECLAIM & Title V Program (please check if applicable)

6. Reason for Submitting Application (Select only ONE):

- (●) New Construction (Permit to Construct)
- ( ) Equipment Operating Without A Permit or Expired Permit*
- ( ) Administrative Change
- ( ) Equipment On-Site But Not Constructed or Operational
- ( ) Title V Application (Initial, Revisions, Modifications, etc.)
- ( ) Compliance Plan
- ( ) Facility Permit Amendment
- ( ) Registration/Certification
- ( ) Streamlined Standard Permit
- ( ) Permitted Equipment Altered/ Modified Without Permit Approval*
- ( ) Proposed Alteration/Modification to Permitted Equipment
- ( ) Change of Condition For Permit To Operate
- ( ) Change of Condition For Permit To Construct
- ( ) Change of Location—Moving to New Site

Existing Or Previous Permit/Application Number:
(If you checked any of the items in this column, you MUST provide a existing Permit/ Application Number)

* A Higher Permit Processing Fee applies to those items with an asterisk (Rule 301 (c) (1) (D)

7. Estimated Start Date of Operation/Construction (MM/DD/YYYY): 04/15/2009

8. Description of Equipment: Landfill Gas Treatment System

9. Is this equipment portable AND will it be operated at different locations within AQMD's jurisdiction? (●) No ( ) Yes

10. For Identical equipment, how many additional applications are being submitted with this application? (Form 400-A required for each)

11. Are you a Small Business as per AQMD's Rule 102 definition? (10 employees or less and total gross receipts are $500,000 or less, or a not-for-profit training center?) (●) No ( ) Yes

12. Has a Notice of Violation (NOV) or a Notice To Comply (NC) been issued for this equipment? (●) No ( ) Yes If yes, provide NOV/NC #:

Section E: Facility Business Information

13. What type of business is being conducted at this equipment location? Commercial & Residential over closed landfill

14. What is your businesses primary NAICS Code (North American Industrial Classification System)? N/A

15. Are there other facilities in the SCAQMD jurisdiction operated by the same operator? (●) No ( ) Yes

16. Are there any schools (K-12) within a 1000-ft. radius of the equipment physical location? (●) No ( ) Yes

Section F: Authorization/Signature

I hereby certify that all information contained herein and information submitted with this application is true and correct.

17. Signature of Responsible Official: [signature]

18. Title: Vice President

19. Print Name: Javier Weckmann

20. Date: 02/04/2009

Check List
- [X] Form(s) signed and dated by authorized official
- [X] Supplemental Equipment Form (400-E-XX or 400-E-GEN)
- [X] CEQA Form (400-CEQA) attached
- [X] Payment for permit processing fee attached

Your application will be rejected if any of the above items are missing.

AQMD USE ONLY	APPLICATION/TRACKING #	TYPE B C D	EQUIPMENT CATEGORY CODE:	FEE SCHEDULE: $	VALIDATION
ENG. A R DATE	ENG. A R DATE	CLASS I III IV	ASSIGNMENT Unit Engineer	CHECK/MONEY ORDER #	AMOUNT $	Tracking #

THE BOULEVARDS AT SOUTH BAY, LLC

APPENDIX 2

SCAQMD FORM 400-CEQA
CALIFORNIA ENVIRONMENTAL QUALITY ACT APPLICABILITY

South Coast Air Quality Management District
Form 400-CEQA
California Environmental Quality Act (CEQA) Applicability

Mail Application To:
P.O. Box 4944
Diamond Bar, CA 91765

Tel: (909) 396-3385
www.aqmd.gov

The SCAQMD is required by state law, the California Environmental Quality Act (CEQA), to review discretionary permit project applications for potential air quality and other environmental impacts. This form is a screening tool to assist the SCAQMD in clarifying whether or not the project[1] has the potential to generate significant adverse environmental impacts that might require preparation of a CEQA document [CEQA Guidelines §15060(a)].[2] Refer to the attached instructions for guidance in completing this form.[3] For each Form 400-A application, also complete and submit one Form 400-CEQA. If submitting multiple Form 400-A applications for the same project at the same time, only one 400-CEQA form is necessary for the entire project. If you need assistance completing this form, contact Lori Inga at (909) 396-3109.

FACILITY INFORMATION

Business Name of Operator to Appear on the Permit:	Facility ID (6-Digit):
Tetra Tech, Inc.	

Project Description:

Carbon Adsorption System for Landfill Gas Treatment

REVIEW FOR EXEMPTION FROM FURTHER CEQA ACTION

Check "Yes" or "No" as applicable

	Yes	No	Is this application for:
A.	(•)	○	**A CEQA and/or NEPA document previously or currently prepared that specifically evaluates this project?** If yes, a permit cannot be issued until a Final CEQA document and Notice of Determination is submitted.
B.	○	(•)	**A request for a change of permittee only (without equipment modifications)?**
C.	○	(•)	**Equipment certification or equipment registration** (qualifies for Rule 222)?
D.	○	(•)	**A functionally identical permit unit replacement with no increase in rating or emissions?**
E.	○	(•)	**A change of daily VOC permit limit to a monthly VOC permit limit?**
F.	○	(•)	**Equipment damaged as a result of a disaster during state of emergency?**
G.	○	(•)	**A Title V** (i.e., Regulation XXX) **permit renewal (without equipment modifications)?**
H.	○	(•)	**A Title V administrative permit revision?**
I.	○	(•)	**The conversion of an existing permit into an initial Title V permit?**

If "Yes" is checked for any question above, your application does not require additional evaluation for CEQA applicability. Skip to page 2, "SIGNATURES" and sign and date this form.

REVIEW OF IMPACTS WHICH MAY TRIGGER CEQA

Complete Sections I-VI by checking "Yes" or "No" as applicable. To avoid delays in processing your application(s), explain all "Yes" responses on a separate sheet and attach it to this form.

	Yes	No	Section I – General
1.	○	○	**Has this project generated any known public controversy regarding potential adverse impacts that may be generated by the project?** Controversy may be construed as concerns raised by local groups at public meetings; adverse media attention such as negative articles in newspapers or other periodical publications, local news programs, environmental justice issues, etc.
2.	○	○	**Is this project part of a larger project?**
			Section II – Air Quality
3.	○	○	**Will there be any demolition, excavating, and/or grading construction activities that encompass an area exceeding 20,000 square feet?**
4.	○	○	**Does this project include the open outdoor storage of dry bulk solid materials that could generate dust?** If Yes, include a plot plan with the application package.

[1] A "project" means the whole of an action which has a potential for resulting in physical change to the environment, including construction activities, clearing or grading of land, improvements to existing structures, and activities or equipment involving the issuance of a permit. For example, a project might include installation of a new, or modification of an existing internal combustion engine, dry-cleaning facility, boiler, gas turbine, spray coating booth, solvent cleaning tank, etc.
[2] To download the CEQA guidelines, visit http://ceres.ca.gov/env_law/state.html.
[3] To download this form and the instructions, visit http://www.aqmd.gov/ceqa or http://www.aqmd.gov/permit

	Yes	No	
5.	○	○	**Would this project result in noticeable off-site odors from activities that may not be subject to SCAQMD permit requirements?** For example, compost materials or other types of greenwaste (i.e., lawn clippings, tree trimmings, etc.) have the potential to generate odor complaints subject to Rule 402 – Nuisance.
6.	○	○	**Does this project cause an increase of emissions from marine vessels, trains and/or airplanes?**
7.	○	○	**Will the proposed project increase the QUANTITY of hazardous materials stored aboveground onsite or transported by mobile vehicle to or from the site by greater than or equal to the amounts associated with each compound on the attached Table 1?[4]**
			Section III – Water Resources
8.	○	○	**Will the project increase demand for water at the facility by more than 5,000,000 gallons per day?** The following examples identify some, but not all, types of projects that may result in a "yes" answer to this question: 1) projects that generate steam; 2) projects that use water as part of the air pollution control equipment; 3) projects that require water as part of the production process; 4) projects that require new or expansion of existing sewage treatment facilities; 5) projects where water demand exceeds the capacity of the local water purveyor to supply sufficient water for the project; and 6) projects that require new or expansion of existing water supply facilities.
9.	○	○	**Will the project require construction of new water conveyance infrastructure?** Examples of such projects are when water demands exceed the capacity of the local water purveyor to supply sufficient water for the project, or require new or modified sewage treatment facilities such that the project requires new water lines, sewage lines, sewage hook-ups, etc.
			Section IV – Transportation/Circulation
10.			**Will the project result in** (Check all that apply):
	○	○	**a. the need for more than 350 new employees?**
	○	○	**b. an increase in heavy-duty transport truck traffic to and/or from the facility by more than 350 truck round-trips per day?**
	○	○	**c. increase customer traffic by more than 700 visits per day?**
			Section V – Noise
11.	○	○	**Will the project include equipment that will generate noise GREATER THAN 90 decibels (dB) at the property line?**
			Section VI – Public Services
12.			**Will the project create a permanent need for new or additional public services in any of the following areas** (Check all that apply):
	○	○	**a. Solid waste disposal?** Check "No" if the projected potential amount of wastes generated by the project is less than five tons per day.
	○	○	**b. Hazardous waste disposal?** Check "No" if the projected potential amount of hazardous wastes generated by the project is less than 42 cubic yards per day (or equivalent in pounds).

REMINDER: *For each "Yes" checked in the sections above, attach all pertinent information including but not limited to estimated quantities, volumes, weights, etc.*

SIGNATURES

I HEREBY CERTIFY THAT ALL INFORMATION CONTAINED HEREIN AND INFORMATION SUBMITTED WITH THIS APPLICATION IS TRUE AND CORRECT TO THE BEST OF MY KNOWLEDGE. I UNDERSTAND THAT THIS FORM IS A SCREENING TOOL AND THAT THE SCAQMD RESERVES THE RIGHT TO CONSIDER OTHER PERTINENT INFORMATION IN DETERMINING CEQA APPLICABILITY.

SIGNATURE OF RESPONSIBLE OFFICIAL OF FIRM: [signature]	TITLE OF RESPONSIBLE OFFICIAL OF FIRM: Vice President	
TYPE OR PRINT NAME OF RESPONSIBLE OFFICIAL OF FIRM: Javier Weckmann	RESPONSIBLE OFFICIAL'S TELEPHONE NUMBER: (310) 9650-137	DATE Signed:
SIGNATURE OF PREPARER, IF PREPARED BY PERSON OTHER THAN RESPONSIBLE OFFICIAL OF FIRM: Michael L. Leonard, Sr.	TITLE OF PREPARER: Senior Project Manager	
TYPE OR PRINT NAME OF PREPARER: Michael L. Leonard, Sr. P.E.	PREPARER'S TELEPHONE NUMBER: (909) 8607-777	DATE Signed: 3/3/2009

THIS CONCLUDES FORM 400-CEQA. INCLUDE THIS FORM AND THE ATTACHMENTS WITH FORM 400-A.

[4] Table 1 – Regulated Substances List and Threshold Quantities for Accidental Release Prevention can be found in the Instructions for Form 400-CEQA.

DEPARTMENT OF TOXIC SUBSTANCES CONTROL
Region 4
245 West Broadway, Suite 425
Long Beach, CA 90802-4444

SUPPLEMENTAL NEGATIVE DECLARATION for

CAL COMPACT LANDFILL UPPER OPERABLE UNIT 20400 South Main Street Carson, California 90745

PROJECT PROPONENT:

Department of Toxic Substances Control
245 West Broadway, Suite 350
Long Beach, California 90802-4444

Contact: Thomas M. Cota (310) 590-4898

PROJECT DESCRIPTION:

BKK Corporation is requesting approval of a draft Remedial Action Plan (RAP) for the Cal Compact Landfill Upper Operable Unit from the Department of Toxic Substances Control (DTSC). This draft RAP is in accordance with Section 25356.1 of the California Health and Safety Code, and Subpart E of the National Oil and Hazardous Substances Pollution Contingency Plan, 40 Code of Federal Regulations 300.400 et seq. DTSC is acting as a Responsible Agency as that term is defined in the California Code of Regulations, Title 14, Section 15381.

The proposed project for which DTSC is acting on addresses the construction and operation of a landfill gas collection and treatment system and a groundwater treatment system. The construction of the landfill cover is not addressed in this document, however, it was addressed in the City of Carson's EIR for the Metro 2000 project. DTSC as a Responsible Agency has carefully reviewed the Final EIR entitled Final Project and Program Environmental Impact Report, MetroMall 2000, dated December 1993. DTSC, using its independent judgement, found that (a) the EIR for the Metro 2000 project adequately complied with the provisions of the California Environmental Quality Act, (b) adequately addressed the proposed construction of the landfill cover, and (c) is adequate for DTSC to assess potential impacts for the Remedial Action Plan. DTSC, after reviewing the Final EIR, concurred with the finding of the City of Carson. DTSC drafted a Statement of Overriding Conditions addressing significant impacts that were not feasibly mitigated to a level of insignificance with the mitigation measures found in the EIR.

The project objectives for this project is to reduce or eliminate the potential threat to human health and the environment. The project objectives for the contaminated groundwater in the Bellflower Aquitard are (1) limit production of leachate through control of surface water infiltration to minimize impact to groundwater, (2) control and prevent off-site migration of groundwater contaminated from waste in the saturated zone, and (3) draw back and contain the contaminant plume that is now off-site. The project objectives for the landfill gases are (1) control production of landfill gases through control of surface water infiltration and (2) control or prevent off-site migration of landfill gases and future releases of landfill gases to the atmosphere under proposed land use scenarios.

The landfill gas system will consist of a series of vertical extraction wells installed at the perimeter of the waste zone. The extraction wells will be connected by HDPE conveyance piping to a landfill flare. The collected landfill gasses will be transported through the series of pipes to the flare for thermal destruction. The landfill gas flare will be one unit with a maximum 750 cfm capacity.

In 1990, a vapor monitoring event was conducted at the project site. Two Calderon compounds were detected during the sampling event. Calderon compounds are chemicals established in California as indicators for hazardous waste landfills. Analytical results from five vadose wells detected vinyl chloride in concentrations ranging form 2 ppm (parts per million) to 20.5 ppm and benzene from 1.4 ppm to 8.8 ppm. Methane, a non-Calderon compound, was detected in the range of 26.7% to 64.4%. Other non-Calderon compounds detected included ethylbenzene, toluene, xylene and dichlorodifluoromethane.

Extraction wells will be installed using standard drilling practices such as a hollow stem auger drill rig. The design of the system shall be developed by a registered California civil engineer, submitted to DTSC for review and approval. A

Department approved quality control/quality assurance program shall be strictly followed by the contractors.

The proposed groundwater treatment system consists of a series of groundwater extraction wells installed along the western and southern portions of the project site. The groundwater extraction wells will be installed in the Bellflower Aquitard saturated zone. The groundwater collection and treatment system will be designed to contain contaminated groundwater migrating from the Bellflower Aquitard beneath the site and to capture contaminated groundwater off-site in the Bellflower Aquitard.

The remedial investigation identified groundwater contamination in the Bellflower Aquitard. Volatile organic compounds, semi-volatile organic compounds, and heavy metals were detected in the groundwater in the Bellflower Aquitard. The remedial investigation also concluded that some off-site contamination has occurred. The proposed groundwater collection and treatment system will control and contain both on-site and off-site contamination.

The groundwater system includes extraction wells, associated piping, dedicated wells pumps, a water equalization tank, filters, precipitation and clarification units, carbon absorbers units, and a final polishing filter unit.

The treated groundwater will be used for on-site irrigation, or discharged to the sewer system or storm drain system. The system is anticipated to treat approximately 100 to 150 gallons per minute.

PROJECT LOCATION DESCRIPTION:

The Cal Compact Landfill (the Site) is located at 20400 Main Street in the City of Carson, County of Los Angeles, California. The Site is located in the western portion of the City of Carson. It is bounded by Del Amo Boulevard to the north, the San Diego Freeway (I-405) to the east with the Dominguez Channel located just east of the San Diego Freeway (I-405), the Torrrance Lateral Channel to the south with residential development just south of the Torrance Lateral Channel, and Main Street and residential development on the west. The primary freeway access to the Site is by means of the Main Street ramps to the San Diego Freeway (I-405) and the Torrance Boulevard ramps to the Harbor Freeway (I-110). The Site is located within the City of Carson's Redevelopment Project Area No. 1.

FINDINGS OF SIGNIFICANT EFFECT ON ENVIRONMENT:

DTSC has determined that the project will not have a significant effect on the environment as that term is defined in the Public Resources Code Section 21068.

A copy of the Initial Study which supports this finding is attached.

MITIGATION MEASURES:

No mitigation measures have been proposed for this project.

Signature: Thomas M Cota
Thomas M. Cota, Project Manager

Date: 10/25/95

Signature: Hamid Saebfar
Hamid Saebfar, Chief
Site Mitigation Cleanup Operations
Southern California Branch

Date: 10/25/95

STATE OF CALIFORNIA — ENVIRONMENTAL PROTECTION AGENCY

PETE WILSON, Governor

DEPARTMENT OF TOXIC SUBSTANCES CONTROL

Region 4
245 West Broadway, Suite 425
Long Beach, CA 90802-4444

Supplemental Negative Declaration Approval

Project Title:

Cal Compact Landfill, Remedial Action Plan, Upper Operable Unit

State Clearinghouse Number:

95081061

Contact Person and Telephone:

Thomas M. Cota - (310) 590-4898

Project Location:

20400 Main Street, City of Carson, County of Los Angeles, State of California

Project Description:

BKK Corporation is requesting approval of a draft Remedial Action Plan (RAP) for the Cal Compact Landfill Upper Operable Unit from the Department of Toxic Substances Control (DTSC). This draft RAP is in accordance with Section 25356.1 of the California Health and Safety Code, and Subpart E of the National Oil and Hazardous Substances Pollution Contingency Plan, 40 Code of Federal Regulations 300.400 et seq. DTSC is acting as a Responsible Agency as that term is defined in the California Code of Regulations, Title 14, Section 15381.

The proposed project for which DTSC is acting on addresses the construction and operation of a landfill gas collection and treatment system and a groundwater treatment system. The construction of the landfill cover is not addressed in this document, however, it was addressed in the City of Carson's EIR for the Metro 2000 project. DTSC as a Responsible Agency has carefully reviewed the Final EIR entitled Final Project and Program Environmental Impact Report, MetroMall 2000, dated December 1993. DTSC, using its independent judgement, found that (a) the EIR for the Metro 2000 project adequately complied with the provisions of the California Environmental Quality Act, (b) adequately addressed the proposed construction of the landfill cover, and (c) is adequate for DTSC to assess potential impacts for the Remedial Action Plan. DTSC, after reviewing the Final EIR, concurred with the finding of the City of Carson. DTSC drafted a Statement of Overriding Conditions addressing significant impacts that were not feasibly mitigated to a level of insignificance with the mitigation measures found in the EIR.

The project objectives for this project is to reduce or eliminate the potential threat to human health and the environment. The project objectives for the contaminated groundwater in the Bellflower Aquitard are (1) limit production of leachate through control of surface water infiltration to minimize impact to groundwater, (2) control and prevent off-site migration of groundwater contaminated from waste in the saturated zone, and (3) draw back and contain the contaminant plume that is now off-site. The project objectives for the landfill gases are (1) control production of landfill gases through control of surface water infiltration and (2) control or prevent off-site migration of landfill gases and future releases of landfill gases to the atmosphere under proposed land use scenarios.

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In 1990, a vapor monitoring event was conducted at the project site. Two Calderon compounds were detected during the sampling event. Calderon compounds are chemicals established in California as indicators for hazardous waste landfills. Analytical results from five vadose wells detected vinyl chloride in concentrations ranging form 2 ppm (parts per million) to 20.5 ppm and benzene from 1.4 ppm to 8.8 ppm. Methane, a non-Calderon compound, was detected in the range of 26.7% to 64.4%. Other non-Calderon compounds detected included ethylbenzene, toluene, xylene and dichlorodifluoromethane.

Extraction wells will be installed using standard drilling practices such as a hollow stem auger drill rig. The design of the system shall be developed by a registered California civil engineer, submitted to DTSC for review and approval. A Department approved quality control/quality assurance program shall be strictly followed by the contractors.

The proposed groundwater treatment system consists of a series of groundwater extraction wells installed along the western and southern portions of the project site. The groundwater extraction wells will be installed in the Bellflower Aquitard saturated zone. The groundwater collection and treatment system will be designed to contain contaminated groundwater migrating from the Bellflower Aquitard beneath the site and to capture contaminated groundwater off-site in the Bellflower Aquitard.

The remedial investigation identified groundwater contamination in the Bellflower Aquitard. Volatile organic compounds, semi-volatile organic compounds, and heavy metals were detected in the groundwater in the Bellflower Aquitard. The remedial investigation also concluded that some off-site contamination has occurred. The proposed groundwater collection and treatment system will control and contain both on-site and off-site contamination.

The groundwater system includes extraction wells, associated piping, dedicated wells pumps, a water equalization tank, filters, precipitation and clarification units, carbon absorbers units, and a final polishing filter unit.

The treated groundwater will be used for on-site irrigation, or discharged to the sewer system or storm drain system. The system is anticipated to treat approximately 100 to 150 gallons per minute.

Project Approval:

DTSC of Toxic Substances Control has found on the basis of the Initial Study and the Supplemental Negative Declaration that there is no substantial evidence that the construction and operation of the landfill gas collection and treatment system and the groundwater treatment system will have a significant effect on the environment.

I hereby approve the Supplemental Negative Declaration for this project.

Signature: ______________________ Date: 10/23/95

Hamid Saebfar, Chief
Site Mitigation Cleanup Operations
Southern California Branch

THE BOULEVARDS AT SOUTH BAY, LLC

APPENDIX 3

SCAQMD FORM 400-XPP
EXPRESS PERMIT PROCESSING REQUEST

South Coast Air Quality Management District
P. O. Box 4944 Diamond Bar, CA 91765
(909) 396-2000

EXPRESS PERMIT PROCESSING REQUEST FORM
FORM 400 - XPP

Form 400-A, Form 400-CEQA and one or more 400-E-xx form(s) must accompany all submittals.

Print Form

Section I - Facility/Application Information

1. Business Name: Tetra Tech, Inc. Boulevards at South Bay   Facility ID:

2. The requested application is for a(n):   Date of Occurrence: Mar 2, 2009

   a. [X] New Construction   b. [ ] Change of Location
   c. [ ] Modification of Equipment/Process   d. [ ] Existing Equipment with Expired Permit
   e. [ ] Existing Equipment Operating without a Permit; Initial Operation Date:
   f. [ ] Change of Condition(s); specify the change of condition(s) requested:
   g. [ ] Change of Operator; List previous name of operator and Facility ID #:

3. I hereby request Express Permit Processing for this application.
4. I understand that this request will incur additional fees.
5. This request is not cancelable once engineering review has been initiated.
6. Express Permit Processing neither guarantees action by any specific date nor does I guarantee permit approval.

Section II - Equipment Information

I HEREBY CERTIFY THAT ALL INFORMATION CONTAINED HEREIN AND INFORMATION SUBMITTED WITH THIS APPLICATION IS TRUE AND CORRECT.

SIGNATURE OF RESPONSIBLE OFFICIAL OF FIRM: [signature]
TITLE OF RESPONSIBLE OFFICIAL OF FIRM: Vice President
TYPE OR PRINT NAME OF RESPONSIBLE OFFICIAL OF FIRM: Javier Weckmann
RESPONSIBLE OFFICIAL'S TELEPHONE NUMBER: 310-965-0137
DATE SIGNED:

I HEREBY CERTIFY THAT ALL INFORMATION CONTAINED HEREIN AND INFORMATION SUBMITTED WITH THIS APPLICATION IS TRUE AND CORRECT.

SIGNATURE OF PREPARER: Michael L. Leonard, Sr.
TITLE OF PREPARER: Senior Project Manager
DATE SIGNED: 3/3/2009
TYPE OR PRINT NAME OF PREPARER: Michael L. Leonard, Sr., P.E.
PREPARER'S TELEPHONE NUMBER: 909-860-7777

AQMD USE ONLY	APPLICATION/TRACKING #	PROJECT #	TYPE B C D	EQUIPMENT CATEGORY CODE: /	FEE SCHEDULE: $	VALIDATION
ENG. A R DATE	ENG. A R DATE	CLASS I III IV	ASSIGNMENT UNIT ENGINEER	ENF. SECT.	CHECK/MONEY ORDER #	AMOUNT $

THE BOULEVARDS AT SOUTH BAY, LLC

APPENDIX 4

SCAQMD FORM 400-E-GI
GENERAL INFORMATION SUMMARY

South Coast Air Quality Management District
P. O. Box 4944
Diamond Bar, CA 91765
(909) 396- 2000

GENERAL INFORMATION SUMMARY
FORM 400-E-GI

The following data, specifications, plans, and drawings must be submitted with each application for Permit to Construct and/or Permit to Operate. Also, if a Form 400-E-xx does not exist for a specific piece of equipment, then the information requested in this Form shall be submitted in its place.

1. EQUIPMENT/PROCESS LOCATION DRAWING

The drawing or sketch shall be submitted to scale (suggested scale: 1 inch = 100 feet; accuracy of measurements to the nearest 5 feet will be satisfactory) and shall show at least the following:

a. The property involved and outlines and heights of all buildings on it. Identify property lines plainly.
b. Location and identification of the proposed equipment on the property.
c. Property location with respect to public and private streets, and all adjacent properties. Show surrounding property owners and uses within 600 feet radius of property. Identify all buildings (as residence, apartment house, machine shop, warehouse, etc.) specifying height of each building (number of stories). Indicate direction (north) on the drawing. Identify schools which have their outer boundaries located within 1000 feet of the equipment.

2. EQUIPMENT DESCRIPTION

Provide detailed description of equipment, including but not limited to, function, make, model, dimensions, size, and maximum capacity. Attach manufacturer's catalog or brochure, if available.

3. PROCESS DESCRIPTION

Provide a general description of each process line (i.e., the process to be carried out by the equipment) or the function of the equipment with respect to a process line. The descriptions must be complete and detailed. Explain all stages in the process where there may be a discharge of emissions to the atmosphere. Supply all obtainable data regarding the nature, volumes, particle sizes, weights, and concentrations of all types of air contaminants that may be discharged at each stage in the process. Similarly, control procedures must be described in sufficient detail to show the extent of the control of air contaminants anticipated, including the expected control efficiency.

4. OPERATING SCHEDULE

Specify the average and maximum number of hours per day, days per week, days per month, and weeks per year the equipment/process is to be operated.

5. PROCESS RATE

On the basis of pounds per hour, or other specified unit of time, indicate the type and total weight of each material charged into the equipment or the process. Include Material Data Safety Sheets (MSDS), when applicable.

6. FUELS AND BURNERS USED

a. For fuel gas, indicate the type and average and maximum cubic feet per hour burned. Except for natural gas, attach fuel gas analysis.
b. For fuel oil, indicate grade and average and maximum gallons per hour burned. Also, indicate the sulfur content of fuel oil.
c. For solid fuels, indicate the type and average and maximum pounds per hour burned. Also, attach fuel analysis.
d. For burners, indicate the make, model, size, type, number of burners, and capacity of each burner.

7. FLOW DIAGRAM

The diagram should illustrate the flow of materials processed or burned either on a separate flow diagram or on the drawings accompanying the application. Show all venting of equipment (see instruction # 9).

8. DRAWINGS OF EQUIPMENT/PROCESS

Supply an assembly drawing, dimensioned and to scale, in plan, elevation and as many sections as are needed to clearly show the design and operation of the equipment/process and the means by which air contaminants are controlled. The following must be shown:

a. Locations, size, and shape of the equipment. Show exterior and interior dimensions and features.
b. Locations, size, and shape details of all features which may affect the production, collection, conveyance, or control of any air contaminant. This includes the size of pressure relief devices.
c. All data and calculations used in selecting or designing the equipment/process.

NOTE: *Structural design calculations and details are not required. When standard commercial equipment is to be installed, the manufacturer's catalog describing the equipment may be submitted in lieu of the above items. All information required above which the catalog does not include must be submitted by the applicant.*

9. DRAWINGS OF THE EXHAUST SYSTEM

Supply drawing(s) clearly showing all ductwork and the connection between air pollution generating (basic) and control equipment. Show all of the following details which apply, using auxiliary drawings, if necessary:

a. Sizes and shapes of all hoods. Show accurately where and how the hood fits over the spot or area where air contaminants are generated or discharged. Show all openings clearly.
b. Diameters or cross-sectional dimensions and lengths of all branch and main ducts.
c. Locations, sizes and shapes of all bends, junctions and transition pieces.
d. Locations, sizes and shapes of all passageways other than ordinary ducts. Also show all cooling devices (spray chambers, heat exchangers, cooling columns, etc.).
e. Locations and descriptions of all dampers, baffles, and similar controls.
f. Locations of any by-passes around the control equipment. Describe how operated, stating under what conditions and for what lengths of time these by-passes are to be used.
g. Locations of all fans or blowers.
h. Location of control equipment and vent(s).

10. STACK/EXHAUST EMISSIONS DATA

Provide emissions data at each source. Include the following information:

a. The maximum mass emission rates (mass per hour) and stack concentrations of all air pollutants. Include emission calculations if available.
b. Stack diameter.
c. Stack height above ground level.
d. Exhaust temperature.
e. Exhaust flow rate (volumetric).

11. AIR QUALITY IMPACT

Provide an analysis of the air quality impact (including risk assessment) in accordance with specific AQMD requirements. Procedures for preparing air quality impact analysis, including screening analyses are available from the AQMD.

12. GENERAL PERMITTING INFORMATION

Further information or clarification concerning permits can be obtained by writing or calling:

South Coast Air Quality Management District
Permitting
21865 Copley Dr.
Diamond Bar, CA 91765
(909) 396 - 2000

THE BOULEVARDS AT SOUTH BAY, LLC

APPENDIX 5

PERMIT FEE CALCULATION

SOUTH COAST AQMD

Online Fee Calculator

Cleaning the air that we breathe...

Below are the permit fees we have calculated based on the information you have entered. To complete the permit process, please click the print button to print the Fee Sheet and submit a signed check for the Total amount due along with your application package.

Thank you for using AQMD's online Fee Calculator!

Fee Sheet

Restart Application Process | Print

Facility Information Edit

Name:	TetraTech, Inc.	ID:
Address:	20400 Main St. Carson, California	
Operation Type:		Non-Manufacturing Facility
Number of Employees:		
Annual Revenue:		$
Prior Permit?:		Yes

Add Applications Add

Permit Unit	
Landfill Gas, Treatment	$5,148.93
Expedited Processing Fee	$2,574.47
Facility Permit Revision Fee	
Administrative Permit Revision Fee	$843.80

Summary of Subtotals

Permit Fees	$5,148.93
Expedited Processing Fees	$2,574.47
Higher Fees	$0.00
Small Business Discount	$0.00

Fees calculated based on current fiscal year (July 1st - June 30th).
Fee calculation date: January, 27 2009.

Grand Total:	**$8,567.20**

Print <<Back

RULE 301 – PERMIT FEES
TABLE OF CONTENTS

District Staff strictly during overtime work. Approval of such a request is contingent upon the District having necessary procedures in place to implement an expedited processing program and having available qualified staff for overtime work to perform the processing requested. The applicant shall be notified whether or not the request for expedited processing has been accepted within 30 days of submittal of the request. If the request for expedited processing is not accepted by the District, the additional fee paid for expedited processing will be refunded to the applicant.

(1) Permit Processing Fee

Fees for requested expedited processing of permit applications will be an additional fee of fifty percent (50%) of the applicable base permit processing fee (after taking any discounts for identical equipment but not the higher fee for operating without a permit) by equipment schedule. For schedule F and higher, expedited processing fees will include an additional hourly fee when the processing time exceeds times as indicated in column 1 below; but not to exceed the total amounts in column 4, based on the applicable schedule as follows:

Processing Time Exceeding	Schedule	Added Base Hourly Fee $	Maximum Added Base Cap Fee $
		FY 06-07	
99 hours	F	$166.24	$31,247.52
117 hours	G	$166.24	$53,534.33
182 hours	H	$166.24	$68,068.79
		FY 07-08	
99 hours	F	$182.87	$34,372.28
117 hours	G	$182.87	$58,887.76
182 hours	H	$182.87	$74,875.67
		FY 08-09	
99 hours	F	$201.15	$37,809.50
117 hours	G	$201.15	$64,776.54
182 hours	H	$201.15	$82,363.24

TABLE IB - PERMIT FEE RATES FOR BASIC EQUIPMENT

Equipment Process	Schedule
IC Engine, Emergency, (> 500 HP)	B
IC Engine, Landfill/Digester Gas	D
IC Engine, Other, 51-500 HP	B
IC Engine, Other, >500 HP	C
Impregnating Equipment	C
Incineration, Hazardous Waste	H
Incinerator, < 300 lbs/hr, Non-Hazardous	E
Incinerator, >=300 lbs/hr, Non-Hazardous	F
Indoor Shooting Range	B
Ink Mfg./Blending Including, but not limited to, all or part of the following: Process Tanks, Mixers	B
Inorganic Chemical Mfg. Including, but not limited to, all or part of the following: Process Tanks, Mixers, Reactors	D
Insecticide Separation/Mfg Including, but not limited to, all or part of the following: Absorbers, Accumulators, Columns, Compressors, Condensers, Coolers, Drums, Ejectors, Heat Exchangers, Knock Out Pots, Pots, Pumps, Reactors, Regenerators, Scrubbers, Settling Tanks, Sumps, Tanks, Towers, Vessels	E
Iodine Reaction Including, but not limited to, all or part of the following: Columns, Compressors, Condensers, Coolers, Heat Exchangers, Pumps, Reactors, Regenerators, Scrubbers, Settling Tanks, Tanks, Towers	C
Isomerization Unit Including, but not limited to, all or part of the following: Absorbers, Accumulators, Columns, Compressors, Condensers, Drums, Fractionators, Heat Exchangers, Knock Out Pots, Pots, Pumps, Reactors, Regenerators, Scrubbers, Settling Tanks, Sumps, Tanks, Towers, Vessels	E
Jet Engine Test Facility	C
Kiln, Natural Gas	C
Landfill Condensate/Leachate Collection/Storage	B
Landfill Gas, Collection	D
Landfill Gas, Treatment	E

Equipment Process	Schedule
Landfill Gas, Treatment	E
Lime/Limestone, Conveying Including, but not limited to, all or part of the following: Bins, Conveyors, Bucket Elevators, Hoppers, Weigh Stations	C
Liquid Separation, Other Including, but not limited to, all or part of the following: Process Tanks, Settling Tanks, Separators, Tanks	D
Liquid Waste Processing, Hazardous Including, but not limited to, all or part of the following: Air Floatation Units, Floatation Units, Filter Presses, Reactors, Process Tanks, Clarifiers, Settling Tanks, Waste Water Separators, Tanks	E
Liquid Waste Processing, Non Hazardous Including, but not limited to, all or part of the following: Air Floatation Units, Floatation Units, Filter Presses, Reactors, Process Tanks, Clarifiers, Settling Tanks, Waste Water Separators, Tanks	C
LPG, Tank Truck Loading	D
LPG, Treating Including, but not limited to, all or part of the following: Absorbers, Accumulators, Columns, Compressors, Condensers, Drums, Fractionators, Heat Exchangers, Knock Out Pots, Pots, Pumps, Reactors, Regenerators, Scrubbers, Settling Tanks, Sumps, Tanks, Towers, Vessels	D
LPG Distillation Unit Including, but not limited to, all or part of the following: Absorbers, Accumulators, Columns, Compressors, Condensers, Drums, Fractionators, Heat Exchangers, Knock Out Pots, Pots, Pumps, Reactors, Regenerators, Scrubbers, Settling Tanks, Sumps, Tanks, Towers, Vessels	E
Lube Oil Additive/Lubricant Mfg.	B
Lube Oil Re-refining Including, but not limited to, all or part of the following: Absorbers, Accumulators, Columns, Compressors, Condensers, Drums, Fractionators, Heat Exchangers, Knock Out Pots, Pots, Pumps, Reactors, Regenerators, Scrubbers, Settling Tanks, Sumps, Tanks, Towers, Vessels	D

FY 08-09

Schedule	Permit Processing Fee	Change of Condition	Alteration/ Modification
A	$1,287.22	$670.49	$1,287.22
A1	$1,287.22	$670.49	$1,287.22
B	$2,051.52	$1,016.31	$2,051.52
B1	$3,244.91	$1,758.90	$3,244.91
C	$3,244.91	$1,758.90	$3,244.91
D	$4,478.51	$3,008.18	$4,478.51
E	$5,148.93	$4,416.74	$5,148.93
F	$12,939.58+T&M,	$6,448.14	$10,257.62+T&M
G	$15,272.72+T&M	$10,942.07*	$12,590.75+T&M
H	$23,666.52+T&M	$13,873.64*	$20,984.56+T&M

F: T&M = Time and Material charged at $134.10 per hour above 99hours; not to exceed $25,206.34
G: T&M = Time and Material charged at $134.10 per hour above 117hours; not to exceed $43,184.35
H: T&M = Time and Material charged at $134.10 per hour above 182hours; not to exceed $54,908.82
*** Correction: revised fees correct a typographical error to reflect the actual Board approved 10% fee increase for FY 08-09**

SUMMARY OF ERC PROCESSING RATES, BANKING, CHANGE OF TITLE, ALTERATION/MODIFICATION, and CONVERSION TO SHORT TERM CREDITS

Schedule	Banking Application	Change of Title	Alteration/ Modification	Conversion to Short Term Credits	Re-issuance of Short Term Credits
FY 06-07 I	$2745.06	$484.90	$484.90	$484.90	$484.90
FY 07-08 I	$3,019.57	$533.39	$533.39	$533.39	$533.39
FY 08-09 I	$3,321.52	$586.73	$586.73	$586.73	$586.73

THE BOULEVARDS AT SOUTH BAY, LLC

ATTACHMENT 1

GAS BLOWER PERFORMANCE CURVE

Houston Service Industries, Inc.
7901 Hansen Rd • Houston, TX 77061
Phone: 713-947-1623 • 800-725-2291 • Fax: 713-947-6409
Web: www.hsiblowers.com • E-mail: hsi@hsiblowers.com

Blower / Exhauster Design Datasheet

Customer : BAS

Datasheet No. : 24114
Design Date : 5/23/2008
Quote/Job No. :

Project : Lane rd blower

Design Data

Inlet Conditions

Volume	: 500.0	**SCFM @ 68F**
Bar Pressure	: 14.609	**PSIA**
Inlet Press.	: 13.165	**PSIA**
Inlet Temp.	: 100.00	**°F**
Humidity	: 100.0	**%**

Design Point

Volume (Inlet)	: 627.3	**CFM**
Differential Press.	: 3.25	**PSI**
Discharge Press.	: 50.00	**inWC**
Inlet Vacuum	: 40.00	**inWC**

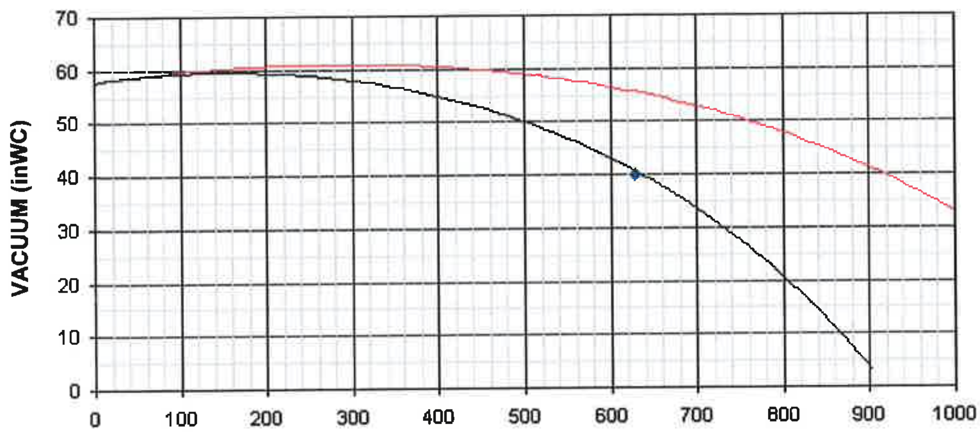
Other Information

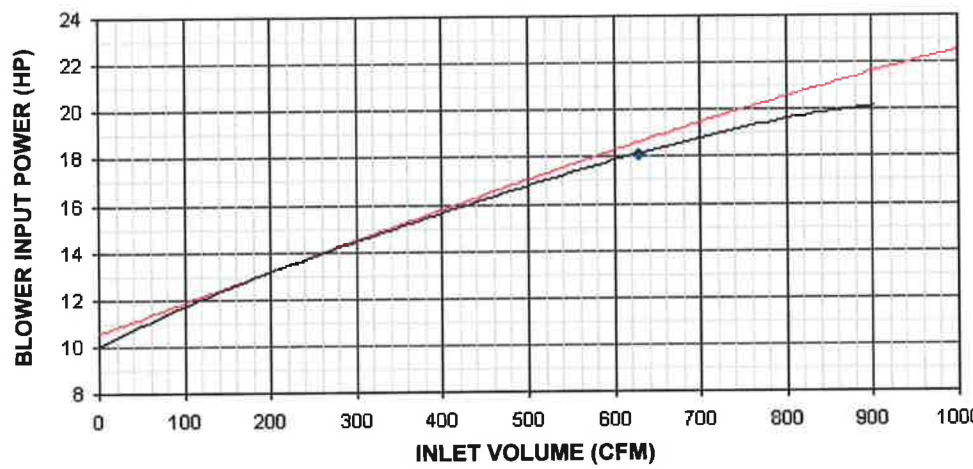
Mol Weight	: 28.1756064	
(k-1)/k Factor	: 0.2816199	
EAP (std)	: 110.02	**inWC**
Isentropic Pwr	: 8.23	**HP**
Op. Speed	: 3525	**RPM**

Exhauster Data

Model	: HSI 5105	
Impeller 1	: (5) 5012	
Power	: 18.13	**HP**
Efficiency	: 45.38	**%**
Disch Temp	: 182.93	**°F**
Rise to Surge	: 17.69	**inWC**
Turndown	: 100.00	**%**
Surge Vac.	: 57.69	**inWC**
Surge Volume	: 0.0	**CFM**
Throttle Valve	: 5.0	**in**
Valve Closed	: 51.5	**%**

Performance Curves





Gas Data

Gas	Pct	MW	Cp	Gas	Pct	MW	Cp
Air (dry)	100.00	28.9660	0.2410				

THE BOULEVARDS AT SOUTH BAY, LLC

ATTACHMENT 2

KURTZ FLOW ELEMENT

SERIES 454FTB

SINGLE-POINT INSERTION THERMAL MASS FLOW TRANSMITTERS

KURZ INSTRUMENTS INC.™

SINGLE-POINT INSERTION THERMAL MASS FLOW TRANSMITTERS

DESCRIPTION

The Series 454FTB represents the newest addition to the Kurz family of state-of-the-art microprocessor based, industrial quality, Single-Point Insertion Mass Flow Transmitters for industrial gases. It has many improvements and features that greatly enhance the performance, including, the new FD2-HT Sensor rated at 260°C, electronic self-check functions, a flow control valve PID controller, a Patent Pending digital thermal anemometer bridge, a more convenient remote electronic mounting configuration, a one-piece PCB for improved reliability and ease-of-use, built-in sensor cleaning purge timer, external input for other process signals such as pressure and other unique Kurz engineering and functional features. The 454FTB includes the most advanced temperature compensation, microprocessor technology and the highest repeatability, accuracy, and reliability available. The 454FTB has CE Compliance, non-incendive hazardous gas safety approvals and a Canadian Registration Number for most applications. Kurz has world-class calibration facilities, and is ISO 9001:2000 certified.

KEY FEATURES

- Easy-to-use menu for display and set-up with HELP screens.
- Two-line 16 character, back-lit LCD with twenty button keypad (optional).
- User selectable scrolling display.
- Adjustable LCD/Keypad orientation allowing ease of reading the display for horizontal or vertical installations.
- Process Temperature Rating of −40˚C to +260˚C (HT) or −40˚C to +500˚C (HHT).
- PID Flow Controller.
- Two optically isolated loop-powered 4-20 mA outputs, one for mass flow rate or mass velocity, one for process temperature or for PID application.
- 4-20 mA outputs meet NAMUR NE43 recommendations.
- Two optically isolated solid-state alarm/relays (optional).
- Pulsed output for use as a remote flow totalizer (optional).
- User selected English or Metric units (SFPM, SCFM, SCFH, PPM, PPH, ˚F; NMPS, NLPM, NCMH, KGM, KGH, ˚C).
- Multi-Point calibration correction factors for Flow and Temperature.
- User-entered METER ID.
- User-entered flow area.
- Programmable sensor out-of-tolerance indication and alarm functions.
- User may change STP reference condition.
- User-selectable digital filtering for each METER.
- Built-in flow totalizers and elapsed time.
- User Access Code.
- USB port for terminal operation.
- Modbus ASCII or RTU communications.
- IP66/NEMA 4X/7 dual chamber epoxy painted electronics enclosure.
- CE Compliance, including the current EMC, ATEX, LVD and PED Directives.
- Configuration upload/download software using a PC and USB connection.
- Velocity/Temperature/Mapping (VTM) for wide ranging velocity and temperature.
- Input power options of 85 to 265 VAC 47/63 Hz or 24 VDC.
- Remote Electronics Enclosure option.
- Velocity range of 0-24,000 SFPM (112 NMPS).
- New Patent Pending digital sensor control.
- Single PCB main electronics.
- Built-in purge timer and "hold value" feature during purge for use with Model 146 Sensor Cleaning System.
- Optional Air Purge Sensor Cleaning System.
- Electronics operating temperature range of −25˚C to +65˚C, non-condensing, and −40˚C to +65˚C without the LCD/Keypad option.
- Process Pressure Rating of 300PSIG.
- Alloy C-276 all-welded sensor construction.
- Fastest response to temperature and velocity changes in the industry.
- Insensitive to orientation
- Sensor lead length independent circuitry.
- Non-Incendive Safety Approvals (ATEX, CSA).
- All components pass an extensive burn-in test for high reliability.
- Zero velocity cut-off.
- Automatic Sensor Blockage Correction Factor (SBCF).
- Built-in zero–midspan–span CEM electronics drift check circuits.
- Two digital inputs (optional).
- One 4-20mA input (optional).

APPLICATIONS

- Industrial and process gas mass flows
- Combustion air flow measurements
- EPA Flow Monitors
- Flare stack metering
- Aeration air flow and digester off-gas flow
- Landfill vapor recovery
- Incinerator stack mass flow
- Solvent recovery system mass flow
- VOC mass flow
- Cement plants
- Coal-fired boiler combustion air
- Compressed air
- Natural gas, and most industrial gases
- Semi-conductor processing gas metering
- Nuclear power plants
- Air sampling in D.O.E. facilities
- O.E.M. applications

OUR MISSION

To manufacture and market the best thermal mass flow meters available and to support our customers in their efforts to improve their business.

Kurz Instruments, Inc. ■ 2411 Garden Road, Monterey, CA 93940 ■ Tel 800-424-7356
Fax 831-646-8901 ■ www.kurzinstruments.com ■ e-mail: sales@kurzinstruments.com

PRINCIPLE OF OPERATION

The Series 454FTB uses the well-recognized Kurz thermal convection mass flow measurement method by detecting the heat transfer from the heated RTD sensor (Rp) referenced to the temperature of the ambient gas stream RTD sensor (Rtc). A constant temperature difference between the heated sensor and the temperature sensor is maintained with a new patent pending digital control circuit providing unexcelled speed of response and the many other advantages of constant temperature thermal anemometry. The microprocessor-based electronics measures the heat transfer, computes the standard velocity and ambient gas temperature, and allows the user to configure and set-up the 454FTB to fit all flow requirements. Display screens are easy-to-use and provide all the flow and temperature and diagnostic information. For a more detailed description of Kurz technology, please see Document Number 364003, "Theory and Application of Kurz Thermal Convection Mass Flow Meters" by contacting the Kurz Factory or by visiting our web site.

***Figure 1**–Series 454FTB LCD/Keypad with Lid Removed.*

***Figure 2**–Fast Dual (FD2) Sensor.*

CALIBRATION CURVE

***Figure 3**–The basic flow calibration curve is non-linear, having a non-zero output (live zero) at zero flow and a nearly constant percent of reading accuracy. Zero is a valid data point for a Kurz meter. The 454FTB electronics linearizes this non-linear Calibration Data.*

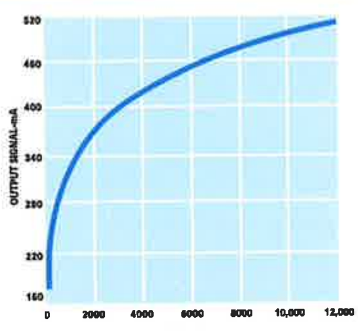


***Figure 3**–Calibration Curve.*

TIME RESPONSE TO FLOW AND TEMPERATURE CHANGES

***Figure 4**–Shows the response of a Kurz Fast Dual (FD2) MetalClad™ sensor to a step change in velocity. Kurz manufactures the fastest industrial quality sensors available.*

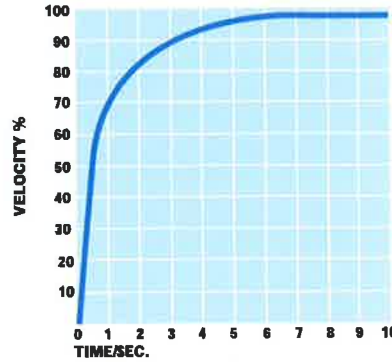


***Figure 4**–Sensor Flow Response.*

***Figure 5**–Shows a typical response to a step change in temperature for a Kurz Fast Dual (FD2) MetalClad™ sensor. It is exceptional and allows use of the sensor for combustion air flow measurements in boilers that mix hot and cold air for temperature control in coal pulverizers, for example.*

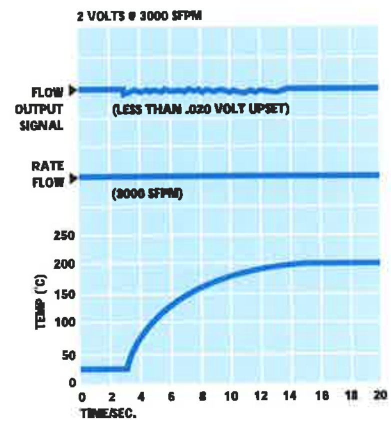


***Figure 5**–Sensor Temperature Response.*

ORIENTATION EFFECTS

***Figure 6**–Shows a typical output response to changes in the incoming velocity direction. Data is shown for rotation and yaw, as defined by Figure 7. Note that the effect is small for angles up to ±20 degrees. This is extremely important for flow applications having severe turbulence and a non-axial velocity direction.*

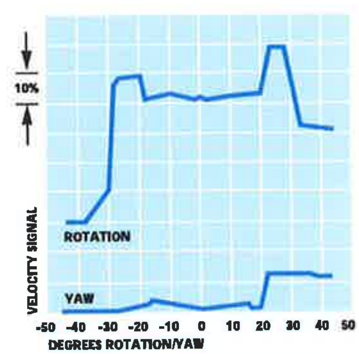


***Figure 6**–Sensor Measurement Error Versus Rotation/Yaw Angles.*

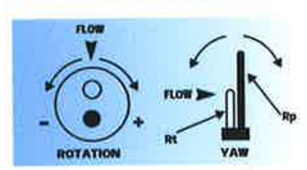


***Figure 7**–Sensor Rotation and Yaw Description.*

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SPECIFICATIONS

Process Temperature Rating:
HT(-40°C to 260°C)
HHT(-40°C to 500°C)

Process Pressure Rating:
300 PSIG (20 BARg)

Sensor Material: Alloy C-276; optional abrasion-resistant Chromium Nitride coating on Alloy C-276 sensor materials. PTFE coating for chemical resistance on Alloy C-276 sensor and sensor support, HHT sensors, 260°C max.

Sensor Support Material:
316L Stainless Steel, optional Alloy C-276.

Repeatability: 0.25%

Velocity Time Constant:
1 second for velocity changes at 6000 SFPM at a constant temperature and 1 second for temperature changes at a constant velocity of 6000 SFPM.

Process Temperature Time Constant:
8 seconds at a velocity of 6000 SFPM.

Velocity Accuracy:
See Feature 4 for overall accuracy including the effects of process temperature.

Temperature Accuracy:
±(1/2% of reading +1°C) for velocities above 100 SPFM.

Power: +24 VDC ±10%, 85-265 VAC, 47/63 Hz; 24 watts max.

Enclosure Temperature Rating: -25°C to +65°C with LCD/Keypad option; -40°C to +65°C without LCD/Keypad option.

Enclosure: Epoxy-Painted aluminum, IP66/NEMA 4X/7 with glass window for display option.

Solid-State Relays:
Optically isolated, 0.5 ampere, 24 VAC/VDC maximum

Analog Outputs (4-20 mA):
Optically isolated, user loop-powered, 12 bit resolution and accuracy, maximum loop-resistance is 300Ω at 18 VDC, 550Ω at 24 VDC, 1400Ω at 36 VDC; meets NAMUR NE43 recommendations.

Meter Filter Time Constant:
Selectable 0 to 600 seconds.

Continued on next page

TECHNICAL DESCRIPTION

SENSOR DESIGN

Series 454FTB Insertion Mass Flow Transmitters use the Kurz MetalClad™ FD2 all-welded Alloy C-276 sensor. In this design, the temperature sensor and velocity sensor are mounted in separate tubes (or "stings"), providing exceptional thermal isolation from the sensor support structure and fast response to process temperature changes.

SENSOR MATERIALS AND CONSTRUCTION

The standard sensor material for all Kurz metal sensors is Alloy C-276. This material is far superior to 316 Stainless Steel in high temperature and corrosive applications. Kurz offers Chromium Nitride coating for abrasive, dirty applications, such as in boiler coal pulverizers. Kurz exclusively uses Inconel sheathed mineral-insulated cable (MI cable) for temperatures above 260°C.

PROCESS TEMPERATURE RATING

Kurz offers sensor process temperature ratings of 260°C and 500°C. Field data verifies that the lifetime at 500°C is at least five years and the lifetime at 260°C is at least 10 years.

TRANSMITTER CONFIGURATIONS

Two configurations are available; Directly Attached Electronics Enclosure and Remote Electronic Enclosure.

PROCESS TEMPERATURE COMPENSATION

The influence of temperature on the thermal properties of gases requires temperature compensation for repeatable and accurate measurements. Standard Temperature Compensation (STC) is used for applications in which the process temperature is below 125°C over a moderate velocity range or below 260°C over a more limited velocity range. If the process temperature and gas velocity vary widely, Velocity/Temperature/Mapping (VTM) is recommended. VTM includes several process temperatures and uses the microprocessor to calculate the velocity based on the built-in process temperature measurement.

GAS CALIBRATION

The customer has a choice of a laboratory calibration or a gas correlation calibration. Air calibrations are performed in the Kurz Model 400D NIST traceable wind tunnel.

SENSOR PROTECTION

The 454FTB circuitry includes circuitry to prevent an over-temperature condition caused by a sensor, wiring or component failure. Our sensors will not overheat at zero flow, unlike most competitive devices because of our constant temperature sensor control method and the power limiting design.

AIR PURGE SENSOR CLEANING SYSTEM

The Model 454PFTB has a special nozzle in the sensor window for use with the Model 146 Air Sensor Cleaning System. The sensor cleaning is accomplished by a short, high pressure blast of air (sonic velocity) directed at the velocity and temperature sensors. Kurz provides solenoid valves and air blow-down tanks to allow periodic or on-demand cleaning. The 454PFTB has a built-in timer and relay to initiate the purge cycle. The measurement value is "held" during the purge cycle. The air blow-down tank uses customer supplied compressed air (instrument quality) at 60 to 125 PSIG. The average cleaning air consumption is less than 0.125 SCFM. The Model 454PFTB is designed to measure air flow only at ambient pressure. Canadian Registration (CRN) is not available for the Model 454PFTB. The primary application is for extremely dirty stacks and ducts having dry particulate matter that may build up on the sensor. Applications include fossil-fueled power boilers, municipal waste incinerators and combustion air flow situations in which fly ash is entrained.

SENSOR ELECTRONICS

The Series 454FTB has several innovations which improve performance, reduce cost and provide extraordinary flexibility. The Patent Pending digital sensor control circuit uses an efficient switching power supply. The single-board PCB has an EEPROM loaded with the PCB serial number, calibration coefficients, and component values which insures the safety of the data. The sensor electronics includes a sensor lead resistance compensation circuit which is extremely important for long sensor wires, rapid gas temperature changes and large temperature gradients between the sensor and the ambient air.

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Fax 831-646-8901 ■ www.kurzinstruments.com ■ e-mail: sales@kurzinstruments.com

SPECIFICATIONS Cont'd.

Safety Approvals:
ATEX Non-Incendive
EN 60079-0/15 and
EN 61241-1
⟨Ex⟩ II 3 GD, EEx nA II;
IP66/NEMA 4X/7 enclosure.

Rated Input:
24 VDC, 24W
Electronics Housing: -40°C to 50°C:T6; -40°C to 65°C:T5.
Sensing Element: -40°C to 55°C:T5; -40°C to 130°C:T3.
Maximum, Effective Sensing Element Temp.: 70°C above Process Temperature.

Rated Input:
85 to 265 VAC, 24 W 47-63 Hz PH1.
Electronics Housing: -40°C to 50°C:T4; -40°C to 60°C:T150°C.
Sensing Element: -40°C to 55°C:T5; -40°C to 130°C:T3.
Maximum, Effective Sensing Element Temp.: 70°C above Process Temperature.

CE Directives: EMC, ATEX, LVD and PED. Consult Kurz for details.

Serial Port Baud Rate:
User selectable: 9600, 14,400, 19,200, 38,400, 57,600.

Communication Ports:
RS485 Modbus ASCII or RTU Mode, and USB.

Digital Inputs:
Two, contact closure, TTL.

Analog Input:
One, 4-20mA, non-isolated.

LCD: Back-lit two-line alphanumeric with 16 characters per line.

LCD Update: Every two seconds.

Keypad: 20-button membrane mounted inside enclosure.

LCD/Keypad Orientation:
Adjustable in 90° increments to accommodate viewing orientation.

Electronics Enclosure Orientation: 0° or 180° for viewing (Feature 1).

Memory: EEPROM for all important data, with automatic sensor identification; Flash EEPROM for Program Memory.

Net Weight/Shipping Weight:
DC Version: 4lbs/5lbs;
AC Version: 6lbs/8lbs,
add 4lbs/5lbs for remote option.

TECHNICAL DESCRIPTION Cont'd.

FIRMWARE

The Display, Executive and Programming menus are very easy-to-use and are largely self-explanatory. The flow and temperature data may be scrolled so it can be seen through the window in the cover. The user may press "D" and see the flow and temperature data, as well as the raw flow data. Pressing "H" holds the display screen (but not the readings). A user access code is required for programming, seeing data and entering configuration and other user data.

HELP SCREENS

By pressing "HH" the user can obtain important information on the use of the Series 454FTB, including the firmware version, Kurz telephone and fax numbers and the web site address, etc.

SELF-DIAGNOSTICS

The 454FTB performs an extensive check-out upon power-up and continuously monitors the sensor inputs/outputs and verifies the integrity of the sensor wiring and the measurements. The Sensor Kick-Out Feature is used to set the velocity and temperature fault limits.

PROGRAMMABLE CORRECTION FACTORS

A multi-point Variable Correction Factor (VCF) may be used to correct the flow calibration data to meet in-situ flow tests over the entire velocity range such as done for EPA Stack Flow Monitors. A Sensor Blockage Correction Factor (SBCF) can be used to correct for the area reduction caused by the sensor support. The user enters the area of the flow passage and the sensor center line distance from the inside of the flow passage and the Series 454FTB automatically calculates the SBCF.

METER FILTER TIME CONSTANT

A digital filter time constant may be set for each METER which affects the display readings and the 4-20 mA outputs. The time constant can be set from 0 to 600 seconds.

COMPATIBILITY WITH SERIES 155 MASS FLOW COMPUTERS

A "Blind" Series 454FTB (ordered with the two 4-20 mA Outputs and +24 VDC power input is fully compatible with the inputs and features of the Series 155 Mass Flow Computers. This Feature is used when two or more Model 454FTBs are used in a multi-point velocity array. (Please see the Series 155 Brochure).

SELECTABLE STP CONDITIONS

The mass flow calibration data is referenced to the Kurz laboratory standard of 77°F/14.69 PSIA (25° C/760 mmHg). The user may change the STP conditions to suit his requirement.

4-20 mA OUTPUTS

These loop-powered outputs are optically isolated, and include the NAMUR NE43 recommendation regarding fault detection. The fault conditions are generally set at the Kurz Factory, but may be set by the user. The user may easily re-calibrate the 4-20 mA outputs by entering "CALIB 4-20 mA OUTPUTS" measuring the output and adjusting it using the LCD/Keypad up/down buttons. The 4-20mA outputs may be set-up for non-isolated, self-powered operation.

NAMUR NE43 COMPLIANCE

Kurz meets the NAMUR NE43 recommendation for the 4-20 mA outputs, under a fault defined by the sensor Kick-Out menu, sensor or system fault. An NE43 alarm may be selected as high or low, but not both. This feature also frees up the alarm/relays so that the user can set-up the flow and temperature alarms for other needs.

TOTALIZER OUTPUT

The customer may order 0 or 2 solid-state optically isolated relays. If no relays are ordered, the alarm functions are displayed on the LCD. Both relays may be used for alarms (LO, HI and HOL) or for the Sensor Kick-Out Feature; or one relay may be used for an alarm function and one may be used as a pulsed output for use as a remote flow totalizer, or both relays may be used as pulsed outputs. Totalizers may be automatically reset at a specific total quantity (i.e., 10,000 SCF). The 454PFTB uses one relay for the purge initiation.

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Fax 831-646-8901 ■ www.kurzinstruments.com ■ e-mail: sales@kurzinstruments.com

SERIES 454FTB SINGLE-POINT INSERTION THERMAL MASS FLOW TRANSMITTERS

TECHNICAL DESCRIPTION Cont'd.

BUILT-IN "ZERO-MIDSPAN-SPAN" DRIFT CHECK/CALIBRATOR

A new feature is the addition of a Daily "Zero-Midspan-Span" Electronics Drift Check meeting the U.S. E.P.A. requirement for CEM Stack Flow Monitors. A menu is entered to select the desired flow value (or 4-20 mA value) for "Zero-Midspan-Span" values and the time interval during each stepped flow value. The Drift Check is initiated by the User with a contact closure or via Modbus. An acknowledgement relay is normally activated. A solid-state relay and a digital input is needed (See Feature 11). The flow signal is compared against the expected set-point for each level of selected velocity or flow rate values. In addition, this feature can be used to check the electronics for accuracy and linearity.

PID FLOW CONTROLLER

The new 454FTB includes the capability of controlling the velocity or flow rate through the use of the user's control valve, damper or position commanded 4-20 mA interface device. The Set-Point may be internal or remote.

USB PORT

A USB port for terminal operations includes a COM emulator driver which can be accessed using a PC terminal emulator program to remotely "echo" the LCD and keypad functions and upload/download the system configuration and calibration data files using XMODEM protocol. The Series 454FTB may be operated in a manual or remote terminal manner. Measurement summary data may be initiated manually and by pushing the "L" button on the keypad or from the PC. The information may also be obtained automatically by activating the LOG interval timer using the Series 454FTB keypad or a PC.

MODBUS

The Modbus local network protocol (ASCII or RTU) is included. The use of Modbus is extremely useful, as most features may be accessed, including configuration up-load, down-load, etc.

ORDERING INFORMATION

FLOW TRANSMITTER SELECTION

Table 1 lists the Series 454FTB Model number, Parent Number and Major Features. **Table 2** lists the Baseline (V*) Full Scale Velocity for each Gas Type. **Table 3** lists the Flow factor (F*) Equation for each Gas Type.

TABLE 1 SERIES 454FTB SELECTION TABLE

Model Number	Parent Number	Sensor Support Dia.	Process Temp. Rating	Air Purge	Safety Approvals
454FTB-08-HT	756051	½"	HT	No	NI
454FTB-08-HHT	756052	½"	HHT	No	NI
454FTB-12-HT	756053	¾"	HT	No	NI
454FTB-12-HHT	756054	¾"	HHT	No	NI
454FTB-16-HT	756055	1"	HT	No	NI
454FTB-16-HHT	756056	1"	HHT	No	NI
454PFTB-16-HT	756057	1"	HT	Yes	NI
454PFTB-16-HHT	756058	1"	HHT	Yes	NI

Table 2: BASELINE V * VELOCITY RANGES (See Notes 1, 2, 3)

Model Number	VELOCITY SFPM (NMPS)					
	Gas group number and gas type					
	A Air, N_2, O_2, Ar CO_2	C Methane Digester Gas, Dry Ammonia	D Dry Chlorine, Ethylene	E Ethane	F Helium, Propane Butane	G Hydrogen
454FTB-08-HT 454FTB-12-HT 454FTB-16-HT To 125°C	18,000 (84)	17,000 (79)	15,000 (70)	13,300 (62)	10,000 (47)	6,000 (28)
454FTB-08-HT 454FTB-12-HT 454FTB-16-HT 454PFTB-16-HT To 260°C	18,000 (84)	N/A	N/A	N/A	N/A	N/A
454FTB-08-HHT 454FTB-12-HHT 454FTB-16-HHT 454PFTB-16-HHT To 500°C	18,000 (84)	N/A	N/A	N/A	N/A	N/A

Note 1: *See Nomenclature for the complete definition of Gas Group Number and Gas Type.*

Note 2: *SFPM: Standard Feet-Per-Minute (Ref.: 77°F, 14.69 PSIA).*
NMPS: Normal Meters-Per-Second (Ref.: 0°C, 760 mm Hg).
NMPS = 0.00466 x SFPM (Approximate).

Note 3: *The Baseline (V*) VELOCITY for each Mass Flow Transmitter Model Number and for each type of Gas is the maximum velocity at standard conditions (See Note 2).*

TABLE 3: FLOW FACTOR (F*) EQUATIONS

Gas Type	DR_P	Equations
Group A: Air, N_2, Ar, CO_2, O_2	Less than1.333	$F^* = DR_P$
	Greater than 1.333	$F^* = 1.333$
Group C: Methane, Digester Gas, Dry Ammonia	Less than 0.945	$F^* = 1.059DR_P$
	Greater than 0.945	$F^* = 1.000$
Group D: Dry Chlorine, Ethylene	Less than 0.833	$F^* = 1.2DR_P$
	Greater than 0.833	$F^* = 1.0$
Group E: Ethane	Less than 0.739	$F^* = 1.353DR_P$
	Greater than 0.739	$F^* = 1.000$
Group F: Helium, Propane, Butane	Less than 0.555	$F^* = 1.8DR_P$
	Greater than 0.555	$F^* = 1.00$
Group G: Hydrogen	Less than 0.333	$F^* = 3.0DR_P$
	Greater than 0.333	$F^* = 1.000$

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SERIES 454FTB SINGLE-POINT INSERTION THERMAL MASS FLOW TRANSMITTERS

NOMENCLATURE:

PROCESS TEMPERATURE RATING		
Identifier	*Description*	*Range*
HT	High Temperature	-40°F to 500°F (-40°C to 260°C)
HHT	Very High Temperature	-40°F to 932°F (-40°C to 500°C)

SENSOR TYPE	
Identifier	*Description*
FD2	Fast Dual Metal-Clad™ Velocity and Temperature Sensor, all-welded construction, 0.105" diameter sensor stings

SAFETY APPROVALS	
Identifier	*Description*
NI	Non-Incendive, ATEX and CSA Approvals

GAS GROUP AND GAS TYPE	
Group	*Gas Type*
A	Air, Nitrogen, Oxygen, Argon, Carbon Dioxide
C	Methane, Digester Gas, Dry Ammonia
D	Dry Chlorine, Ethylene
E	Ethane
F	Helium, Propane, Butane
G	Hydrogen

DEFINITIONS FOR THE USE OF TABLES 1, 2, 3

Equation 1: $DR_P = \frac{P_P}{P_S} \times \frac{T_S}{T_P}$

Equation 2: $V_{MAX} = F^* \times V^*$

V^* = Baseline Velocity as listed in Table 2 (SFPM for English Units or NMPS for Metric Units at Standard conditions).

V_P = Process Velocity (SFPM for English Units, NMPS for Metric Units).

V_{MAX} = Maximum Velocity for a specific Gas Type under Process Conditions.

F^* = Flow Factor.

T_S = Standard Absolute Temperature: 537°R (77°F + 460) for English Units or 273°K (0°C) for Metric Units.

T_P = Process Absolute Temperature: °R (T°F + 460) for English Units or °K (T°C + 273°C) for Metric Units.

P_S = Standard Absolute Pressure (14.69 PSIA for English Units and 760mm Hg for Metric Units).

P_P = Process Absolute Pressure (PSIA for English Units and mm Hg for Metric Units).

DR_P = Process Gas Density Ratio.

Example: Calculate the maximum allowable Gas Velocity (V_{MAX}) for compressed air at 100°F and 135 PSIA for the Model 454FTB-12-HT.

a) From **Table 2**, V^* = 18,000 SFPM

b) Calculate DR_P from Equation 1:

Equation 1: $DR_P = \frac{P_P}{P_S} \times \frac{T_S}{T_P} = \frac{135}{14.69} \times \frac{537}{560} = 8.81$

c) Using **Table 3** for Group A, Air: F^* = 1.333 (DR_P greater than 1.333)

d) Using Equation 2: $V_{MAX} = F^* \times V^*$ = 23,9444 SFPM (111.8 NMPS)

Part Number Generation Procedure

With the selected Parent Number, specify the entire Part Number by selecting an Option for each Feature as shown in the example below. Feature Options in Bold type indicate the most available Models, other options usually require a longer delivery time.

Example Part Number for a Model 454FTB-16-HHT:

756056	D	32	F	4	F	077	M	01	A	015	B	1392
Parent Number	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**	**F12**

SUMMARY OF FEATURES	
Feature	*Feature Description*
1	**Electronics Enclosure Configuration and Input Power, LCD/Keypad**
2	**Sensor Material/Sensor Support and Flange Material**
3	**Sensor Support Length**
4	**Process Temperature Compensation**
5	**Optional Flange Connection Size and Rating**
6	**Optional Flange U Dimension**
7	**Gas Velocity Calibration Data Range**
8	**Specialty Gas Velocity Calibration**
9	**Safety Approvals**
10	**Process Pressure**
11	**Analog & Digital Inputs/Outputs**
12	**Process Temperature**

FEATURE 1: ELECTRONICS ENCLOSURE CONFIGURATION AND INPUT POWER (See Note 1)	
Option	*Description*
A	Directly Attached Dual-Chamber Electronics Enclosure, AC-Power, LCD/Keypad.
B	Directly Attached Dual-Chamber Electronics Enclosure, AC-Power, without LCD/Keypad.
C	Directly Attached Dual-Chamber Electronics Enclosure rotated 180° for viewing, AC Power, LCD/Keypad.
D	Remote Dual-Chamber Electronics Enclosure, AC-Power, LCD/Keypad.
E	Remote Dual-Chamber Electronics Enclosure, AC-Power, without LCD/Keypad.
F	Directly Attached Dual-Chamber Electronics Enclosure, 24VDC-Power, LCD Keypad.
G	Directly Attached Dual-Chamber Electronics Enclosure rotated 180° for viewing, 24VDC-Power, LCD/Keypad.
H	Directly Attached Single-Chamber Electronics Enclosure, 24VDC-Power, without LCD/Keypad.
I	Remote Dual-Chamber Electronics Enclosure, 24 VDC-Power, LCD/Keypad.
J	Remote Single-Chamber Electronics Enclosure, 24 VDC-Power, without LCD/Keypad.

Note 1: *The temperature storage and operating rating of the Electronics Enclosure is -25°C to +65°C with the LCD/Keypad and -40°C to +65C without the LCD/Keypad. The conduit or cable seal must be installed by an experienced and careful installer to prevent water intrusion into the enclosure and to maintain the enclosure rating. Failure to properly install the conduit seals may void the Kurz warranty and may compromise the safety approval rating.*

Note 2: *Stainless Steel Identification Tags are available. Customer must provide labeling information up to four lines of text with 32 characters each line.*

FIRST DIGIT OF FEATURE 2: SENSOR MATERIAL	
Option	**Description**
3	Alloy C-276
7	Alloy C-276 with Abrasion-Resistant Chromium Nitride Coating (CrN)

SECOND DIGIT OF FEATURE 2: SENSOR SUPPORT AND FLANGE MATERIAL	
Option	**Description**
2	316L Stainless Steel
3	Alloy C-276
8	Alloy C-276 with PTFE Teflon Coating cured for chemical resistance. Includes support, sensor and flange; FD2-HHT sensors only, temperature rating of 260°C Max.

FEATURE 3: SENSOR SUPPORT LENGTH L			
Option	**Support Length L**	**Option**	**Support Length L**
B	6" (125°C Max)	J	30"
C	9" (260°C Max)	K	36"
D	12"	M	48"
F	18"	P	60"
H	24"		

FEATURE 4: PROCESS TEMPERATURE COMPENSATION

The influence of temperature on the thermal properties of gases requires temperature compensation of the Thermal Mass Flow Sensor for repeatability and accurate measurements. Standard Temperature Compensation (STC) is used for applications in which the process temperature is below 125°C over a moderate velocity range (Option 1); or below 260°C over more limited velocity range (Option 2).

If the process temperature and gas velocity vary widely, Velocity/Temperature/Mapping (VTM) is recommended. VTM (Options 3, 4) includes several calibrations. The multiple velocity calibrations are entered into the Microprocessor which performs a double interpolation between the velocity calibration curves using the built-in process gas temperature measurement. The temperature compensation is based upon air, therefore, the accuracy at a high temperature when using gases other than Air, Nitrogen or Oxygen may be reduced.

Option	Description
1	Standard Temperature Compensation (STC) over process temperature range of -40°C to +125°C. Accuracy: ± [(1% + .025%/°C) reading + 20 SFPM/°C] Above or below 25°C, all gases.
2	Standard Temperature Compensation (STC) over process temperature range of 0°C to 260°C. Accuracy: ± [(2% + .025%/°C) reading +(20 SFPM + .25 SFPM/°C)] Above or below 125°C; Air, O_2 and N_2 only.
3	Velocity/Temperature/Mapping (VTM) with data sets over process temperature range of 0°C up to 260°C. Accuracy: ±(2% reading + 20 SFPM), Air, O_2 and N_2 only.
4	Velocity/Temperature/Mapping (VTM) with data sets over the process temperature range of 0°C up to 500°C. Accuracy: ±(3% reading + 30 SFPM), Specify Process Temperature Range, Air, O_2 and N_2 only. HHT Models.

FEATURE 5: OPTIONAL FLANGE CONNECTION SIZE AND RATING (Note 1)

How to Determine the U, L and L2 Dimensions for a Flange Connection

When ordering a flange, you must specify the U dimension, and verify that the sensor support length L and L2 are appropriate for the Process Temperature. Kurz recommends that the centerline of the sensor be located at the center of the pipe or duct, and that experimental flow profile tests be made to obtain the velocity profile correction factor (VCF) and enter it into the 454FTB. Refer to the outline drawings in the Series 454FTB Brochure. **Note:** *Flange material must match Sensor Support Material (Feature 4).*

U = The dimension between the centerline of the mass flow sensor and the flange mounting surface. The minimum U dimension is 4.0".
L = The length of the sensor support tube (Feature 3).
L2 = The length of sensor support between the flange mounting surface and the sensor support fitting. The minimum L2 is 5 inches for HT process temperatures and 8 inches for HHT process temperatures.
L = U + L2 – 2.00"

Option	Sensor Support Diameter	Description
A	½", ¾", 1"	No flange connection
B	½"	½", Class 150, ANSI B16.5
C	½"	½", Class 300, ANSI B16.5
D	½", ¾"	¾", Class 150, ANSI B16.5
E	½", ¾"	¾", Class 300, ANSI B16.5
F	½", ¾", 1"	1", Class 150, ANSI B16.5
G	½", ¾"	1", Class 300, ANSI B16.5
H	¾", 1"	1¼", Class 150, ANSI B16.5
I	¾", 1"	1¼", Class 300, ANSI B16.5
J	¾", 1"	1½", Class 150, ANSI B16.5
K	¾", 1"	1½", Class 300, ANSI B16.5
L	¾", 1"	2", Class 150, ANSI B16.5
M	¾", 1"	2", Class 300, ANSI B16.5
N	1"	2½", Class 150, ANSI B16.5
P	1"	2½", Class 300, ANSI B16.5
S	1"	3", Class 150, ANSI B16.5
T	1"	3", Class 300, ANSI B16.5
U	1"	4", Class 150, ANSI B16.5
V	1"	4", Class 300, ANSI B16.5

Note: *Flange material must match the Sensor Support Material (Feature 2).*

FEATURE 6: OPTIONAL FLANGE U DIMENSION

Directions

Divide the U Dimension (inches) by 100, round off the resulting number to the right of the decimal point to three significant digits, enter the resulting three digit number without the decimal point. Enter 000 for no flange connection. U_{MIN} = 4"

Example: The U Dimension is 7.74"; Enter 077.

FEATURE 7: GAS VELOCITY CALIBRATION DATA RANGE SFPM (NMPS) (Note 1)			
Option	**Velocity**	**Option**	**Velocity**
A	V_{MAX}	M	6,000 (28.0)
B	300 (1.4)	P	9,000 (41.9)
C	600 (2.8)	R	12,000 (56)
E	1,000 (4.7)	T	15,000 (70)
G	2,000 (9.3)	V	18,000 (84)
I	3,000 (14)	X	24,000 (112)
K	4,000 (18.6)		

Note 1: *The Gas Velocity must be greater than V_{MAX} for the Process Absolute Temperature and Pressure for specific Gas Group and Type as determined using Tables 2 & 3 and Equations 1, 2.*

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FEATURE 8: SPECIALTY GAS VELOCITY CALIBRATION (Note 1)			
Laboratory Calibration		Gas Type	Correlation Calibration Option
Option	Pressure		
01	Ambient	Air	–
07	to 150 PSIA	Air	–
–	–	Dry Amonia	56
08	to 150 PSIA	Argon	58
–	–	Butane	60
14	to 150 PSIA	Carbon Dioxide	64
–	–	Dry Chlorine	68
20	to 150 PSIA	Ethane	70
22	to 150 PSIA	Ethylene	72
26	to 150 PSIA	Helium	76
28	to 150 PSIA	Hydrogen	78
32	to 150 PSIA	Methane	82
35	to 150 PSIA	"Digester Gas" 50% CH_4, 50% CO_2	85
36	to 150 PSIA	"Digester Gas" 60% CH_4, 40% CO_2	86
37	to 150 PSIA	"Digester Gas" 70% CH_4, 30% CO_2	87
40	to 150 PSIA	Nitrogen	90
44	to 150 PSIA	Oxygen (Note 2)	94
46	to 50 PSIA	Propane	96

Note 1: *Laboratory Gas calibrations are performed with gases of high purity and are NIST Traceable. Customer must specify calibration pressure. (Feature 10). Correlation calibrations are based on experimental data correlated to an air calibration at ambient pressure and temperature. The user's flow element is calibrated in air, and an additional calibration data sheet is made for the specialty gas based upon the correlation factors. Add ±5% of Reading to the accuracy specifications when using a gas correlation calibration.*

Note 2: *It is the customer's responsibility to insure that the Mass Flow Element is clean of Hydrocarbons and is safe for oxygen use. (See Accessories in Section C-1 for Cleaning and Bagging).*

FEATURE 9: SAFETY APPROVALS	
Option	Description
A	Non-Incendive (NI), HT and HHT Models See Specifications for Details

FEATURE 10: PROCESS PRESSURE
Enter the Absolute Pressure (PSIA), rounded off to 3 digits. Example: For a Process Absolute Pressure of 14.7 PSIA, enter 015; for 150 PSIA, enter 150.

FEATURE 11: ANALOG AND DIGITAL INPUTS/OUTPUTS	
Option	Description
B	Two 4-20 mA Optically Isolated Outputs (Note 1).
C	Two 4-20 mA Optically Isolated Outputs, two solid-state Relays (maximum 12 watts), one external non-isolated 4-20 mA Input, two non-isolated Digital Inputs (Note 2)

Note 1: *For Process Measurement Analog Outputs, NAMUR NE43 Alarms, and Internal Set-Point, PID Flow Control.*

Note 2: *Required for Process Measurement Analog Outputs, NAMUR NE43 Alarms, Remote set-Points, PID Flow Control, Daily "Zero-Midspan-Span" Drift Check and Acknowledgement, Alarm Relays, Automatic Sensor Cleaning Purge Timer and "Hold-Reading" Feature, and Pulsed Flow Totalizer. See the chart which follows as not all functions can be used due to the available number of inputs and outputs.*

SERIES 454FTB & 454PFTB AVAILABLE FUNCTIONS VERSUS INPUT/OUTPUT OPTIONS OF FEATURE 11				
Series 454FTB 454PFTB Functions	Relays (2 Max.)	4-20mA Outputs (2 Max.)	Digital Inputs (2 Max.)	4-20mA Inputs (1 Max.)
Flow Rate or Temp. Relay Alarm Outputs	2 (Note 1)	–	–	–
Flow Rate or Temp. Analog Outputs	–	2	–	–
Pulsed Flow Totalizer Output	1	–	–	–
PID Flow Controller, Internal Set-Point	–	1 (Note 2)	–	–
PID Flow Controller, External Set-Point	–	1 (Note 2)	–	1 (Note 3)
Daily EPA Zero-MidSpan-Span Drift Check	1 (Note 4)	2 (Note 5)	1 (Note 6)	– –
Auto Sensor Cleaning Purge Model 454PFTB Only	1 (Note 7)	–	1 (Note 8)	–

Note 1: *Flow Rate, Temperature and other alarms may be programmed to activate with the available relays. The LCD will display these alarms, even if relays are not available.*
Note 2: *The PID Controller uses one 4-20 mA output for the flow controller.*
Note 3: *The External Input PID Controller requires a 4-20 mA flow reference input.*
Note 4: *This function normally requires an acknowledgement contact closure to verify that the Drift Check has been truly initiated.*
Note 5: *Both 4-20 mA outputs are used during the Drift Check Calibration Procedure.*
Note 6: *This contact closure is generated by the Continuous Emissions Monitor Computer at a specific time every day to indicate the Daily Drift Check.*
Note 7: *The built-in Purge Timer activates one of the Relays to open the customer's air solenoid. This is a pre-set at the factory. This leaves one relay left for other functions.*
Note 8: *The purge cycle is initiated by an external contact closure from the customer or by the built-in timer, or via modbus.*

Example:
Assume a Model 454FTB is to be used as an EPA Flow Monitor. Feature 11, Option C is selected. The Daily Drift Check is needed, which requires:

One Relay, two 4-20 mA Outputs, one Digital Output

This leaves one relay, and one digital input for other functions. The possibilities are:
a) One Flow Rate or Temperature Alarm Relay.
b) A Pulsed Flow Totalizer Relay Output.

FEATURE 12: PROCESS TEMPERATURE
Enter the Absolute Process Temperature (°Rankin = °F + 460) rounded off to 4 digits. Example: For a Process Temperature of 77°F, enter 0537; for 932°F, enter 1392.

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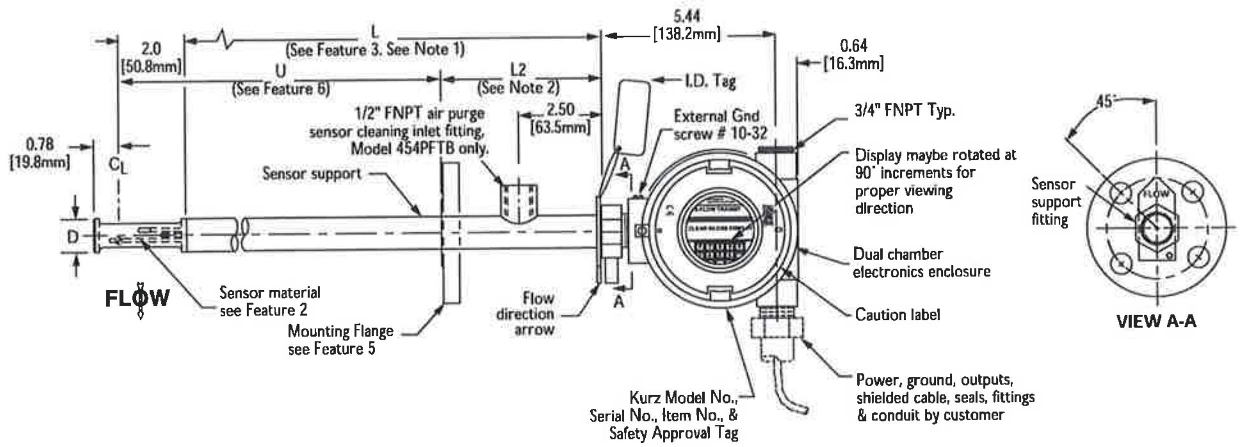
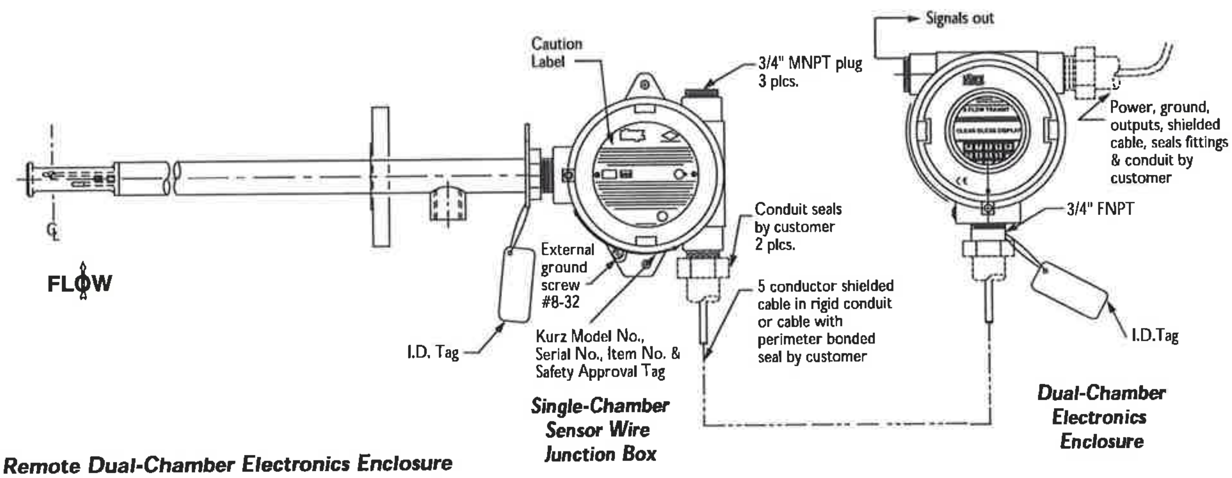
SERIES 454FTB OUTLINE DRAWINGS

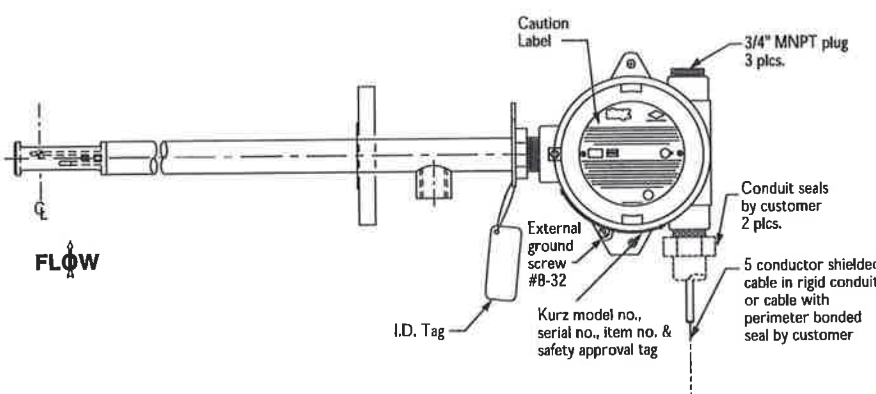


Directly Attached Dual-Chamber Electronics Enclosure
Feature 1, Options A, F (Shown with Standard Display Orientation

Note 1: L = U + L2 - 2.00", U(min) = 4"
Note 2: L2 (min) = 5" for HT Models and 8" for HHT Models



Remote Dual-Chamber Electronics Enclosure
Feature 1, Options D, I



Directly Attached Single-Chamber Electronics Enclosure
Feature 1, Option H

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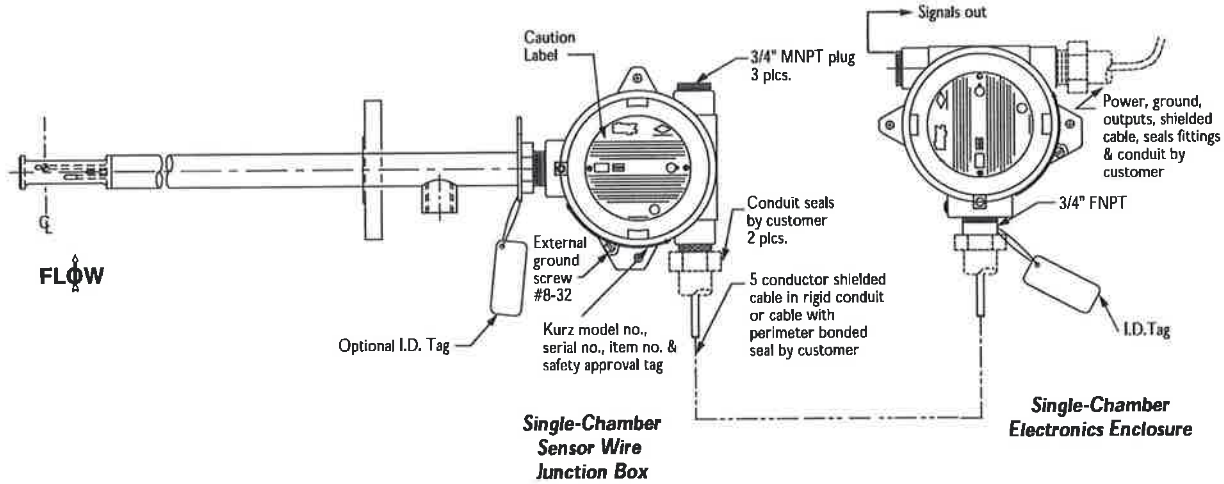
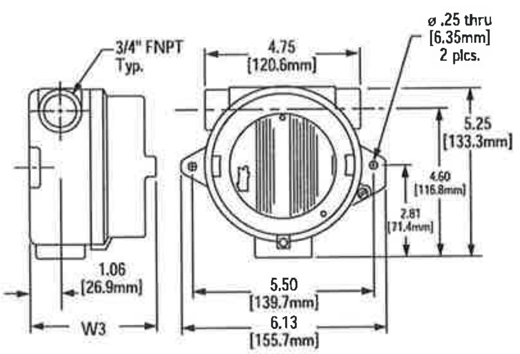
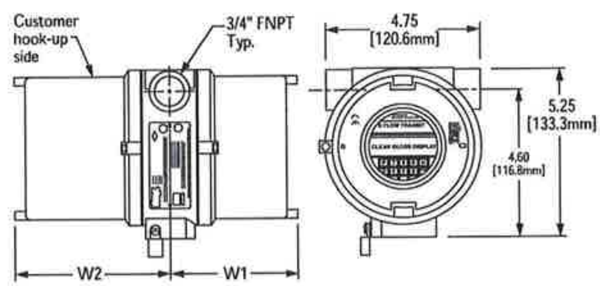


Remote Single-Chamber Electronics Enclosure
Feature 1, Option J



Single-Chamber Sensor Wire Junction Box,
Single-Chamber Electronics Enclosure Dimensions

Enclosure Type	W3
Junction Box	3.88 [99mm]
Electronic Enclosure	5.94 [151mm]



Dual-Chamber Electronics Enclosure Dimensions
(Shown with Display)

Input Power	Display/Keypad	W1	W2
AC	Yes	3.41" (87mm)	4.69" [119mm]
AC	No	2.75" [70mm]	4.69" [119mm]
24 VDC	Yes	3.41" [87mm]	4.69" [119mm]

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IMPORTANT NOTICE: Specifications are subject to change without notice.

 DCN 367521 REV. H

THE BOULEVARDS AT SOUTH BAY, LLC

ATTACHMENT 3

BAKER FILTRATION KLEENAIR 1000S AND 2000S

PRODUCT DATA SHEET

November, 2005

KLEEN.AIR 1000S & 2000S

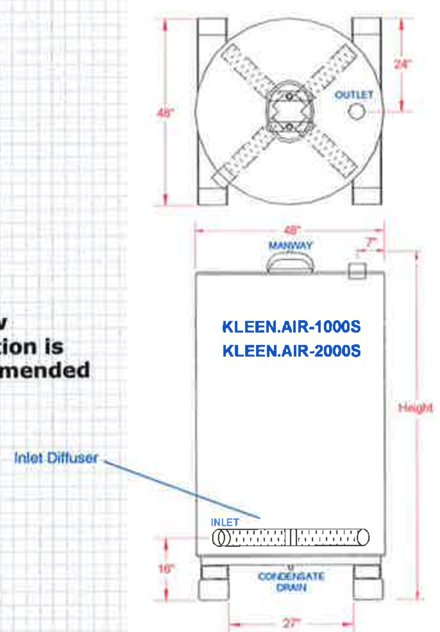
GENERAL INFORMATION

These units are designed for the efficient purification of contaminated vapor waste or process streams. They have the ability to remove contaminants to non-detectable levels. The vessels are constructed of heavy-duty mild steel and are lined with a double-layer epoxy coating. These filters are shipped from our warehouse with high quality filtration media ready for connection to process piping. Once the media is "spent", Baker Filtration can provide a number of service and disposal options.

WEIGHTS AND MEASURES

Max. Flow:	*1000S*: 600 cfm *2000S*: 600 cfm
Max. Press:	15 psi
Max. Temp:	150°F
Height:	*1000S*: 66" *2000S*: 92"
Diameter:	46"
Shipping Wt*: (drum + media) (*Media dependent)	*1000S*: 1800 lbs. – 2800 lbs. *2000S*: 3050 lbs. – 5050 lbs.

Upflow operation is recommended



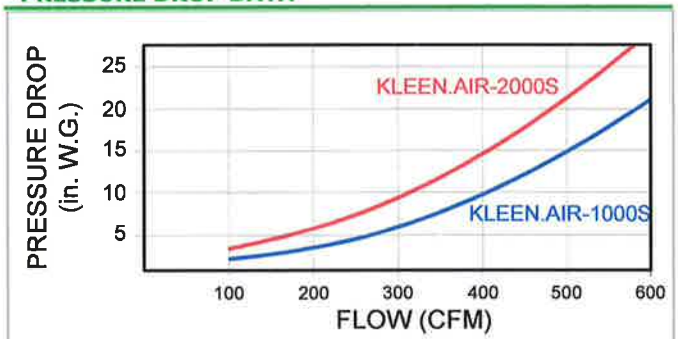
FILTER MEDIA

Types:	•Activated Carbon •Specialty Media
Volume:	*1000S*: 34 cu. ft *2000S*: 67 cu. ft.
Weight*: (*Media dependent)	*1000S*: 1000 lbs. – 2000 lbs. *2000S*: 2000 lbs. – 4000 lbs.

MISCELLANEOUS DATA

Inlet:	4" FNPT
Outlet:	4" FNPT
Interior Coating:	Double-layered epoxy coating
Internals:	PVC inlet diffuser
Media Access:	Top manway (neoprene gasket)

PRESSURE DROP DATA



NOTES:

1. In the presence of activated carbon, some contaminants may oxidize, polymerize or otherwise react resulting in the release of heat and become a potential fire hazard. Extreme care should be taken in the design and operation of such applications.
2. Wet activated carbon preferentially removes oxygen from air. In closed or partially closed containers and vessels, oxygen depletion may reach hazardous levels. If workers are to enter a vessel containing carbon, appropriate procedures for potentially low oxygen spaces must be followed, including all federal and state requirements.

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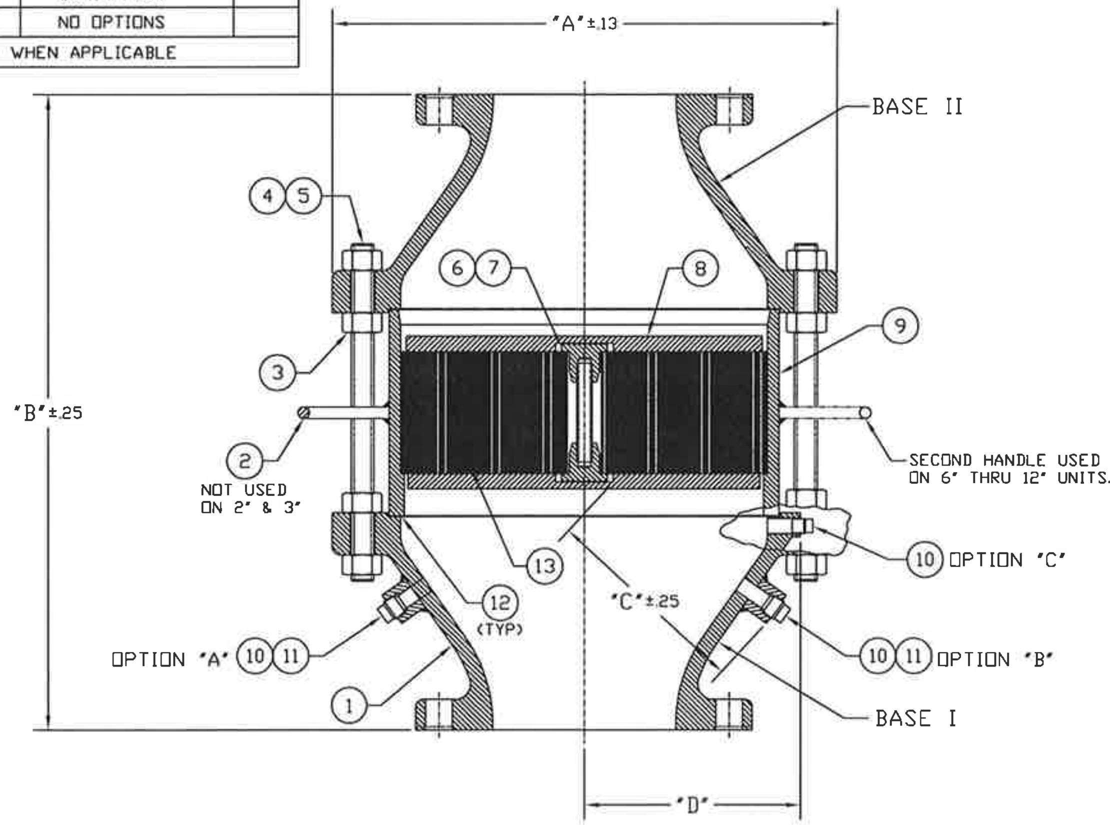
THE BOULEVARDS AT SOUTH BAY, LLC

ATTACHMENT 4

GROTH FLAME ARRESTOR

PORT CONNECTIONS				
BASE		LOCATION	DESCRIPTION	THD
		A	THERMOCOUPLE	
		B	PRESSURE TAP	
		C	DRAIN PORT	
		D	NO OPTIONS	
CHECK WHEN APPLICABLE				

MODEL 7618 VERTICAL FLAME ARRESTER



NOTES:

1. SEE DWG C-92796 FOR ANSI 150 & ALTERNATE DRILLING PATTERNS.

INSTRUMENT & DRAIN PORT CONNECTION					
THRD SIZE	DRILL Ø		OPT "A"	OPT "B"	OPT "C"
	In.	mm			
1/4"-18 NPT	.438	11	2" - 12"	2" - 12"	2" - 12"
1/2"-14 NPT	.703	18	2" - 12"	2" - 12"	2" - 12"
3/4"-14 NPT	.906	23	2" - 12"	2" - 12"	6" - 12"
1"-11 NPT	1.141	29	2" - 12"	2" - 12"	8" - 12"

SIZE	A		B		C		D	
	In.	mm	In.	mm	In.	mm	In.	mm
2"	8.75	222	14.00	356	5.06	129	3.06	78
3"	9.50	241	16.00	406	5.75	146	3.59	91
4"	11.50	292	18.25	464	6.25	159	4.59	117
6"	16.50	419	21.00	533	7.06	179	6.63	168
8"	21.00	533	25.00	635	8.03	204	8.50	216
10"	24.75	629	30.00	762	10.63	270	10.75	273
12"	28.63	727	32.50	826	11.81	300	12.69	322

TAGS AND SPECIFICATIONS

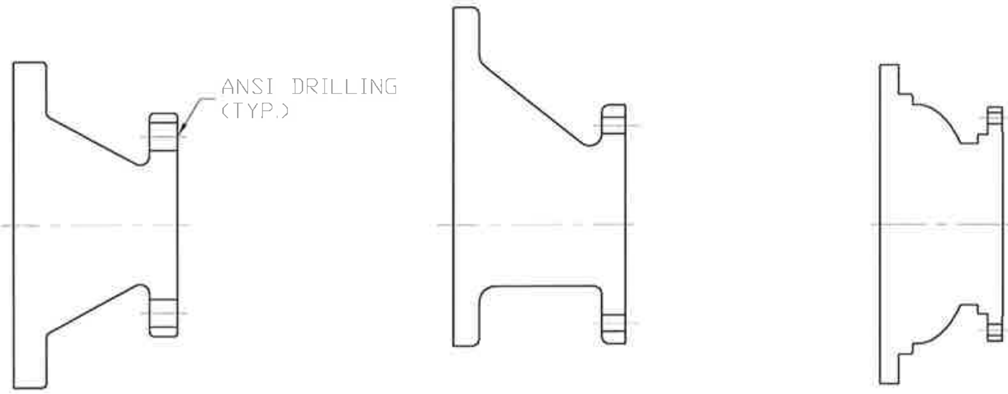
REV.	DATE	BY	ECN NO.
B	01-23-97	ESQ	97013
C	06-20-97	ESQ	97059
D	08-23-01	MP	10276

GROTH CORPORATION
a Continental Disc Company

APPROVED BY:	CHECKED BY:	DWG. NO. : C-84501
DATE:	DATE:	DWN BY: ES QUINTERO

NOTE: (1.) MODEL 7658A IS ONLY MODEL AVAILABLE WITH 1" FLANGE CONNECTION.

FLAME ARRESTER
FLANGE DRILLING DIMENSION TABLES
ANSI/CLASS 150 & ALTERNATE DRILLING



7618 7628 7658

DRILLED HOLE PATTERNS

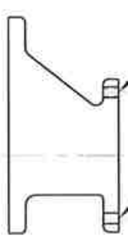
SIZE	FLANGE DRILLING	HOLE DIA. in	HOLE DIA. mm	NO. OF HOLES	BOLT CIRCLE DIA. in	BOLT CIRCLE DIA. mm
1"	ANSI 150	.63	16	4	3.13	80
2"	ANSI 150	.75	19	4	4.75	121
3"	ANSI 150	.75	19	4	6.00	152
4"	ANSI 150	.75	19	8	7.50	191
6"	ANSI 150	.88	22	8	9.50	241
8"	ANSI 150	.88	22	8	11.75	298
10"	ANSI 150	1.00	25	12	14.25	362
12"	ANSI 150	1.00	25	12	17.00	432
14"	ANSI 150	1.13	29	12	18.75	476
16"	ANSI 150	1.13	29	16	21.25	540
18"	ANSI 150	1.25	32	16	22.75	578
20"	ANSI 150	1.25	32	20	25.00	635
24"	ANSI 150	1.38	35	20	29.50	749
30"	CLASS 150	.88	22	44	33.31	846
36"	CLASS 150	1.00	25	44	39.75	1010

SIZE	FLANGE DRILLING	HOLE DIA in	HOLE DIA mm	TAPPED HOLE	NO. OF HOLES	BOLT CIRCLE DIA in	BOLT CIRCLE DIA mm
1"	JIS 10K	.75	19	M16 x 2.0-6H	4	3.54	90
2"	JIS 10K	.75	19	M16 x 2.0-6H	4	4.72	120
3"	JIS 10K	.75	19	M16 x 2.0-6H	8	5.91	150
4"	JIS 10K	.75	19	M16 x 2.0-6H	8	6.89	175
6"	JIS 10K	.91	23	M20 x 2.5-6H	8	9.45	240
8"*	JIS 10K	.91	23	M20 x 2.5-6H	12	11.42	290
10"*	JIS 10K	.98	25	M22 x 2.5-6H	12	13.98	355
12"*	JIS 10K	.98	25	M22 x 2.5-6H	16	15.75	400

* NOT APPLICABLE TO 7658A

SIZE	FLANGE DRILLING	HOLE DIA. in	HOLE DIA. mm	TAPPED HOLE	NO. OF HOLES	BOLT CIRCLE DIA. in	BOLT CIRCLE DIA. mm
1"	PN 10	.55	14	M12 x 1.75-6H	4	3.35	85
2"	PN 10	.71	18	M16 x 2.0-6H	4	4.92	125
3"	PN 10	.71	18	M16 x 2.0-6H	8	6.30	160
4"	PN 10	.71	18	M16 x 2.0-6H	8	7.09	180
6"	PN 10	.87	22	M20 x 2.5-6H	8	9.45	240
8"*	PN 10	.87	22	M20 x 2.5-6H	8	11.61	295
10"*	PN 10	.87	22	M20 x 2.5-6H	12	13.78	350
12"*	PN 10	.87	22	M20 x 2.5-6H	12	15.75	400

* NOT APPLICABLE TO 7658A



SIZE	FLANGE DRILLING	HOLE DIA. in	HOLE DIA. mm	TAPPED HOLE	NO. OF HOLES	BOLT CIRCLE DIA. in	BOLT CIRCLE DIA. mm
1"	PN 16	.55	14	M12 x 1.75-6H	4	3.35	85
2"	PN 16	.71	18	M16 x 2.0-6H	4	4.92	125
3"	PN 16	.71	18	M16 x 2.0-6H	8	6.30	160
4"	PN 16	.71	18	M16 x 2.0-6H	8	7.09	180
6"	PN 16	.87	22	M20 x 2.5-6H	8	9.45	240
8"	PN 16	.87	22	M20 x 2.5-6H	12	11.61	295
10"	PN 16	1.02	26	M24 x 3.0-6H	12	13.98	355
12"	PN 16	1.02	26	M24 x 3.0-6H	12	16.14	410

REV	DATE	BY	ECN NO
A	05/29/02	MP	10390

GROTH CORPORATION
a Continental Disc Company

APPROVED BY:	CHECKED BY:	DWG. NO. : C-92796
DATE:	DATE:	DWN BY: MP

MODEL 7618 **BILL OF MATERIAL**

ITEM	DESCRIPTION		STANDARD MATERIALS OF CONSTRUCTION			OPTIONAL FEATURES
			ALUMINUM	CARBON STL	316 SS	
1	BASE		ALUM GR 356 T6	CS WCB	CF-8M (316 SS)	
2	HANDLE		ALUM	CS	SS	
3	NUT, SPREADER	(HEX)	SS	SS	SS	
4	NUT, HEX		SS	SS	SS	
5	STUD		SS	SS	SS	
6	PLUG, ELEMENT		SS	SS	303 SS	
7	ROD, ELEMENT		SS	SS	316 SS	
8	GRID, ELEMENT		ALUM	316 SS	316 SS	
9	HOUSING, ELEMENT		ALUM	CS	316 SS	
10	PLUG, PLUG	(OPTIONAL)	ALUM	CS	316 SS	
11	COUPLING	(OPTIONAL)	ALUM	CS	316 SS	
12	* GASKET		NON-ASB	NON-ASB	NON-ASB	
13	ELEMENT, FLAME		ALUM **(1)**	316 SS	316 SS	

* SPARE PARTS

(1) Available in 316 SS

DWG. NUMBER: C-84501
BOM NUMBER: 84501BOM.XLS Rev. A

GROTH CORPORATION
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THE BOULEVARDS AT SOUTH BAY, LLC

ATTACHEMENT 5

ROG (TGNMOs) EMISSIONS CALCULATION

THE BOULEVARDS AT SOUTH BAY
TGNMOs Mass Emissions Calculation

PPM TGNMOs =	13.6	from Pilot Test GAC Vent Stack outlet
Landfill gas flow rate (scfm) =	350	projected gas extraction--initial phases

Example Only

$$\text{Pounds TGNMOs per day} = 1000\ \text{scfm} * \left(\frac{4.31\ \text{scf}}{10^6\ \text{scf}}\right) * \left(\frac{1}{379.5}\right) * 16 * \left(\frac{60\text{min}}{1\text{hr}} * \frac{24\text{hr}}{1\text{day}}\right)$$

	16	molecular weight of **"reported as"** compound (i.e. methane = 16, hexane = 86)
Pounds TGNMOs Per Day =	0.2890	
	105.4801	Lb/yr
	0	DRE (use "0" if sampling outlet gas)
	0	Pounds removed per day
	0.2890	Pounds emitted per day